

SSET205 – My Electric Avenue (I²EV)

Project Close-Down Report

Authors: EA Technology & Southern Electric Power Distribution (SEPD)
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The 'My Electric Avenue' project is the public identity for the Low Carbon Networks Fund Tier 2 project "I²EV." The formal title "I²EV" is used for contractual and Ofgem reporting purposes.

Project leads



Project partners



My Electric Avenue has received support from Ofgem through the Low Carbon Networks (LCN) Fund.

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1. Project background

The My Electric Avenue Project, originally conceived and submitted as “I²EV – Innovation-squared: managing unconstrained EV connections”, was developed and delivered as a partnership Project by EA Technology and Southern Electric Power Distribution (SEPD). The Project¹ was formulated and submitted to Ofgem’s Low Carbon Networks (LCN) Fund as a Tier 2 project in 2012. It started in January 2013 and was delivered over a three year period. The Project Team² developed a novel commercial agreement whereby a non-Distribution Network Operator (DNO) could manage an innovation project on behalf of a DNO; it also trialled an innovative technology to manage the demand of electric vehicles on the local electricity network.

An introduction to the Commercial Problem

At the point of Project conception, Ofgem had been seeking methods by which third party, non-DNO companies can access innovation funding mechanisms under RIIO³-ED1 as a potential vehicle to accelerate technology development and adoption to the benefit of the industry. A key challenge to this is the need for trials to be deployed on real networks with real customers, whilst ensuring the DNO gains the learning necessary to secure buy-in to any Project outputs.

The My Electric Avenue Project was designed to be managed by EA Technology within the limitations of SEPD’s regulatory and legal obligations. This enabled the Project to be implemented with customers on SEPD’s network whilst EA Technology undertook the majority of the work necessary to manage and deliver the Project deliverables. The benefit from this approach derived from enabling the Project to be more efficiently delivered by the correct mix of Project Partners⁴, allowing each company to ‘play to their strengths.’

Currently, Ofgem is considering the role of third parties and their ability to bring innovative ideas forward as part of the NIA and NIC governance review.

An introduction to the Technical Problem

The Government’s support to the automotive sector for low emission vehicles has supported a significant increase in the number of electric vehicles (EVs) on UK roads since 2010. This increase, from less than 100 EVs to more than 53,000 in less than five years, shows no sign of abating, particularly with further subsidies announced in February 2016.

Whilst the support for low emission vehicles is a vital weapon in the arsenal to help reduce carbon emissions, the electricity distribution network was not designed to accommodate the uptake of significant high load, low carbon technologies (LCTs) such as EVs or heat pumps.

The number of EVs on our roads is anticipated to increase substantially over the coming years. It an aspiration of UK Government that every new car and van in the UK will be some form of Ultra Low Emission Vehicle by 2040⁵ and global vehicle manufacturers are rapidly gearing up with an ever increasing array of vehicles coming to market⁶. This has the potential to place significant strain on low voltage (LV) distribution networks due to the increased demand. Traditionally, increasing capacity on LV networks would require reinforcement, causing potential disruption to local communities and at a significant financial cost to the DNO and consequently, the customer.

As a parallel, when photovoltaic solar panels were first installed across the UK, natural clustering occurred with high numbers of installations occurring in close proximity. Whilst the process outlined in G83/2⁷ aims to prevent clustering causing issues sufficient to require network reinforcement, no such safeguard exists for deployment of EV charging

¹ “The Project” refers to the My Electric Avenue Project rather than another project that may be discussed in general terms.

² The Project Team refers to the core staff working on the Project across all companies involved in the delivery of My Electric Avenue.

³ RIIO (Revenue = Incentives + Innovation + Outputs) is a performance based model for setting the network companies’ price controls

⁴ Project Partners is used to refer to companies participating within the Project that provided an in-kind contribution to the Project.

⁵ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/239317/ultra-low-emission-vehicle-strategy.pdf

⁶ <http://www.smmmt.co.uk/wp-content/uploads/sites/2/ULEV-report-Final.pdf>

⁷ http://www.energynetworks.org/assets/files/electricity/engineering/distributed%20generation/March%202015/G83%20Single%20Full%20June%202014%20v2_Comms_Red.pdf

points. If such natural clustering occurs with respect to EVs, (without the presence of safeguards equivalent to G83/2), then network overloads can be expected long before significant numbers of vehicles in the UK have been transitioned to an EV.

The My Electric Avenue Project sought to investigate and identify at what point EV penetration can be expected to cause problems for a local network, and to trial a prototype technology known as ‘Esprit’ (refer to Appendix I) that has the potential to manage or alleviate this problem. This responsive solution would allow DNOs to defer, or even avoid, expensive and disruptive reinforcement of the LV network.

