Logical White Paper

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FEVRE (Future Electric Vehicle & Reduced Emissions) Strategy

Foreword

We started our FEVRE programme in Q1 2017. We have been undertaking significant levels of research in terms of how the fleet manager might be impacted by future changes to engine and battery technologies. This in turn will be driven by global policies and legislation. The 'fleet manager' label applies to individuals throughout the UK. Equally, it applies to organisations (like Logical) who bring a level of fleet management expertise to the businesses we deal with.

Our focus is centred around what individuals and businesses need to know and how we will support them in the immediate and near-term future and beyond. Our views are opinions, based on years of experience not only in fleet, but within our partner group in respect of renewable energy and reduced emissions capabilities. They are intended to inform thinking and to shape our proposition and operating model so that we can be a first mover and 'ahead of the wave' in a space that is generally regressive to the speed of change that is with us already.

The Logical view is that the fleet of tomorrow will undoubtedly be centred around electricity technologies and that the future is rapidly evolving and huge changes are nearer than many organisations believe. Is the future ten, twenty, thirty years away? We believe it is already with us. Legislation such as the Clean Air Act are already impacting organisational thinking.

To this end, we are engaging in a wide-ranging review of how we need to support our clients with the appropriate insights, strategic thinking and include the varied opinions relating to approach. Towards the end of 2017, we will consult further with various organisations (including customer focus groups) and roll out our strategy and guidance when complete.

Introduction – The future is electric

Without doubt, the future of vehicle power is electric. Within a relatively short space of time, the engine technologies of all vehicles will be, at the very least, hybrid technology or, increasingly, wholly electric battery powered. Engine power might come from alternative sources; Hydrogen for example, but global technologies, legislation, policy direction and strategic thinking suggest that battery power via electric charging is the future.

By 2020, JLR and Volvo have already announced that they will not produce any solely petrol or diesel engines and hybrid or all-electric options will be manufactured. Others are likely to follow. For its part, the government has set out strategic thinking to prepare the UK with infrastructure that supports an electric dominant vehicle type by 2040. It is anticipated that 50% of all vehicles will have some form of electric motor within the next ten years.

Limitations to this growth expectation are not necessarily related to battery technology in the vehicle, speed of charge, range anxiety or engine engineering challenges (they are already well advanced and improving quickly) but more over related to the network of energy supply (charging) into the vehicles at appropriate times.

There is no doubt, in its current form, that total electricity capacity generated today is not capable of meeting the demands of a dominant electrically powered vehicle supply as predicted in the future. Quite obviously, millions of electric cars – charged predominantly by owners at home – would put an unachievable demand on the grid network. Equally, battery tops ups; say through a network of forecourt operations- are likely to place at times of peak demand, and therefore, compromise power supply across the grid.

At the high level (generation level), electricity produced must be used. It cannot be stored in vast reserves (like oil or gas for example) for use at peak periods or when needs arise. Therefore, electricity generation capacity will need to increase massively or, preferable technologies will need to evolve to store power in batteries, to be used later.

It is in this area that some of the most exciting progress will need to be made as the future of power generation is already committed way out into the future (wind, nuclear etc.).

It is stated that this generation will not be able to meet the needs of many millions of vehicles requiring heavy charging throughout a given day and, most often, during peak periods. (As is the case now for vehicles being filled up with petrol/diesel.)

Vehicle-to-grid

Vehicle-to-grid (V2G) describes a system in which plug-in electric vehicles, such as electric cars (BEV) and plug-in hybrids (PHEV), communicate with the power grid to sell demand response services by either returning electricity to the grid or by throttling their charging rate.

Vehicle-to-grid can be used with 'gridable' vehicles. That is, plug-in electric vehicles (BEV and PHEV), with grid capacity. Since at any given time 95 percent of cars are parked, the batteries in electric vehicles could be used to let electricity flow from the car to the electric distribution network and back. This represents an estimated value to the utilities of up to £3800 per year per car.

History

The company AC Propulsion Inc. coined the term V2G for vehicle-to-grid. Versions of the vehicle-to-grid concept, all of which involve an onboard battery:

- A hybrid or Fuel cell vehicle, which generates power from storable fuel, uses its generator to produce power for a utility at peak electricity usage times. Here the vehicles serve as a distributed generation system, producing power from conventional fossil fuels, biofuels or hydrogen.
- A battery-powered or plug-in hybrid vehicle which uses its excess rechargeable battery capacity to provide power to the electric grid in response to peak load demands. These vehicles can then be recharged during off-peak hours at cheaper rates while helping to absorb excess night time generation. Here the vehicles serve as a distributed battery storage system to buffer power.
- A solar vehicle which uses its excess charging capacity to provide power to the electric grid when the battery is fully charged. Here the vehicle effectively becomes a small renewable energy power station. Such systems have been in use since the 1990s and are routinely used in the case of large vehicles.

