SMART CHARGING

How will the growth of electric vehicles impact the grid?

Photo: Electric Nation

Following striking media headlines about how much new electricity generating capacity might be needed to support electric vehicles, *Nick Storer* explains how the truth will be less dramatic – through the use of smart charging and demand management.

National Grid's *Future Energy Scenarios*, published in July this year, included a number of forecasts that estimated that the additional system-wide peak electricity demand from electric vehicles could range from 6 GW to 18 GW in 2050. This resulted in a selection of articles in the media with dramatic claims about the impact that electric vehicles (EVs) would have on the UK's electricity grid – including the need for up to ten new nuclear power stations to support them.

Barely two weeks after National Grid's scenarios were published, the UK government announced that it would ban the sale of conventional petrol and diesel cars and vans by 2040. Although this wasn't particularly newsworthy to the automotive industry, as it was heading towards a similar target anyway, this resulted in further media stories about whether the UK's electricity grid would be able to cope with charging millions of EVs.

In response to the various items of media coverage, National Grid issued an 'EV myth buster' document in August, which aimed to clarify the most likely future scenario – termed 'Two Degrees' – with regards to EVs and the grid.

The additional peak demand from EVs in that scenario wasn't 30 GW (which was based on there being no petrol or diesel cars on the road by 2040), but instead it was more likely to be 5 GW. Peak demand is typically around 5.30 pm on a winter weekday evening, when homes need light and heat before factories and offices have closed.

Since then there have been many more stories published on this subject. But there is one key issue that has not been made clear, which is the differentiation between National Grid's power supply (generation) and local, low voltage electricity network capacity to deliver that power to consumers.

Local distribution effects

The main issue around network capacity relates to clusters of EVs charging at peak times on local electricity networks – ie the cables running from local substations to people's homes, which Distribution Network Operators (DNOs) are responsible for. The expected peaks on such networks are likely to be for short periods in the early evening in winter months.

In addition to coverage in the media, there has been much commentary about EVs and the grid within the industry which ignores the viewpoint from the DNOs, whose job is to maintain security of supply to households and businesses.

Two recent research projects, both supported by the UK's electricity regulator Ofgem, have looked at the issue of EVs and local electricity networks.

The first, 'My Electric Avenue', was delivered between January 2012 and December 2015 by EA Technology on behalf of Scottish and Southern Electricity Networks (SSEN) as part of the Low Carbon Networks (LCN) Fund. The project examined the impact that clusters of EVs charging at peak times have on local networks.

The trial included one type of electric vehicle, the Nissan LEAF, with 3.5 kW charging. The energy demand for an electric vehicle such as this can be equivalent to that of a house, and so charging can result in a near doubling of evening peak load for a household.

The results of the My Electric Avenue project showed that, across Britain, 32% of medium voltage (11 kV) and low voltage feeders, totalling 312,000 circuits, will require intervention (upgrading or even complete replacement) when 40–70% of households have EVs. The cost of such intervention would be at least £2.2bn up to 2050.

But My Electric Avenue also demonstrated that a simple on/off

system for managing EV charging during winter peak electricity demand, to protect local electricity networks from damaging loads, could help DNOs to defer the need to invest in upgrading or replacing their assets or even avoid it all together – thus reducing additional costs on customers' bills.

Since My Electric Avenue there has been a rapid growth of range in EVs that are available, as well as an increase in battery capacities, charging rates and advances in charger technology.

More data

A second project began in 2016: Electric Nation, hosted by the DNO Western Power Distribution (WPD) and delivered by collaboration partners EA Technology, DriveElectric, Lucy Electric, GridKey and TRL.

Electric Nation is trialling smart charging solutions to address the issue of potential local electricity network capacity challenges with 500–700 electric vehicle drivers, comprised of over 40 makes and models of battery electric vehicles and plug-in hybrids.

Smart chargers have the ability to communicate, as opposed to the 'dumb' chargers that are widespread in the UK at present, and allow demand management to take place at times of excess load on local electricity networks.

In practice this could mean that if a car is plugged in at home from 6 pm in the evening until 6 am the following morning, the charging of the vehicle may not be possible at the 6 pm winter evening peak period. But within the 12-hour window for charging, the vehicle would still be fully charged by the next morning.

Initial findings from Electric Nation show that smart charging and demand management systems can work. Electric Nation is using two demand control providers, CrowdCharge and GreenFlux, which send signals to the smart chargers, which are provided by Alfen and eVolt. GreenFlux already has experience of a number of successful smart charging projects in the Netherlands. Early customer research conducted by Impact Research suggests that there also appears to be broad customer acceptance of managed charging.

Electric Nation's initial findings are based on almost 70,000 hours of charging data, and show that 48% of plug-in events begin between 5 pm and midnight. On average, these vehicles are plugged in for 12 hours, but are only charging for just over two hours. This suggests that there is likely to be sufficient flexibility in the majority of EV charging sessions to manage charging away from peak electricity demand periods. This will be explored in detail through the remainder of the trial taking place during 2017 and 2018.

An Electric Nation smart charger

Photo: Electric Nation

How does this impact demand scenarios?

