SmartGrid GB Plug-in Electric Vehicle Briefing Note

1. Abstract

The purpose of this paper is to inform the attendees of the PHEV EV Infrastructure and Business Japan 2012 conference of the interplay between greater Plug-In electric vehicle uptake and smart grid development in Great Britain. Plug-in electric vehicles or PEVs refers to both plug in hybrid electric vehicles (PHEVs) and full electric vehicles (EVs). The British electricity networks will not be able to sustain future energy needs such as the increased electricity demand that comes with the decarbonisation of heat and the increased use of Plug-in electric vehicles. Using conventional technology to ensure that the grid is able to meet future energy needs has been projected to cost £46bn, but this could be reduced by around £19bn with the use smart technology options (SmartGrid GB, 2012). Two emerging smart grid technologies that can help the grid withstand the electricity demand that Plug-in Vehicles require are demand response and vehicle to grid integration technologies. As the Plug-in electric vehicle market grows an understanding of how these smart grid solutions can enable greater Plug-in electric vehicle use will become ever more important to those in the PEV marketplace.

2. Executive Summary

SmartGrid GB research consisted of analysis of government and industry reports on Plug-in electric vehicles and smart grid technologies and a series of phone interviews with 15 private and public sector stakeholders active in the UK Plug-in electric vehicle market. SmartGrid GB has found that the cost of adapting to the future energy needs of the grid, which includes dealing with increased electricity demand due to a greater number of Plug-in vehicle use, may cost £46bn (SmartGrid GB, 2012). To reduce this cost by £19bn and to facilitate greater PEV uptake smart grid technologies will need to be deployed.

Check Appendix I for Background on Smart Grids

3. UK PEV Market

3.1 Consumer Demand

Currently UK consumers are not purchasing Plug-in electric vehicles at scale which has exacerbated a number of challenges facing the nascent market including vehicle cost, formation of commercial business models, and testing the impacts of charging infrastructure on the grid.

Registration of Alternatively-fuelled vehicles (AFVs) in 2010 was 25,440 vehicles – 92% were petrol/electric hybrids – which have grown from only 9,141 AFVs registered in 2006. Alternatively-fuelled vehicles include pure electric as well as diesel/electric, petrol/alcohol, petrol/electric and petrol/gas. However, current UK consumer demand for AFVs is modest as AFVs comprise 1.3% of the total new vehicles registered in 2011 (SMMT, 2012).

In the UK there are roughly 30 million registered vehicles and in 2010 and 2011 around two million vehicles were registered (Dft, 2012a). If this trend were to continue year by year, and every vehicle being registered was a PEV (an extremely unlikely occurrence), it would take close to a decade for a PEV dominated vehicle market to emerge.

3.2 UK Government interventions

In the short term to help to create an early market and address the relatively small number of PEVs on the road - the UK government is providing grant funding for charging infrastructure through the Plugged-In Places (PiPs) programme. Other European governments, such as the Netherlands through E-ladd.nl, are also supporting public infrastructure.

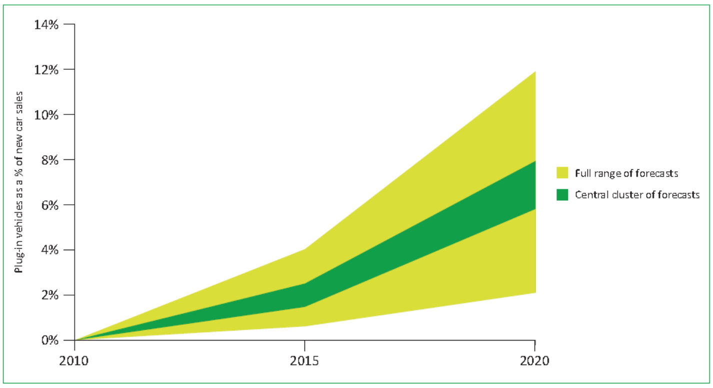
In the UK there are currently eight Plugged-in Places trial projects located in East of England, Greater Manchester, London, Midlands, Milton Keynes, North East, Northern Ireland and Scotland. The scheme offers grant funding to organisations and individuals to support the installation of electric vehicle recharging infrastructure. Data derived from the programme about how drivers use and recharge their electric vehicles will provide the necessary evidence base to shape the design of a national system of recharging infrastructure (Dft, 2012b).