It should also be noted that besides vehicles which have an onboard battery, vehicles without a large battery, but which connect to/recharge a battery placed at the house (for example being part of an off-the-grid electrical system or net metering system) could in effect form a vehicle-to-grid system. Even a renewable energy source could be used. Logical / EVS is currently in discussions to do this via solar panels on roofs to power a customer fleet.

Types

V2G is classified based on the power flow direction: Unidirectional V2G and Bidirectional V2G

Peak load levelling

The concept allows V2G vehicles to provide power to help balance loads by "valley filling" (charging at night when demand is low) and "peak shaving" (sending power back to the grid when demand is high, see duck curve). Peak load levelling can enable utilities new ways to provide regulation services (keeping voltage and frequency stable) and provide spinning reserves (meet sudden demands for power). In future development, it has been proposed that such use of electric vehicles could buffer renewable power sources such as wind power, for example, by storing excess energy produced during windy periods and providing it back to the grid during high load periods, thus effectively stabilizing the intermittency of wind power. Some see this application of vehicle-to-grid technology as a renewable energy approach that can penetrate the baseline electric market.

It has been proposed that public utilities would not have to build as many natural gas or coal-fired power plants to meet peak demand or as an insurance policy against blackouts. Since demand can be measured locally by a simple frequency measurement, dynamic load levelling can be provided as needed.

Carbitrage

Carbitrage is a portmanteau of 'car' and 'arbitrage'. When the electric utility would like to buy power from the V2G network, it holds an auction. The car owners can define the parameters under which they will sell energy from their battery pack. Many factors would be considered when setting minimum sale price including the cost of the secondary fuel in a PHEV and battery cycle wear. When this minimum price is satisfied, it is deemed as meeting carbitrage.

Backup power solutions

Future battery developments may change the economic equation, making it advantageous to use newer high capacity and longer-lived batteries in BEV/PHEVs. These newer batteries can be used in grid load balancing and as a large energy cache for renewable grid resources. Since BEVs can have up to 50 kWh worth of battery storage they represent somewhat more than the average home's daily energy demand.

Even without a PHEV's gas generation capabilities such a vehicle could be used for emergency power for several days (for example, lighting, home appliances, etc. with combined load of 1 kW could be powered for 50 hours). This would be an example of Vehicle-to-home transmission (V2H). As such they may be a complementary technology for intermittent renewable power resources such as wind or solar electricity.

Efficiency

Any conversion of energy has losses due to the laws of thermodynamics. Lower losses mean better efficiency. Most modern battery electric vehicles use lithium-ion with an 80–90% efficiency. The lithium titanate version has a battery efficiency (less charger) from 90 to 98%, depending on circumstances like charge rate, charge state and temperature.

Lead-acid batteries may be 76% efficient, but are rarely used in modern road vehicles. The charge/discharge cycle for the battery alone may be 80-90%. The charge/discharge electronics also have losses.

Future Plans for Vehicle-to-Grid (V2G) in various Countries

A study conducted in 2012 by the Idaho National Laboratory, revealed the following estimations and future plans for V2G in various countries. It is important to note that this is difficult to quantify because the technology is still in its nascent stage, and is therefore difficult to reliably predict adoption of the technology around the world. The following list is not intended to be exhaustive, but rather to give an idea of the scope of development and progress in these areas around the world.

United States

Current environmental issues in the US are playing a vital role in the demand for V2G technology. The decrease in costs for implementation of V2G will be directly related to the speed of adoption by consumers. As smart grid rollout continues, and the population realizes the lower cost of electric vehicle ownership, demand will increase. Continued V2G testing and the further development of two-way communications standards will offer interoperability across systems.

Fleets such as the US Postal Service will be crucial to V2G development. Private grid testing will continue as utilities, automakers, and colleges form partnerships. The University of Delaware has recently signed its first license for V2G testing with Autoport, Inc. They expect that by the second or third quarter of 2011, 100 electric vehicles on the road will be capable of V2G testing (Bryant 2010).

