

# Intelligent Management of Electric Vehicle Charging

## A white paper by EA Technology

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### Introduction

Transport, dominated by road vehicles, is responsible for around 21% of the UK's greenhouse gas emissions<sup>1</sup>. The automotive sector continues to unveil innovations in Electric Vehicles and Plug-In Hybrids (EVs and PHEVs) to help meet (legally binding) carbon targets. As consumers adopt these technologies new challenges fall to the electricity transmission and distribution network operators.

Energy which is now moved around the country as fuel could soon be moving through the electricity networks. In addition, as groups of neighbours acquire EVs, localised clustering of demand is likely to cause problems for some electricity networks. This would mean expensive work replacing cables and transformers. Through a project called My Electric Avenue, EA Technology and partners have been working to find an alternative.

My Electric Avenue has shown that a 'smart' technology called Esprit will allow more EVs to charge without needing upgrades to the electricity networks – resulting in lower costs for customers. Esprit works by pausing EV charging at peak times when the distribution network – which carries electricity to customers – is in danger of overloading. Once peak time has passed, EVs resume charging normally.

This White Paper sets out EA Technology's vision for Esprit, based on the key findings from My Electric Avenue. Simply put, that vision is to support reliable and cost effective electricity networks as they enable the move towards a low carbon future.

### What Do Electric Vehicles Mean for the Electricity Networks?

The power drawn by a Nissan LEAF is currently roughly equivalent to that of a kettle operating continuously for several hours. This demand coincides with peak demand in the evening as people plug in their vehicles after returning home. The My Electric Avenue project showed average peak demand per customer more than doubling to 2 kW (Figure 1).

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<sup>1</sup> DECC (3 February 2015) "UK Greenhouse Gas Emissions, Final Figures" Available: [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/407432/20150203\\_2013\\_Final\\_Emissions\\_statistics.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/407432/20150203_2013_Final_Emissions_statistics.pdf)

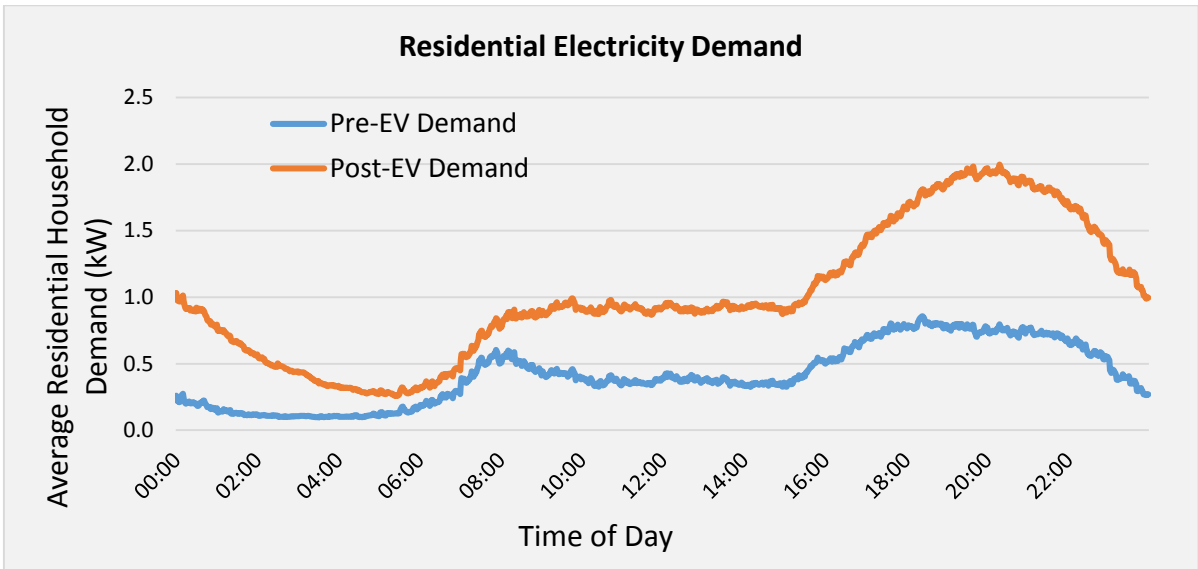


Figure 1: The demand (in kW) by time on a typical weekday.

Peak demand on the network will rise further with the increase in the number of EVs (number of registered vehicles has grown and is expected to continue growing exponentially, Figure 2). The effect of clusters will accentuate the strain put on the local electricity networks, increasing the likelihood of localised problems with network voltage or thermal capacity. In extreme cases this will lead to outages causing inconvenience to the customer, reputational damage for the EV industry and penalties for the Distribution Network Operators (DNOs).