Over 3,000 charge points have been installed in the UK to the end of March 2012 (BEAMA, 2012). This figure includes publically accessible, domestic and private workplace charge points. 1,673 have been delivered through the Plugged-In Places program, of which sixty per cent are publically accessible (BEAMA, 2012). The remainder have been installed by private sector organisations and local authorities outside of the Plugged-in Places regions.

3.3 Predicted Consumer Demand

In 2009 the UK Climate Change Committee set out a number of scenarios for electric vehicle uptake based on a variety of factors. In the most modest scenario electric vehicles were predicted as being 10% of new car sales in 2022, the most optimistic scenario saw electric vehicles as being over 25% of new car sales in 2022 (Climate Change Committee, 2009). More recently the UK Government took a more conservative view of PEV uptake as highlighted in the graph below which shows that by 2020 PEVs will make up between 2% to 12% of the market (OLEV, 2011).

Figure 1.2 Plug-in vehicle uptake forecasts for 2015 and 2020



Source: Graph based on selected plug-in vehicle uptake forecasts by Arup-Cenex, BCG, Berger, Cheuvreux, Deutsche Bank, Frost & Sullivan and McKinsey

The overall uncertainty of what PEV uptake would be was a consistent point made to SmartGrid GB by those interviewed. Whether the UK market develops in line with UK government predictions (see figure above) will be determined by many factors including vehicle attributes, consumers, infrastructure, policy and incentives. There was a general consensus among those interviewed that the following would greatly influence PEV uptake:

- **Customer Acceptance**. Many different factors potentially weigh in customers' minds when deciding to purchase a vehicle including vehicle cost , vehicle range, vehicle availability, accessibility of infrastructure, vehicle subsidies, non-monetary benefits including waiving of congestion charges, access to dedicated lanes, tax incentives, lower running costs in comparison to conventional vehicles, and prestige associated with owning new technology.

* **Vehicle Prices.** Today the cost of PEV's prohibits all but a small niche of consumers from purchasing the vehicles. However an Element Energy report suggests that alternative technology prices will converge with diesel vehicle prices by 2020 – 2030 (Element Energy, 2011).

3.4 Challenges to formation of robust PEV market

Many of the current challenges the nascent PEV market face relate to scale – the small number of PEVs on the road lead to increased vehicle cost, difficulty in formation of commercial business models, and inability to test the impacts of charging infrastructure on the grid.

* **Vehicle Cost** – The current high price of vehicles prohibits consumers purchasing vehicles at scale. Batteries account for the large majority of the cost of PEVs, and an Accenture report has stated that until the cost per kilowatt-hour (kWh) dramatically decreases (to reach approximately $300/kWh), consumer uptake is likely to be limited to a niche consumer market segment (Accenture, 2011a). Similarly a CENEX report found that although 65% of users were willing to pay a premium for EVs, they were not willing to pay a premium in excess of 50% which suggests that that prices need to drop dramatically before PEVs are attractive to the general public (CENEX, 2011).

  Some solutions include measures to increase volumes and allow economies of scale to act, new regulations to encourage the production of more low emission and ultra-low emission vehicles, and amortisation of R&D costs over a longer period. As mentioned above some have suggested that alternative technology prices will converge with diesel vehicle price by 2020 – 2030 thus encouraging uptake of these vehicles (Element Energy, 2011).

* **Commercial business models** – The transition from publically funded to commercial business models is constrained by the modest consumer uptake of PEVs. The UK market is dominated by the public infrastructure business model where government subsidies encourage installation of charge points to ensure availability of infrastructure for PEV consumers. The preferable outcome of the public infrastructure business model is to act as a market starter for commercial markets going forward.