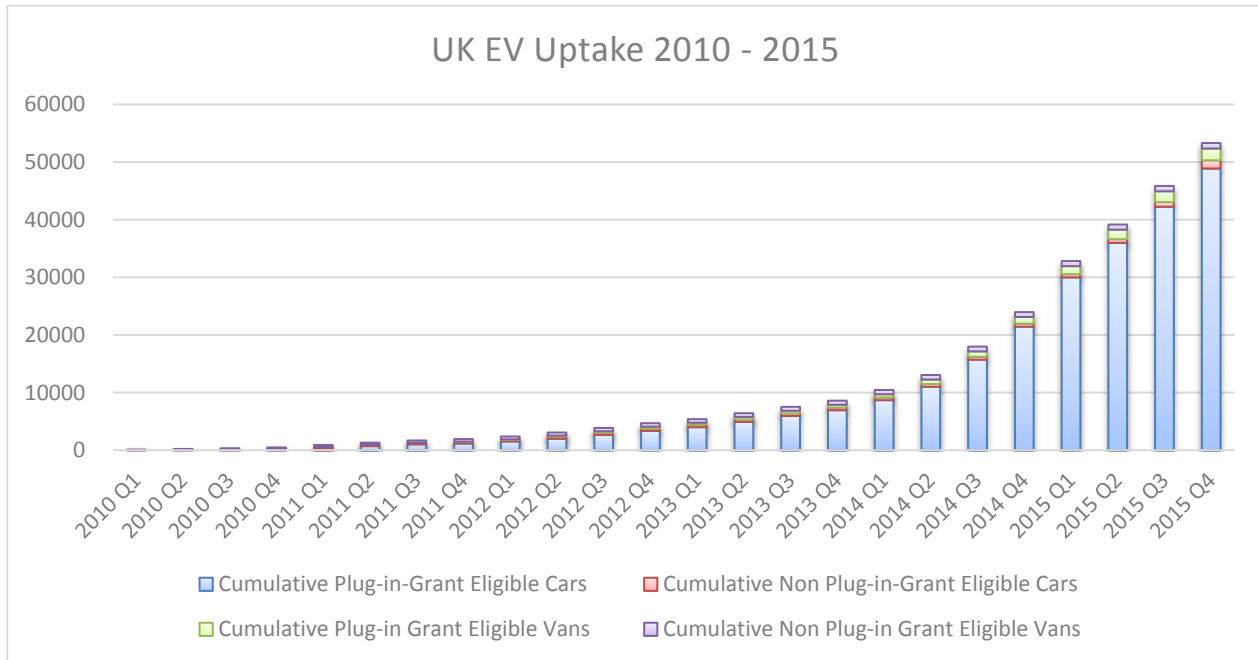


Figure 1 – Cumulative EV registrations 2010 – 2015

Note: The uptake profiles for EVs in the UK, shown above are extracted from the Department for Transport (DfT) published vehicle statistics⁸ and detail all EVs, whether eligible for the Plug-in Car Grant or not. Originally, the plug-in grant provided a £5,000 subsidy to purchasers of an EV, this has now been reduced to a maximum of £4,500 for an electric car and £8,000 for an electric van, depending on the specific model chosen.

The potential problem is exacerbated by the continually increasing capacities of vehicle batteries, and the rate at which they charge. In 2012, the standard rate of domestic charge for EVs was 3.5kW; in 2016, 7kW is becoming more standard as battery capacities increase. Domestic charging points rated for 22kW are now available for sale, demonstrating the EV trend anticipated by charging point manufacturers.

The analysis within the My Electric Avenue Project reflects the dataset available, specifically 24kWh batteries charged at a rate of 3.5kW and a profile for the probability of any EV charging has been created. A relatively simplistic extrapolation of the outputs and learning from the Project have been used to provide an initial estimate of the impact on the LV network of 7kW charging rates from adapting the data gathered at 3.5kW. This indicates that the increased diversity (due to faster charging) does not offset the higher load. This extrapolation shows that peak load due to EV charging is likely to be worse than reported here as manufacturers move towards 7kW charging by default.

Traditionally, DNOs’ Business-As-Usual (BAU) approach would be to reinforce the LV network through installation of additional cables and potentially upgrading transformers, depending on the scale of the local problem. My Electric Avenue trialled and proved an alternative solution to this traditional approach, utilising Demand Side Response (DSR) to manage uptake of clusters of EVs on GB’s electricity networks – with the potential to make an economic saving of around £2.2bn by 2050, in comparison to current business-as-usual reinforcement methods. This is based on projected network expenditure taken from the GB version of the Transform Model⁹, a practical tool used to

⁸ <https://www.gov.uk/government/statistical-data-sets/all-vehicles-veh01>

⁹ <http://www.eatechnology.com/products-and-services/create-smarter-grids/transform-model%C2%AE>

understand investments necessary for the integration of low carbon technologies onto today's distribution networks¹⁰.

It is essential for collaboration between DNOs and appropriate industry partners to agree a standard approach for implementation of DSR in this area, and as a result SSEPD and EA Technology are embarking on a new project to ensure this collaboration and standardisation occurs to allow easy adoption of Esprit-type charge control in the future.

¹⁰ For more detail regarding the Transform Model®, please refer to SDRC 9.8, section 7.1.1.

2. Executive summary

2.1 Project scope

The scope of the My Electric Avenue Project was to deliver two strands of innovation:

- A novel commercial arrangement, allowing EA Technology (a SME), to access innovation funding and deliver a Project on behalf of a DNO.
- Trial a prototype Technology known as ‘Esprit’ on the distribution network to determine its effectiveness at monitoring network load and managing the risk of overload due to high numbers of EVs connected in a local area.

2.1.1 Novel commercial arrangement

The novel commercial arrangement was required to link the various legal and regulatory obligations between SEPD and Ofgem, (spanning the licence agreement and governance requirements of the LCN Fund), with a delivery contract between SEPD and EA Technology. This arrangement delegated elements of SEPD’s responsibility in relation to delivery of a LCN Fund project, including all requirements relating to the Project Direction, to EA Technology, whilst retaining overall accountability and responsibility for maintaining its network and providing service to its customers.

The My Electric Avenue Project developed a commercial structure under which the Project was delivered, and a revised contractual template published for use by any company wishing to implement a Project Team structure similar to that under My Electric Avenue.

Due to the nature of the Project and the diverse skill set required, the novel commercial arrangement was perfectly suited for the management and delivery by a non-DNO, resulting in a more effective and efficient delivery than if purely delivered by a DNO.

Improvements to the contractual arrangements were identified through the course of the Project and implemented in an update to the contract templates at Project completion.

Ricardo, the independent reviewers for the My Electric Avenue Project highlighted a number of strengths of the Project Management approach, shown in Figure 2.

The Project Steering Group, consisting of senior staff from both SSEPD and EA Technology, were charged with overseeing successful delivery of all project commitments detailed in the Project Bid Submission and Project Direction.

Highlighted strengths

- Strong leadership by EA Technology
- Teamwork, dedication and long term commitment
- Recruitment
- Good management of customer relationships
- Timely and effective public engagement
- Good understanding of the data collected
- Dissemination of project learning

Figure 2 – My Electric Avenue Project Management Highlighted Strengths

2.1.2 Technical trials

The technical trials were designed to investigate the extent at which the uptake of EVs is likely to affect the distribution networks and test a potential innovative solution. This alternative would be easier, quicker, cheaper and less disruptive to deploy than current BAU methods.