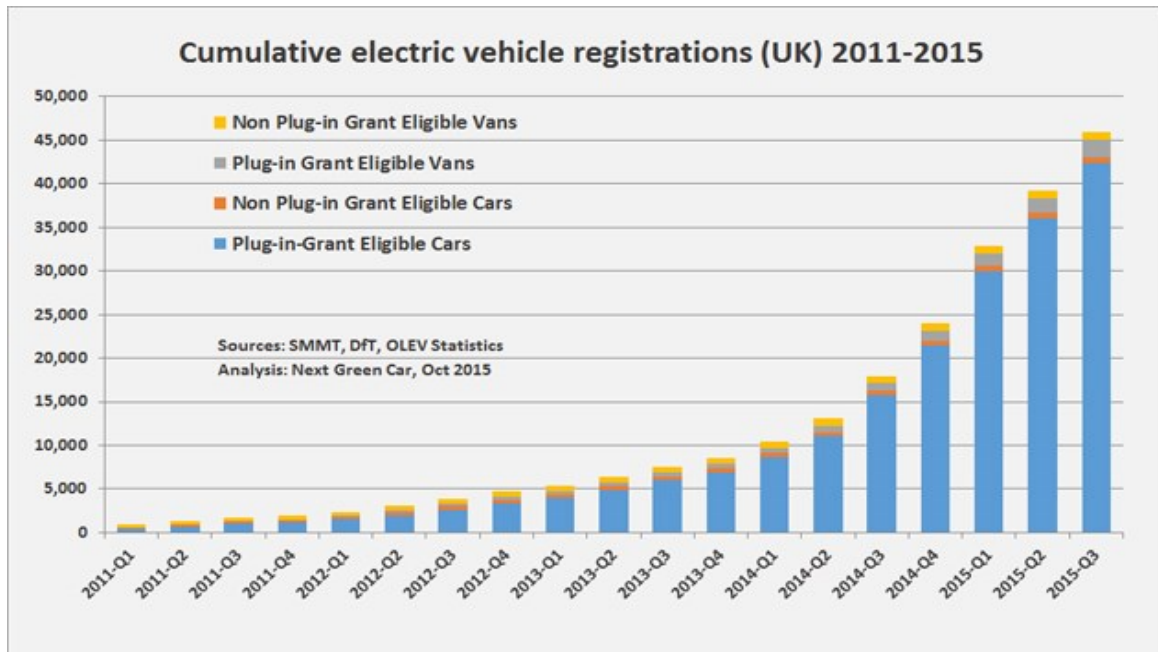


Figure 2: EV registrations in the UK (Source: Next Green Car 2015)

Mapping and modelling the My Electric Avenue results indicates that 312,000 GB LV feeders (around 30%) will need reinforcement by 2050 to cope with clustered EV uptake. In addition, transformers and other upstream assets will need upgrading. Industry trends towards higher power charging for vehicles with increasing battery capacities may further exacerbate this issue.

## The Conventional Approach to Network Problems

In the past, network capacity problems have been solved by installing more cables to increase capacity. Generally this approach has been reliable and economically viable. However, with climate change legislation, the mounting cost of raw materials and the rising uptake of low carbon technologies, the feasibility of this approach is being questioned.

The civil works required - excavation, laying, backfill and reinstatement - are disruptive and expensive both economically and environmentally. Reinforcement also adds significant local capacity, that often isn't needed for a small increase in peak load.