  One solution is to send clearer messages to consumers. Currently the UK PEV market is hindered by a confusing customer journey and consumers would benefit from receiving clear messages regarding charge rates, range, connector types, charging modes, charging locations and access types (e.g. RFID card access and PAYG).

* **Impact of charging infrastructure** – The impacts of charging infrastructure on the grid remains largely untested as there are still relatively few vehicles on the road. In the UK theoretical studies have predicted impacts on the grid and a few studies through the Low Carbon Network Fund have begun to test real-life effects however these studies will not conclude for another year.

  Solutions include continuing to collect learning regarding impact on the UK networks through the Plugged-in Places scheme and Low Carbon Network Fund.

3.5 Lessons from other new markets

An Accenture report provides lessons learnt from other nascent markets that can be applied to the PEV market (Accenture, 2011a). These insights include –

* In the mobile telecommunications market when a consumer uses their phone abroad the companies settle costs among themselves which simplifies the customer journey. In the PEV market charge point operators could similarly settle the costs amongst themselves and retain a single point of customer contact.

- Within banking a customer can use the automated teller machines (ATMs) of any bank. Similarly, consumers in the PEV market could use multiple charging points regardless of the supplier.

Supporting both of these examples is a set of market agreements between the relevant parties, which facilitate market entry for new players and ensure a customer-friendly solution. Vocalink and BACs are examples of companies that run these market agreements. Vocalink – processes more than 500 million payments per month (real-time inter-bank transfers) and connects more than 60,000 ATMs (Vocalink, 2012). BACs – Membership based industry body manages direct debits.

The establishment of these types of agreements in the electric transport market could be the underpinning of a commercial market model.

4. Grid - Effect of Plug-in Electric Vehicles on UK networks

4.1 Strain on UK electricity networks

Even if the most modest scenario of PEV uptake is realised the increased electricity demand from these PEVs in combination with other activities such as the decarbonisation of heating (introduction of more electric heat pumps) and domestic-scale renewable generation (introduction of more solar photovoltaic panels) will introduce substantial new levels of demand onto the UK electricity networks. Additionally, localised peaks of electricity demand could emerge due to clustered PEV charging at homes and public charging points. When you consider this with the fact that ownership of an electric car can double the electricity demand of a small household, the potentially highly disruptive implications that PEV will have on the grid become clearer (DECC/Ofgem Smart Grid Forum, 2012).

4.2 Mitigation of effects

A number of reports from government and non government sources have highlighted the cost efficiency of using smart grid solutions as a means of dealing with future energy demand on the grid such as the electricity demand that charging PEVs will necessitate. For example the Low Carbon Innovation Coordination Group recently published a report stating that by 2050, the deployment of EVs in combination with other predicted changes to the UK networks will place significant new demands on the UK's aging electricity transmission and distribution networks (Low Carbon Innovation Coordination Group, 2012). The group concluded that electricity networks and storage technologies have the potential to meet the new stresses placed on the electricity system more cost-effectively than would be possible through traditional methods of grid reinforcement and continued investment in back-up fossil fuel power plants. The report highlights innovation areas with the biggest benefit to the UK include EV integration technologies and installation methods (particularly Vehicle-to-grid controllers) as they are easily usable by consumers and can be managed alongside Demand Response, home hub, smart distribution and distribution-level storage.

SmartGrid GB's economic report - "Smart Grid - A Race Worth Winning?" highlights a potential £19bn in savings to be made if smart grid technologies are used to update grid infrastructure opposed to conventional technologies, which would cost £46bn. The UK gas and electricity market regulator Ofgem has also confirmed that smart grid technologies are the most cost effective way of lessoning future energy demand on the grid through the work done in the DECC/Ofgem Smart Grid Forum.

For background information on Smart Grids see Appendix II.