The trials introduced a significant EV load to disparate local networks across Southern Electric Power Distribution (SEPD) and Northern Powergrid licence areas in a controlled manner, creating small scale instances of the problematic networks anticipated in the future. To accomplish this, multiple clusters of up to 12 participants on the same LV feeder, each using a Nissan LEAF, were established. This enabled significant amounts of data to be gathered relating to how and when EVs were used and charged and most importantly, the impact this had on the LV network.

A prototype technology known as ‘Esprit’ was used to monitor the LV networks and EV charging points and dynamically prevent the EVs charging during periods of high network load. Charging points, installed for participants as part of the Project, were connected to the Esprit Technology. This enabled the Project Team to prevent the EVs from charging in relation to usage of the LV network. As a result the Project Team determined the ability of Esprit to protect the network from overload due to EVs, and the level to which the public can be expected to accept this type of control over charging their vehicle.

Drivers participating in the technical trials were asked to utilise their EV as normal, with the knowledge that the Project's equipment could curtail their vehicle charging, depending on the usage of the local LV network. Importantly, these participants were not informed as to when, or if, they were being curtailed.

EV drivers expressing an interest in participating in the trials who were not located in a 'cluster' were offered the opportunity to lease an EV and provide the Project Team with tracking data relating to the vehicle's usage and charging patterns. These social trial participants did not have any technology curtailing their charging and so were able to use their vehicle as normal; this provided a 'control group' for comparison of the attitude towards the EV and availability of charging between participants who risked insufficient vehicle charge due to curtailment by the Esprit Technology, and those who did not.

2.2 Project objectives and outcomes

The My Electric Avenue Project had the following principal objectives, summarised from the bid submission:

- Commercial
 - Determine whether a third party can accelerate deployment of innovation on the DNO networks
 - Establish an effective governance structure
 - Create a process whereby the different parties were engaged and managed
 - Document how successful delivery of the Project is achieved
- Technical
 - Determine to what extent can DNO direct control facilitate the connection of low carbon technology
 - Identify what social factors (if any) impact the use of DSR technology
 - Establish the technical benefits and disadvantages of the DSR technology

2.2.1 Commercial

At a fundamental level, the commercial learning of the My Electric Avenue Project was to determine if innovation, on the scale of LCN Fund Tier 2 Projects, could be effectively and efficiently delivered by a third party company on behalf of a DNO.

Linked to this learning, was the need to understand that if it were proved to be possible, would a DNO (SEPD in the case of the My Electric Avenue Project) choose to implement such an approach again when considering all the challenges and benefits associated with such a decision.

SEPD's evaluation of this commercial approach is summarised as:

- Delivery of a LCN Fund Project by EA Technology on behalf of SEPD was achieved in a manner that is repeatable, whilst completing the Project within budget and on schedule.
- Development of a novel commercial arrangement was successfully achieved in a manner that will allow future Projects to benefit from the learning achieved.
- All procurement relating to the My Electric Avenue Project was effectively managed by EA Technology in a recorded, repeatable manner.
- The successful management and delivery of the My Electric Avenue Project by EA Technology allowed SEPD to spend less time supporting delivery of the Project than originally anticipated. This enabled DNO staff working on the Project to be utilised elsewhere in the business, allowing parallel deployment of multiple innovation Projects overseen by a single team that would otherwise have been wholly focussed on the delivery of a single Project.
- EA Technology's differing skillset and areas of expertise enabled effective recruitment of partners and management of the customer recruitment and equipment deployment. This, combined with the ability to focus on the Project made it more efficient than a DNO taking on this role.

2.2.2 Technical

The analysis of data gathered by the Project Team revealed that some networks will experience difficulties when more than 40% of the connected properties have an EV. Due to the vehicles used in the trials, this calculation is based on vehicles charging at a rate of 3.5kW, whereas the latest generation EVs are migrating towards 7kW charging as standard for all but the smallest battery capacities. A simple extrapolation of the difference between these two charging standards is available in Appendix III but all outputs from the Project are based on the data gathered at 3.5kW.

The Esprit Technology demonstrated that it can curtail the load on a network during times of high utilisation, although further development was identified as being required before the Esprit Technology can be reliably deployed. The capacity of the Project’s equipment to control the charging point’s ability to charge the connected EV was limited by the communication medium utilised; there were issues with reliability and so alternative methods for communications will be investigated to improve reliability. Esprit is currently considered to be at TRL-8, although transitioning to TRL-9 would require a viable commercial model for deployment of the technology to be in place to justify development expenditure by EA Technology.

Consequently, Esprit, and Esprit-type solutions have the potential to provide significant benefits to networks that are not yet under stress, through increasing the available capacity, potentially to a point where reinforcement will not be required. On a network where very little capacity remains, Esprit-type solutions may extend the useful ‘life’ of that network to enable planned reinforcement rather than an emergency upgrade to be undertaken. In both cases, this would require customer acceptance and for the additionally connected load to be controllable by the Esprit technology.

It was found that most of the participants whose EV charging was curtailed were either not aware of the curtailment or were not impacted by it. Comparing the acceptability of the EV between participants who were and were not curtailed showed no statistically significant difference in their opinions. The social analysis did not reveal any factors that impacted the acceptability of DSR technology or the EVs being used in the trial.

2.3 Successful delivery of objectives

EA Technology and SEPD proposed a number of Successful Delivery Reward Criteria (SDRCs) to evidence meeting the Project objectives. These SDRC deliverables related to customer recruitment, deployment of trial equipment and analysis of results covering both the LV networks and customer opinions of the trials. In all cases, the SDRCs were delivered on or ahead of schedule.