PJM interconnection has envisioned using US Postal Service trucks, school buses and garbage trucks that remain unused overnight for grid connection. This could generate millions of dollars because these companies aid in storing and stabilizing some of the national grid's energy.

The US is projected to have one million electric vehicles on the road between 2015 and 2019. Studies indicate that 160 new power plants will need to be built by 2020 to compensate for electric vehicles if integration with the grid does not move forward (ZigBee 2010).

Japan

Japan currently is a leader in the electric vehicle industry. This may allow the country to pioneer new V2G technology for the mainstream. In order to meet the 2030 target of 10% of Japan's energy being generated by renewable resources, a cost of $71.1 billion will be required for the upgrades of existing grid infrastructure.

The Japanese charging infrastructure market is projected to grow from $118.6 million to $1.2 billion between 2015 and 2020 (ZigBee 2010). Starting in 2012, Nissan plans to bring to market a kit compatible with the LEAF EV that will be able to provide power back into a Japanese home. Currently, there is a prototype being tested in Japan. Average Japanese homes use 10 to 12 KWh/day, and with the LEAF's 24 KWh battery capacity, this kit could potentially provide up to two days of power (Howard 2011). Production in additional markets will follow upon Nissan's ability to properly complete adaptations.

Denmark

Denmark currently is a world leader in wind power generation, with 20% of the country's energy coming from wind (there are enough installed turbines to meet up to 40% of the country's energy needs). Initially, Denmark's goal is to replace 10% of all vehicles with PEVs, with an ultimate goal of a complete replacement to follow. The Edison Project implements a new set of goals that will allow enough turbines to be built to accommodate 50% of total power while using V2G to prevent negative impacts to the grid. Because of the unpredictability of wind, the Edison Project plans to use PEVs while they are plugged into the grid to store additional wind energy that the grid cannot handle. Then, during peak energy use hours, or when the wind is calm, the power stored in these PEVs will be fed back into the grid.

To aid in the acceptance of EVs, policies have been enforced that create a tax differential between zero emission cars and traditional automobiles. The Danish PEV market value is expected to grow from $50 to $380 million between 2015 and 2020. PEV developmental progress and advancements pertaining to the use of renewable energy resources will make Denmark a market leader with respect to V2G innovation (ZigBee 2010).

Following the Edison project, the Nikola project was focused on demonstrating the V2G technology in a lab setting, located at the Risø Campus (DTU). DTU is a partner along with Nuvve and Nissan.

The Nikola project is finishing in 2016, and lays the groundwork for Parker, which will use a fleet of EVs to demonstrate the technology in a real-life. Besides demonstrating the technology, the project also aims to clear the path for V2G-integration with other OEMs as well as calculating the business case for several types of V2G, such as Adaptive charging, overload protection, peak shaving, emergency backup and frequency balancing. the project starts in August 2016 and runs for 2 years. Other notable projects in Denmark are the SEEV4-City Interreg project which will demonstrate V2G in a car sharing fleet in the north harbour of Copenhagen and the ECOGrid 2.0, which will not include EVs but build the aggregator software to fully integrate it into the Danish electricity markets.

United Kingdom

The V2G market in the UK will be stimulated by aggressive smart grid and PEV rollouts. Starting in January 2011, programs and strategies to assist in PEV have been implemented. The UK has begun devising strategies to increase the speed of adoption of EVs. This includes providing universal high-speed internet for use with smart grid meters, because most V2G-capable PEVs will not coordinate with the larger grid without it.

The "Electric Delivery Plan for London" states that there are only 500 on-road charging stations; 2,000 stations off-road in car parks; and 22,000 privately owned stations installed. Local grid substations will need to be upgraded for drivers who cannot park on their own property. By 2020 in the UK, there will be a smart meter in every residential home, and about 1.7 million PEVs on the road. The UK's electric vehicle market value is projected to grow from £0.1m to over £1billion between 2015 and 2020.

Summary

Electricity/Battery technologies for power supply to propel vehicles is the future. Technologies are advancing rapidly. Batteries can be charged quicker, range is getting greater, performance is improving, and costs are beginning to lower. The future is now and the importance of understanding the technologies and how they can be deployed today and tomorrow for businesses throughout the UK is not an outlook, conceptual programme, it is strategic thinking that should take place now for today's capabilities and later for the future shape of an electric vehicle world.

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Sources: Egnida Group, Wikipedia, Harvard Business School. National Grid. SMMT.