By introducing smart chargers and the ability for demand management between a person's home and their local substation, the extra peak energy demand from EVs referred to in the National Grid *Future Energy Scenarios* report could be minimised.

In fact, National Grid's Two Degrees scenario (where the peak demand from electric vehicles is around 5 GW) is based on people using smart chargers. If we continue to install 'dumb' chargers as we are now, we will use up any spare capacity at a quicker rate and force DNOs to spend large amounts of customers' money on reinforcing the networks.

Additional power generation will be required to fulfil the needs of EV charging in a world where EVs are becoming the norm, but investment in peak power plants, which are used infrequently and are expensive to operate, could be optimised if EV demand management is widely available.

The impact of EV charging at peak periods could be reduced further if combined with other initiatives such as time-of-use tariffs, encouraging drivers to charge at times of low electricity demand, and vehicle-to-grid (V2G) technology, whereby the energy in an EV's battery could be put back into the grid at times of peak demand.

No V2G charger has been available for domestic use in the UK to date, but the Electric Nation project aims to source and trial this technology in the near future. Ultimately, EV owners with a V2G charger could help to create decentralised power generation and get paid for putting energy back into the grid at peak times. Other forms of energy storage will also play a part in helping to reduce the peak demand from EVs.

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Electric Nation is trialling one technological solution to EV demand management – smart chargers managed by a centralised back office system, and others are being trialled elsewhere in the world, such as demand management through on-board charger management systems on an EV itself.

The ultimate aim of Electric Nation is to provide DNOs with an understanding of how EV demand management could provide a solution to management of peak loads, to minimise the cost of upgrading and replacing local electricity network assets where EV loads could damage those networks. The project is also looking at whether customers will accept EV demand management at home, what interaction with the systems they might require (eg the ability to override demand management in cases where a charge is required sooner rather than later for planned journeys), and whether customers would need to be incentivised to participate in EV demand management.

All this work will eventually provide DNOs with a model of how EV demand management could work and a specification to allow them to go to market to buy EV demand management services. Who will provide these services and how is not clear at this time, but it is highly unlikely that the DNOs themselves would take direct control of customers' smart chargers.

Given the plethora of charger manufacturers operating in the UK market at this time it is likely that some form of aggregation of EV demand management would be required to provide geographically based EV demand management coverage – Electric Nation will be investigating potential market models in 2019.

For 'universal' EV demand management to work using smart chargers, some form of standardisation of charger functionality, communications and protocols could be envisioned, to enable EV demand management service providers to manage a wide variety of makes of chargers.

Alternatively, aggregators of EV demand management would require a standardised system for communicating demand management requirements to EV demand management service

providers, again, to get the geographical coverage a DNO would require. All this needs further thought and development by stakeholders in the electricity industry, vehicle manufacturers and the EV charging community.

SSEN's Smart EV project, being delivered by EA Technology, is already looking at establishing industry standards for smart charging, working across industry sectors to achieve consensus. Consultation on a range of technical architectures will take place in the coming months.

How many EVs?

So, are we really going to see a huge increase in sales of electric vehicles? To answer this question we need to look at some background issues.

First, by 2050 the UK government has to reduce its greenhouse gas emissions by 80% compared with 1990 levels. One of the easier ways to achieve this is by encouraging people to buy cars with lower carbon dioxide emissions.

The government may have recently announced the ban of conventional petrol and diesel cars and vans by 2040, but car manufacturers such as Volvo and Jaguar Land Rover have said that all their new cars will be electrified from 2019 and 2020 respectively, showing that the car industry is ahead of the government on this issue.

There's also the fleet average carbon dioxide targets that carmakers in Europe have to achieve – the next one being 95g/km CO_2 by 2021. To meet future targets manufacturers will have to find ways to lower emissions substantially, otherwise they face the prospect of huge fines. Electric cars are the obvious way to do this.

However, the big issue that industry experts have been aware of for a long time, but that the mainstream media has only picked up on recently (due in large part to Volkswagen's Dieselgate scandal) is air quality. The problem of poor local air quality, caused by NOx and particulates, and the resulting adverse impact on people's health, is gaining a higher political priority around the world, and clearly EVs deliver zero tailpipe emissions.

Most EVs are charged at home at the moment, although it is expected that there will be more use of Tesla supercharger-style rapid public charging stations in the future. These would not, necessarily, be connected to local low voltage networks.

It should also be noted that the UK's electricity generation – the source of the power for electric cars – is also decarbonising at a faster rate than many people thought.

So, what needs to happen to facilitate the transition to smart charging? First, any decisions need to be based on evidence. My Electric Avenue showed that there is likely to be a challenge for some local electricity networks if clusters of EVs are charged at peak times. Electric Nation is currently trialling a solution to this issue, in the form of smart charging and demand management.

Whatever the outcome, consultation and collaborative working between different elements of the energy sector, the automotive industry, and of course government, will be required. Within such a collaborative approach, the voice of the DNOs should be listened to, as it is they who are on the front line in terms of the impacts of growing numbers of EVs on local electricity networks.

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