Table 1 Successful Delivery Reward Criteria

SDRC Details	Delivered on Schedule
SDRC 9.1 – Document the learning from the experience of a third party leading a Tier 2 Project bid including suggestions for where the process could be more open or streamlined.	✓
SDRC 9.2 – The blueprint of the contractual arrangements put in place with the DNO for a third party lead on a LCN Fund Tier 2 project.	✓
SDRC 9.3 – An assessment, based on direct experience, of how a third party can effectively manage delivery on innovation projects with a DNO, and whether this allows DNOs to take on more innovation projects.	✓
SDRC 9.4 – An assessment of how the DNO and other interested parties can ensure independent validation of a third party’s Solution throughout a project, and upon completion.	✓
SDRC 9.5 – Sign up and involvement of sufficient customers in the trial to adequately test the Technology.	✓
SDRC 9.6 – An assessment of the public acceptance (or otherwise) to Demand Side Response of EVs (or HPs as defined in 9.5) using this sort of technology.	✓
SDRC 9.7 – An assessment of the most appropriate integration of the Technology for different applications and suitable cycling times or reasons why this is not possible if the trials are not successful.	✓
SDRC 9.8 – An assessment of how much headroom this sort of technical solution would yield, considering different network topologies and load types.	✓

2.4 Main project learning

The Project Team identified technical learning that was both anticipated in the bid submission, and additional learning that arose from the work as it developed. It is important to consider the identified learning in the context of the EVs utilised in the Project. At the time of bid submission, the Nissan LEAF provided to customers was the only all-electric vehicle available for mass market purchase and deployment. The model issued to participants utilised a 24kWh battery capable of charging at a rate of 3.5kW in domestic premises. The EV industry is moving quickly with larger battery capacities and charging rates already available as standard on many makes and models at the time of writing.

2.4.1 EV impacts

The peak demand for residential EV charging was found to coincide with the traditional evening peak, confirming expectations from the bid submission. As a consequence, the After Diversity Maximum Demand (ADMD) observed in the Project for non-electrically heated households with a 3.5kW EV charger is approximately 2kW, double the conventional demand observed in the Project.

2.4.2 Network capabilities

Increasing penetration of EVs on LV feeders can cause both thermal and voltage problems, with thermal problems generally occurring at lower penetration levels than voltage problems.

Modelling of representative feeders with data gathered throughout the My Electric Avenue Project demonstrates that 32% of UK LV feeders will require intervention to protect against thermal or voltage problems at EV penetration levels exceeding 40%.

Networks that are most susceptible to experiencing problems as a result of EV uptake are typically characterised by an available spare capacity of less than 1.5kW per customer.

2.4.3 Esprit capabilities

The core capabilities of the Esprit Technology are:

- It works as intended with more than 7,000 charging curtailment events occurring throughout the Project.
- It is capable of mitigating thermal constraints in all types of residential networks through the use of dynamic thresholds, delivering additional thermal headroom of up to 46%¹¹.
- It delivered an additional voltage headroom equivalent to an additional 10% of customers connecting EV chargers through reducing network load at peak times. This was in addition to reducing by up to 70% the number of customers whose voltage moved outside statutory limits at the highest levels of EV uptake considered.

The scenario driven network investment tool, Transform Model^{®12}, has been used to assess the likely uptake of Esprit or alternative DSR technology¹³. Using the GB dataset, which includes UK Government scenario uptake profiles for EVs and other Low Carbon Technologies, it found that Esprit would commence deployment around 2021 and could be controlling in up to two million homes by 2047. When compared against the costs of conventional reinforcement methods, this corresponds to a financial benefit of approximately £2.2 billion.

2.4.4 Esprit cycle times

The use of Esprit, or an equivalent DSR technology, must consider the impact of cycling the availability of power on connected devices such as EVs and heat pumps. The use of such a technology will not be acceptable if it causes premature degradation of EV batteries or failure of heat pump components. Correspondence was undertaken with EV and heat-pump manufacturers to determine how frequently their equipment could be safely cycled, without causing a perceptible decrease in useable lifespan.

This information was combined with the industry specific knowledge held by EA Technology and SSEPD, and the learning from the trial to derive recommended cycle times for any such DSR technology. A 'minimum-off-time' of 15 minutes and a 'maximum-off-time' of 60 minutes is recommended.

2.4.5 Powerline Carrier communications

Powerline Carrier (PLC) was found to be effective for 65% of all measurements across the My Electric Avenue participants. Ultimately, the use of PLC in sparsely populated networks with relatively long communication distances

¹¹ The analysis behind this figure is available in SDRC 9.8

¹² The Transform Model[®] is a practical tool which allows key stakeholders, e.g. electricity DNOs to determine the potential impact of low carbon technologies and the investment requirements to efficiently accommodate their integration. The GB model takes inputs from UK Government, and DNOs; producing quantifiable outputs that have informed the GB Smart Grid Forum and DNO business plans.

¹³ The model analysis undertaken included allowances for other LCTs such as Solar PV.

is not conducive to highly reliable communications. The deployment of additional units to increase the number of devices within the network would likely increase the reliability significantly. Key learning points relating to the use of PLC in future innovation projects are:

- There is an exponential correlation between distance and reduced reliability of communications, however the certainty of this correlation is low due to the relatively low number of participants.
- The Esprit Technology utilised a PLC architecture that allowed any device in the network to relay messages. It was found that increasing the number of units in the network increased communication reliability and enabled communication with participants up to 300 meters away from the substation, in contrast to the normally expected reliable range of 150 – 200m.
- In one instance cable joints were found to significantly impact the capability of the PLC to reach participants on a spur from the main feeder. There was no evidence that other cable joints affected the quality of PLC communications.
- There was a strong correlation between PLC reliability and network load, with communication reliability decreasing as network load increased. Specific tests would be required to determine if increasing the penetration of PLC communication devices would sufficiently compensate for increasing load such that a reliable PLC based control system could be implemented.

Further information relating to the effectiveness of PLC in the Project and for future implementations is detailed in the report issued in support of SDRC 9.8 – PLC Communication Reliability¹⁴, available on the Project website.

2.5 Main methodology learning

2.5.1 Project organisation

The use of a third party organisation to deliver the My Electric Avenue Project required less effort on the part of SEPD than had been anticipated. This approach has demonstrated the potential to enable a DNO to deliver multiple innovation projects simultaneously with less resource than would otherwise be required. The approach also lends itself extremely well to recruiting project partners that best suit the goals of each proposal as it enables specialised project teams to be created as required to make best use of diverse skillsets not held by a DNO. The Project's commercial learning could help to further facilitate third parties entering innovation projects, by informing Ofgem's review of the NIC and NIA governance arrangements from 2017.