In order to help direct charging to the optimal time there are a number of measures (see below) aimed at ensuring recharging of PEVs does not lead to grid failure largely by ensuring that charging occurs off-peak or during periods of low electrical demand. In the short term timers and tariffs could be deployed while home automation, smart meters, demand response, and intelligent vehicles could be available in the medium to longer term (BEAMA, 2012).

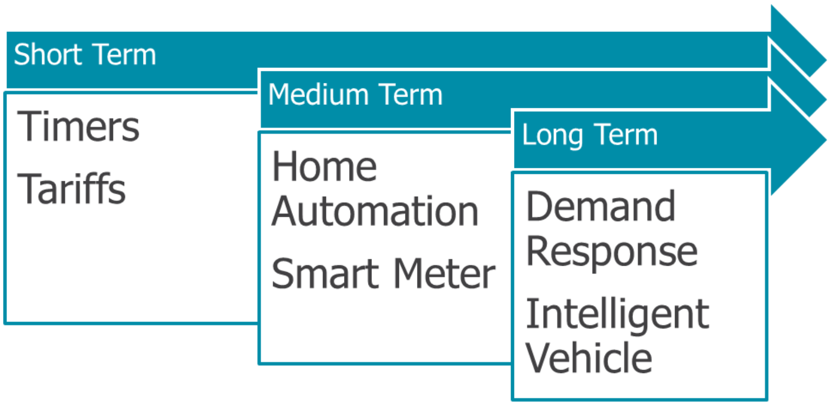


Figure 1 (above)

Further explanation into the potential technologies and techniques that can be employed to control PEV recharging are set out below (BEAMA, 2012).

Off-Peak recharging measure	Availiability	Advantages	Disadvantages
Timers	Short Term – availiable now	Simple and cost effective soluton	As UK move to 'smarter' recharging system simple controls will not be able to meet more complex charging demands
Tariffs	Short Term – TOU tariffs will be developed in next few years	Low barriers to introduction as Time of Use tariffs are accepted by UK customers	Early PEV adoptors may be insensitive to tariff pricing (relatively low cost of recharging a PEV – likely to be no more than £3.50 at current prices – in comparison to high price of PEV)
Home Automation	Medium Term – Technology is availiable now	Relatively simple, low cost, well understood technology	Low uptake as it involves additional cost to consumer without consumer benefit
Smart Meter	Medium Term – Deadline for roll out is 2019	All UK smart meters built to a consistent functional and technical specification, enabling easier interoperability with PEV recharging infrastructure.	May require purchase of additonal control equipment by the customer
Demand Response	Medium to Long Term	Can aid network operators in	Vehicle manufacturers and

	– Availiable after smart meter roll out thus likely to be post 2020	avoiding local electricity network overloading and therefore the potential deferment of investment in reinforcement.	energy industry will need to ensure interoperability Customer concerns regarding data privacy and security would need to be managed
Intelligent Vehicle	Long term – Availiable 2030 and beyond	Could enable vehicle to grid data sharing. Could supersede other options.	Will require the development of proposed initiatives such as smart grid and demand response

4.3 Demand Response

Of the techniques and technologies listed above demand response - the active, short-term reduction or shifting in consumption of electricity at a particular time - is emerging as a key means of alleviating demand from the grid during PEV recharging. Most people will charge their PEV at a similar time in the day, often after 5pm when people have finished work. If everyone charges their vehicle at this time the demand on the grid will be unsustainable, this is why demand response can be so useful in relation to alleviating the energy demands that PEVs create.

The UK Government's Department of Energy and Climate Change has recently highlighted the value of demand response in relation to alleviating the demands of the electricity grid, stating that demand response can be used to help balance supply and demand of electricity by providing system flexibility, especially at times when customer demand and availability of variable renewable generation pull in opposite directions (i.e. demand is increasing while availability of variable renewable generation is falling and vice versa). This could be achieved by self-supplying using local backup generation, or by not using the electricity at that time, reducing the need for peaking plant and network reinforcement. In this way, demand response can reduce the total capacity needed on the system, and reduce the need for generation capacity to meet peaks in demand (Department of Energy and Climate Change, 2012).