## The Esprit Solution

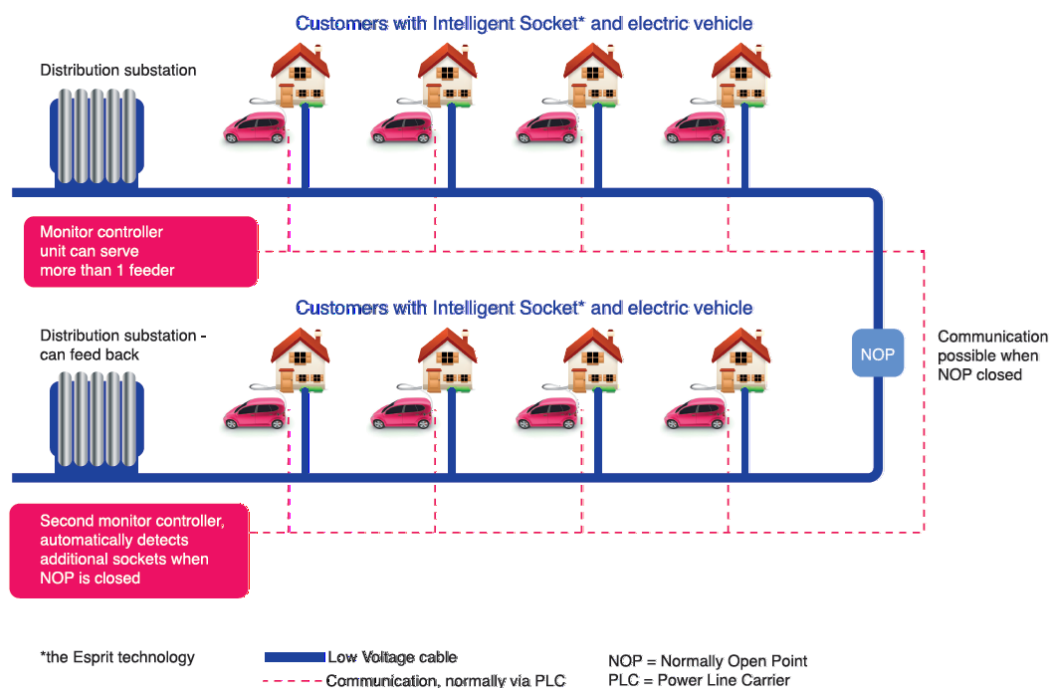


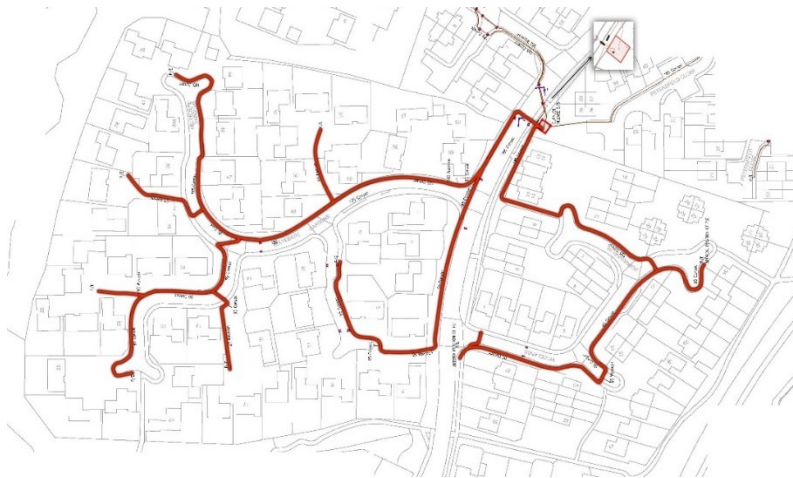
Figure 3: Overview of Esprit

## Esprit during My Electric Avenue

The Esprit design tested by My Electric Avenue consists of two main components. At the substation a Monitor Controller (MC) imposes a pre-defined threshold for the current on each phase. When the threshold is surpassed (at peak demand and particular EV penetration levels) the MC triggers instructions to switch off EV charging

via an Intelligent Socket at a property. The MC cycles the Intelligent Sockets to allocate charge between the EVs which remain connected and reconnects them when demand drops below the threshold.

Esprit can alleviate thermal problems on all types of residential networks. The thermal headroom can be increased to accommodate an extra 46% of customers at the highest levels of EV uptake and the voltage headroom created can accommodate an additional 10% of customers. As an example, one of the LV cables feeding a My Electric Avenue cluster (shown in Figure 4) could accommodate an extra 90 EVs by deploying Esprit.



*Figure 4: My Electric Avenue's Chineham Cluster*

### Next Steps for Esprit

Learning from My Electric Avenue and three years of innovation from automotive and charging point manufacturers means that the next stage of Esprit will refer to the technological solution that:

- Integrates the control into chargers/cars
- Adjusts power used to charge EVs, as well as switching charge off temporarily
- Supports transformers and upstream assets

As the hardware already exists in chargers and EV battery management systems there is no need for a separate intelligent socket. The communications necessary for Esprit to work can be loaded to existing infrastructure allowing each of the stakeholders - from automotive to utilities - to focus on their areas of expertise. Power adjustment (rather than switching) will in turn improve customer satisfaction and acceptance of the product enabling widespread use of the technology – this is particularly important for workplace charging.