2.5.2 Relevant expertise

The My Electric Avenue Project would not have been possible without the partnership of organisations that were highly specialised and skilled in their area of expertise. The target for recruiting trial participants for the Project was ambitious but with the efforts of Fleetdrive Electric and Zero Carbon Futures it was achieved ahead of schedule. Where a project requires the inclusions of skills that are outside the expertise of a DNO, securing the involvement of a Project Lead or partner companies that expand the capabilities of the team is essential.

2.5.3 Contingency

Making contingency available for use by the Project Team on an 'as-required' basis was highly beneficial. Due to the nature of innovation, projects will always experience challenges that were not anticipated during the development phase. To protect the available contingency budget from unjustified use, members of the Steering Group from both EA Technology and SSEPD (at least one from each company) had to approve each individual request.

2.5.4 Trial equipment deployment

Where trial equipment is undergoing first field trials, the Project should plan to deploy initial, small-scale tests prior to full project deployment. This affords the chance to identify issues that did not arise under controlled conditions and the opportunity to resolve them whilst the majority of the equipment is readily available. Funding restrictions, where deemed necessary in future projects must take this into account to minimise unnecessary expenditure.

¹⁴ <http://myelectricavenue.info/sites/default/files/PLC%20Communication%20Reliability%20Report.pdf>

2.5.5 Customer Recruitment

When it came to customer recruitment, highly focused efforts once initial interest in participation was identified was extremely effective. A less focused, ‘shotgun approach’ was unsuccessful, with recruitment events held to cultivate initial interest resulting in no participants being recruited. Making use of local champions to recruit neighbours and form a cluster proved highly successful. Many participants in the trials commented that they only took the Project’s offer seriously because it was a trusted neighbour trying to recruit them. Initial correspondence from the Project directly was considered a ‘scam’ or ‘too good to be true.’

3. Details of the work carried out

From the 217 EVs which were monitored during the trial, 101 were recruited to participate in a technical trial, which ran from January 2014 to October 2015. The EVs were spread over ten clusters; nine domestic and one commercial. Of the nine domestic clusters, one was a rural Overhead Line (OHL) LV feeder, with the remaining classed as underground, urban/suburban LV networks. The remaining participants were within the social trials, providing vehicle usage and charging data to the Project Team.

The purpose of the technical trial was to demonstrate that DSR was possible to accommodate EV charging in clusters. Specifically that the direct control functionality of Esprit could be used in real LV network environments, with the EVs acting as a controllable load. The version of the Esprit Technology implemented consisted of a ‘Monitor Controller’ (MC) installed in a local substation and an ‘Intelligent Control Box’ (ICB) installed at a participant’s property to control the provided charging point.

3.1 Novel commercial arrangement

The My Electric Avenue Project was delivered under a novel commercial arrangement created by EA Technology and SEPD. It was necessary to establish a limited transfer of responsibility and accountability relating to the delivery of a LCN Fund Tier 2 Project from SEPD to EA Technology so that the My Electric Avenue Project could be effectively delivered. The overall commercial structure developed was based on the standard approach utilised in LCN Fund projects, and is shown in Figure 3.

This approach passed all commercial responsibility, including financial risk, for delivery of the My Electric Avenue Project to EA Technology, with specific elements then passed on to Project Partners, based on the organisation’s specific expertise.

For example, Fleetdrive Electric were responsible for recruitment of participants and provision of EVs, whilst Zero Carbon Futures were also responsible for recruitment of participants and installation and maintenance of charging points. Other elements of the Project management requirements such as control of the Project’s bank account remained with SEPD who, amongst other roles in the Project, held the position of ‘Treasurer.’

The principal contract established between EA Technology and SEPD was based on the standard supplier contract used by SEPD with changes made where identified as being required. For example, an additional clause acknowledged the payment by EA Technology into the Project’s bank account and confirmed its return in the event the Project were returned the compulsory contribution via SDR Application process.

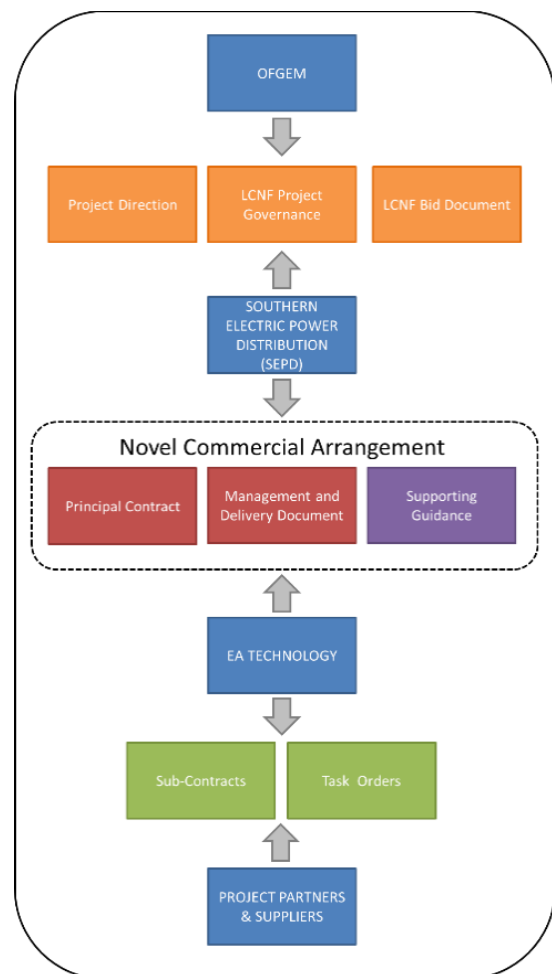


Figure 3 – My Electric Avenue Commercial Structure

Similarly, the sub-contracts between EA Technology and the Project Partners and suppliers were based on the principal contract, allowing back-to-back transfer of responsibility and liability as appropriate. The resulting hierarchy within the Project is shown in Figure 3.