A joint Ricardo and National Grid report predicts that using demand-side management alongside charging of PEVs in 2020 could provide an average of 6% of daily UK network balancing service requirements. This would rise to a maximum of 10% in the evenings and overnight (Ricardo/National Grid, 2011).

A joint Ricardo and National Grid report predicts that using demand-side management for a fleet of 600,000 vehicles in 2020 could provide an average of 6% of daily UK network balancing service requirements. This would rise to a maximum of 10% in the evenings and overnight (Ricardo/National Grid, 2011).

The ENA, the UK trade association for distribution network operators, has stated that at the national level, full penetration of Electric Vehicles (EVs) and Heat Pumps (HPs) could increase the present daily electricity consumption by about 50%, while doubling the system peak (requiring in turn significant generation and network reinforcements). However, by optimising demand response the peak increase could be restricted to only 29%, resulting in massively improved utilisation of generation and network capacity, and significantly reduced network investment (ENA, 2011).

Although the functionality of demand response is particularly key when dealing with the energy demands of PEV use because PEVs concentrate electricity demand to specific times of the day, overall the effectiveness of demand response in relation to mitigating increased demand is dependent on a number of other technologies as highlighted in figure 1.

There are currently a handful of projects in the UK testing the real-life effects of demand response. Initiatives such as the UK Low Carbon Network Fund include projects in London and the North East that are currently gathering information on how consumers charge and are using this to better inform network managers who make grid network infrastructure decisions. Findings from project in the North East will available from mid-2013. The London project has identified peak times in which EVs are being charged, giving an indication of how demand response technology could be used as a means to shift electricity demand from peak times.

4.4 "Vehicle to Grid" concept

Another important smart grid development is the "Vehicle to Grid" concept whereby energy from the grid can flow into batteries within PEVs to be stored and then can be extracted and put back into the grid for use at a later time. This could also provide financial incentives for consumers, making an attractive business case for PEV owners (Ricardo/National Grid, 2011). Full trails into using the "Vehicle to Grid" concept and the financial benefits it might produce for PEV owners are still unclear (Ricardo/National Grid, 2011).

4.5 Smart grid development and the PEV marketplace

The above touches on some of the main aspects of smart grid development which could play a role in mitigating the increased electricity demand that comes with greater PEV uptake. More solutions are being developed internationally through academic and market research, and technological trails. As the PEV market continues to grow so will the smart grid market as more companies involved in the creation and selling of smart grid solutions develop their products to try and meet future energy demands.

The results of technological trails into smart grid functionality that are taking place will continue to define what the most energy efficient and cost effective solutions are to increased electricity demand and the strain this demand places on electricity networks. As a result engagement and understanding of the smart grid is likely to be an increasingly important activity for those involved in the PEV market.

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Appendix I Background on Smart Grids

Building a 'smarter' grid is an incremental process of applying information and communications technologies (ICTs) to the electricity system, enabling more dynamic 'real-time' flows of information on the network and more interaction between suppliers and consumers. These technologies can help deliver electricity more efficiently and reliably from a more complex network of generation sources than the system does today.

With a progressively smarter grid, operators get more detailed information about supply and demand, improving their ability to manage the system and shift demand to off-peak times. Consumers are offered far more information about, and control over, their electricity use, helping reduce overall demand and providing a tool for consumers to reduce cost and carbon emissions.

Smart grids offer the prospect of delivering electricity in a low carbon future more efficiently and more reliably, intelligently integrating the actions of all participants in the system.

Below is a graph highlighting grid infrastructure in Great Britain from the Department of Energy and Climate Change paper - Electricity System: Assessment of Future Challenges.

The concept of smart grids focused on the distribution circle - the transfer of electricity from medium and low voltage substations to homes and businesses.