## Esprit in the Longer Term

The smart grid reinforcement model, Transform Model<sup>®</sup>, has been used to assess the likely uptake of Esprit based on Government growth scenarios<sup>2</sup>. It found that by 2050 Esprit will be the most cost-effective way to manage the load on up to 2 million homes. Compared to conventional reinforcement, this would correspond to a saving of £2.2 billion for British customers and DNOs<sup>3</sup>. Again this relates to demand based purely on slow charging points (3.5 kW) as with the Nissan LEAF used in My Electric Avenue trials. This may be a conservative estimate when considering the move towards higher power, longer duration charging for larger battery packs.

Looking forward there are many pathways for development which will be informed by the industry. Esprit could:

- Use intelligence to prioritise customers based on need.
- Support national as well as local infrastructure.
- Integrate with other smart grid solutions.

Esprit is essentially a demand side management tool. It can be used not just for EVs but also for anything that has a significant load. In an investigation of the potential for use with heat pumps, 80% of manufacturers confirmed Esprit could be integrated directly into their products and the remaining 20% suggested the units could respond to signals from Esprit to control the output<sup>4</sup>.

## The Effect on Customers

Enabling more EVs on the roads means less tailpipe emissions leading to better air quality and less air pollution.

Esprit allows customer charging to be paused at peak times. Reducing the peak demand in this way reduces the need for physical network reinforcements, saving time

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<sup>2</sup> HM Government (2011) The Carbon Plan: Delivering our low carbon future. Available: [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/47613/3702-the-carbon-plan-delivering-our-low-carbon-future.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/47613/3702-the-carbon-plan-delivering-our-low-carbon-future.pdf) Last Accessed: 06 October 2015

<sup>3</sup> EA Technology (2015) "SDRC 9.8 An assessment of how much headroom an Esprit type solution would yield" Available: <http://myelectricavenue.info>

<sup>4</sup> EA Technology (2015) "SDRC 9.7.1 Impact of Esprit on Heat Pumps." Available: <http://myelectricavenue.info/>

and expense for both the DNO and the customer (16% of the average household electricity bill comes from the cost of distribution<sup>5</sup>).

Customer satisfaction with Esprit was good during My Electric Avenue - 84% of the trial participants who had their charging curtailed said they were positive or neutral about their experience and the difference compared to non-curtailed participants was insignificant. These are encouraging findings at such an early stage of technology development.

## So What Happens Now?

My Electric Avenue has shown the potential for Esprit to save millions of pounds for DNOs and customers. It won't be the right option every time, but it is an important part of the solution. So how will we make Esprit – and similar solutions – available?

Installing equipment at substations to monitor and respond to network performance is much cheaper and faster than conventional reinforcement. But it is more challenging to engage with customers, install equipment in residential homes and manage the relationship. In order to ensure that Esprit is available when needed, we are setting out a plan, which will be developed through engagement across industry.

There are two potential approaches:

1. Ensure the Esprit capability is included in EV chargers as they are installed
2. Retrofit Esprit to EV chargers in target locations as a need arises

**EA Technology is engaging across the industry through an initiative called the Automotive-Utilities Working Group. Automotive OEMs and key industry groups have offered support and we welcome input from organisations interesting in participating.**

**We are also working with a DNO to address the need to standardise how distribution networks integrate with EV chargers and how customers are engaged to buy-in to these tools.**

These approaches require very different strategies and will rely on engagement between the automotive and utilities sectors – and customers – to ensure their success.

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<sup>5</sup> Ofgem (2013) Updated Household energy bills explained. Available: <https://www.ofgem.gov.uk/ofgem-publications/64006/householdenergybillsexplaineddudjuly2013web.pdf> Accessed: 6 October 2015

There are questions to be answered about the balance between regulation and incentives to make this happen: A balance between ensuring a critical need is met and ensuring that EV charger manufacturers are rewarded for their input and customers for their contribution.

It is vital that industry collaborates to develop a long-term solution to facilitate customers' access to low carbon vehicles without risking financial and reputational damage to all sides of the industry. We are pleased to be able to support this process.

## Conclusions

Continued exponential increase in the uptake of EVs is likely to cause problems for some electricity networks. My Electric Avenue has demonstrated Esprit's capability to alleviate these issues through intelligent demand side management. Deploying Esprit can be financially beneficial to the DNO and end customers. It can also save unnecessary civil works which are environmentally damaging.

My Electric Avenue has also highlighted the areas of development that will benefit customers most. With wider industry input on the future requirements of the technology, Esprit can help the DNOs to continue delivering electricity to customers reliably and economically.



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