In the closing months of the My Electric Avenue Project, an evaluation of the Principal Contract was undertaken, with a specific focus on “whether the contract delivered the aims of enabling a LCN Fund Tier 2 project to be delivered by a third party, working in partnership with a DNO.”

This review found that whilst the initial Principal Contract had enabled delivery of the My Electric Avenue Project, elements of the contract needed further refinement to make an ‘off-the-shelf’ template more useful for future projects. These areas were rectified with an update to the contractual template issued in conjunction with the SDRC 9.2 & 9.3 report. The final issued template includes guidance notes, identifying key areas where further thought and discussions are recommended, on a case-by-case basis, between the signatories of a similar contractual arrangement in the future.

Multiple partners increased the complexity of Project Management but increased the strength and capability of the Project Team, enabling the Project Team to handle the multiple changes that occurred.

3.2 Customer recruitment

The challenging milestones stipulated under the technical trials meant that a robust and workable customer engagement strategy was essential to successful achievement of those milestones. This was underpinned by strategic marketing and PR, a great ‘hook’ for customers (the heavily-discounted leasing of a Nissan LEAF), provision of a free charging point (retained by the participant if desired at the end of the Project), and a dedicated team supported and led within a well-managed project management infrastructure. Figure 4 shows the milestones that the Project achieved; at least seven clusters of at least ten customers in each, across ten clusters in total, totalling at least 100 trial participants. The social trials, delivered to support statistical significance, had to recruit at least 100 customers on to its trials (the social trials did not involve any technology or free charging point).



Figure 4 – Customer recruitment milestones – My Electric Avenue technical trials

The customer recruitment process

From the outset of the recruitment process, it was made clear to potential trial participants that there were certain eligibility criteria to pass before being accepted onto the trial. The management of customer expectations was a priority throughout the engagement process, and ensuring that customers were fully informed as to the process and requirements were highlighted at every contact stage – whether verbal, on the website, or in follow-up paperwork (including the Declaration of Intent Form, and final contract and leasing documents).



Figure 5 – Example recruitment area

The first step to assess eligibility was via an online form on the website, for customers to check through submission of postcode if they lived in the eligible geographic areas of either SEPD’s or Northern Powergrid’s licence areas. If this initial check was passed, the customer was then asked if they had off-street parking- a simple yet essential check to ensure that they would be able to have a charging point installed. The marketing strategy for recruitment involved asking for cluster champions to come forward and embrace the challenge of contacting their neighbours to find at least ten people in their locality to form a cluster for the trials. The critical eligibility test for forming a cluster was that all of those ten (or more) people had to live in properties connected to the same LV feeder.

Therefore, once a potential cluster champion was identified, the team at EA Technology did an LV network diagram check to assess exactly where on their local network potential champions could go and search for other trial recruits. Each LV diagram network check took between one to three hours to complete; 250 were performed and results fed back to the (potential) cluster champions during the recruitment period.

Armed with the knowledge of which neighbours they could approach to take part and form a cluster, and being fully informed as to the need to recruit at least ten to the group, the Project provided marketing materials such as posters and leaflets, to distribute to neighbours and to put up in shop windows and other local amenities.

Once the cluster champion had found between 8-10 people interested, Fleetdrive Electric organised an EV test drive event in each locality. It was this community event that proved to be a crucial tool in firming up the engagement and enthusiasm of trial participants. With perhaps only one exception (a customer who considered the Nissan LEAF to be too big for their purposes), every person who had a test drive of the Nissan LEAF was keen to sign up. Commitment was captured more formally at this stage, by each potential triallist being asked to sign a Declaration of Intent Form (to allow the Project to notify Ofgem of recruitment progress) either at the scene of the EV test drive or within a few days following.

It was made clear to potential recruits that there were still hurdles to overcome, namely the electricity network checks to determine the capacity of each network (i.e. how many EVs they could support without being stressed), a home check to assess power supply, a PLC check to check communications between the MC at the substation and the ICB at the household, and finally a credit check for each possible cluster participant.

Only when all of these checks had been undertaken and passed was a formal Cluster Establishment Evidence Report drafted. This was then reviewed by SEPD, submitted by SEPD to Ofgem, and a cluster deemed to have been established.

The overall cluster establishment process is illustrated in Figure 6.

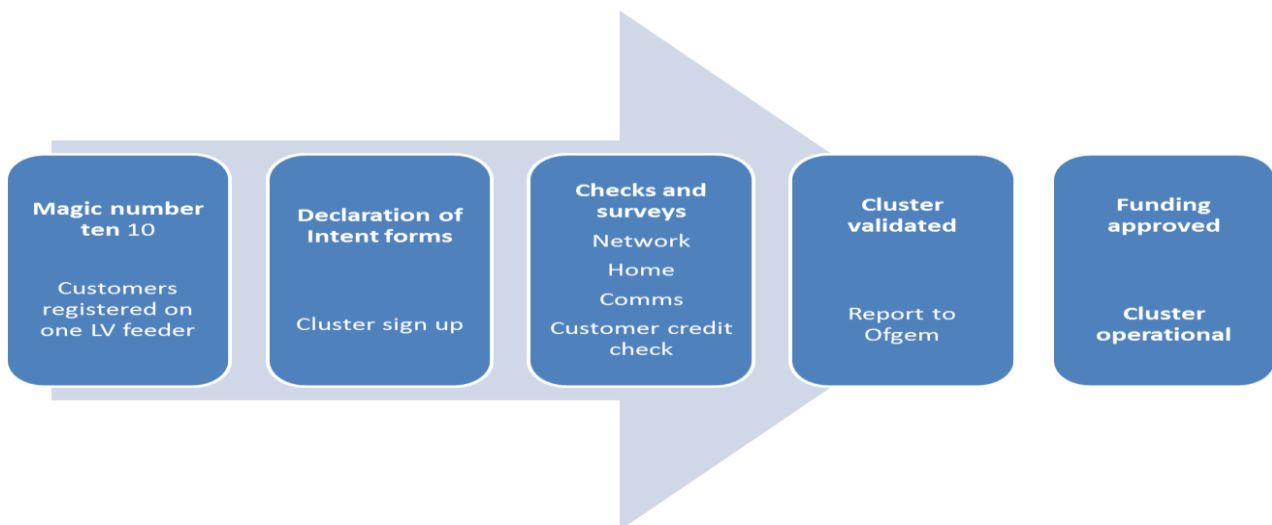


Figure 6 – My Electric Avenue cluster validation process

Marketing for recruitment

Embedded in the Customer Engagement Plan, the strategic and focused marketing plan and PR strategy supported the effective and far-reaching promotion of the trials, underpinning the recruitment of customers. The website served as an initial engagement and filtering tool for people interested in the Project and wanting to take part. It also supported an introductory animated film of the Project. This was useful to point people to, and was also a great tool for inclusion in presentations to both potential trial participant groups and other stakeholders. Customers were directed to the website through a number of press releases in the national and regional press.



Figure 7 – My Electric Avenue launch event, June 2013

The PR focus was especially well received in the automotive press, which resulted in a number of the ‘EV enthusiastic’ cluster champions coming forward with the impetus to succeed in making the cluster happen. The springboard for the PR strategy was the Project’s launch event in June 2013, where the key partners came together in front of a press audience to sign a Memorandum of Understanding to signal their commitment to the Project.

A major tool in the recruitment kit was the hook of the Nissan LEAF for just £100 per month over 18 months for the technical trial customers. Although we had reached agreement during project set up phase with Nissan that we would not directly market this lease per month cost, in deference to other dealer offers, the Project Team was at liberty to relay this information at first contact from an interested party. At the time, no other lease deal for an EV came close to being this attractive; plus the Project supplied and installed a free charging point at each trial participant’s home address.



As mentioned earlier, the EV test drive events worked well as a recruitment tool. There was significant media interest around an EV test drive event held at Drayson Racing Technologies, where Robert Llewellyn filmed an episode of Fully Charged about the My Electric Avenue project, further boosting the awareness of the Project and its ambitions.

What did not work as well, was a more scatter gun approach that was taken through two roadshows that the Project Team organised. These roadshow events were driven from the ‘top down’, i.e. senior figures keen for a cluster to happen in their local area.

Figure 8 – Drayson Racing Technologies recruitment event

A key learning point from the recruitment experience is that the bottom up approach can be far more effective for the recruitment of household participants. That is, someone from the community coming forward to personally engage with their neighbours and drive it forward.

3.3 Technology trials

Once recruitment to the technical trials was complete, deployment of the Esprit Technology across all clusters was implemented. The system consisted of two primary elements, a monitor control (MC) installed at the substation for each established cluster, and Intelligent Control Boxes (ICBs) installed in the properties of trial participants.

The technology trials element of the Project covers four phases: installation; monitoring; analysis and decommissioning, the life-cycle of which is shown in Figure 9.

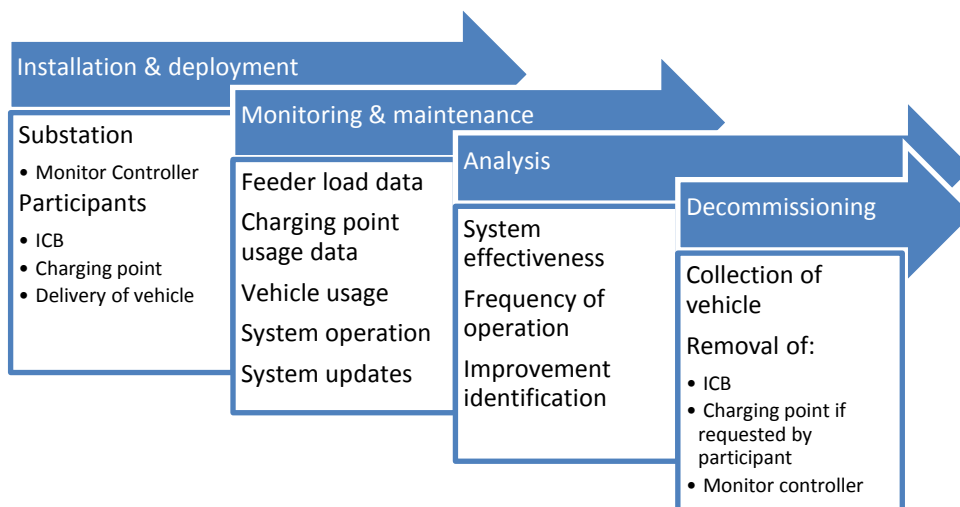


Figure 9 – Technology life-cycle

The equipment associated with the Monitor Controller installed in the substation was all energised through a single commando socket connector. This point of connection was also used to inject the PLC signal into the LV network.

The monitor controller and Rail350 units made use of Current Transformers (CTs) or Rogowski coils, dependent on the available space within the respective substations.



Both the MC and Rail350 connected to the Nortech Envoy unit which transmitted recorded data and information on system operation to Nortech's servers for subsequent download.

Direct connection could be made to the MC for investigative purposes, or to change settings, via connecting a laptop to the RS232 service port on the bottom of the MC case.

Method statements covering the installation and decommissioning of the trial equipment are available on the Project Website. Links are provided in section 13.

ICBs and Charging Points

For trial equipment installed in participant's premises, qualified electricians were used whom had some prior working relationship with either the DNO or one of the Project partners. Through careful selection of installation contractors, lead times for training were lowered, installation quality was improved and a reduced chance of equipment problems throughout the trial was achieved.

Figure 12 – MC installation

Overall management of the process remained with EA Technology but where access to participant premises was required, liaison between the customer and the installation contractor was undertaken by ZCF. This approach was used as ZCF had formed a relationship with the customers during the recruitment phase and would also be responsible for maintenance of the charging points for the duration of the Project. Further details of the trial technology are in Appendix II.

Installation of the charge point was managed by the project partner, Zero Carbon Futures, using the same electrical contractors and similar approach as for the ICB installations. Once installed, the majority of charge points remained in place throughout and after the test trial period.

An installation showing the ICB, charging point and associated smart meter is presented in Figure 13.

During the 18-month trial period a range of different issues with the MC and ICBs were encountered. Since the Esprit Technology requires the MC and ICBs to operate effectively, these issues impacted on the performance of Esprit as a whole and thus required remedial action at various points in the trial. See Appendix II for further details.

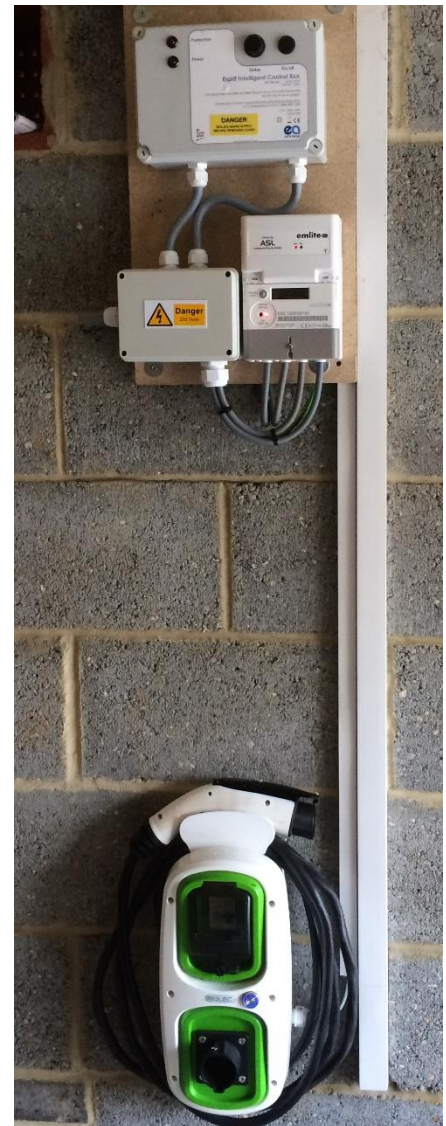


Figure 13 – ICB and charging point installation

3.3.2 Monitoring of trials

The Esprit equipment was installed such that the ICBs transmitted monitoring data using PLC to the MC which subsequently passed it, along with the monitored data relating to the LV network via a Nortech Envoy unit to Nortech's iHost system. This system was then interrogated on a regular basis by a dedicated My Electric Avenue server at EA Technology to download all stored data for subsequent analysis.

Participants' EVs were configured to transmit all charging and vehicle usage (trip duration, distance travelled and energy used) via the Nissan CARWINGS telematics system to Nissan's servers. This data was downloaded on a regular basis by the dedicated My Electric Avenue server at EA Technology and stored for analysis.

The University of Manchester and De Montfort University were provided with the (anonymised) data from the trials to inform the network modelling and socio-economic analysis undertaken. This informed the SDRC 9.6 and 9.8 reports, and the five reports from the University of Manchester issued in support of SDRC 9.8.

EA Technology utilised the data to determine the effectiveness of the Esprit system in responding to network load, and providing curtailment benefits. The data also allowed for analysis of the effectiveness of the PLC communication system. All of these findings were published in SDRCs 9.7 and 9.8 and supporting reports.

3.3.3 Technical Trial Equipment Removal

The decommissioning process involved the same approaches adopted for MC and ICB installations, as outlined in Section 3.3.1 and occurred during the 2nd and 4th weeks of October 2015. The MC decommissioning process for each DNO license area (4–5 EV clusters) took 1-day, faster than originally anticipated, highlighting the low impact nature of the Technology on DNO network assets.

Participants were requested to sign a removal contract, stating that they acknowledged removal of the ICB and were satisfied with the condition of the removal location.

4. Project outcomes

The outcomes and learning associated with the My Electric Avenue Project have been published throughout the Project life cycle, either as part of an SDRC report, Project Progress Report, or as a supporting document. The key outcomes sought as part of the My Electric Avenue Project are covered below, but the results and detailed analysis upon which these outcomes are based can be found in the Project's SDRC documents, available on the Project website. Links are provided in section 13.

4.1 Commercial

The novel commercial agreement created, tested and published as part of the My Electric Avenue Project has demonstrated that a third party organisation can effectively deliver innovation projects on DNO networks. This approach can enable the DNOs to realise the benefits of multiple innovation areas through the deployment of parallel projects; an approach that may be otherwise unfeasible depending on the size of the delivery team.

Through outsourcing the management and delivery of individual projects to third party suppliers, whilst retaining a high-level oversight and supporting role, DNOs can more effectively utilise available innovation funds. SEPD had expected that the time required by their staff to deliver the Project would be reduced in comparison to previous Tier 2 Projects due to the planned management arrangements. In reality, the cost required was approximately 75% of the forecasts, demonstrating a greater benefit than anticipated.

This approach, having been identified to work extremely effectively, could also be deployed to BAU projects where dependent on the type of Project, third party delivery may be a more efficient delivery mechanism. Consequently, the commercial approach trialled under the My Electric Avenue Project can aid DNOs in accelerating deployment of both innovation and BAU projects on their networks.

It is noted that the level of involvement by the DNO will vary from project to project, with a key influencing factor being the level of risk associated with particular elements of the Project and the corresponding extent to which the DNO chooses to exercise Governance Authority.

The review of the commercial arrangement undertaken at the end of the Project identified areas that had potential to disproportionately affect any SME taking on the role of Project Lead. These areas have been rectified in the final commercial template published as SDRC 9.2.3 with commentary provided where specific considerations must be

taken. In general, these focus on equitably balancing risk and reward between all signatories whilst clearly identifying boundaries of responsibility within the Project.

Project templates detailed in SDRC 9.2 & 9.3 provide the methods and level of detail believed necessary for effective management of subcontractors.

4.2 Technical

Are EVs a problem for GB distribution networks?

The My Electric Avenue Project was conceived out of the expectation that if the uptake of EVs proceeded in line with predictions, then LV networks would have insufficient capacity to withstand the additional load at peak times.

Using the data from all trial participants the Project Team has generated a revised ADMD for non-electrically heated domestic properties, assuming that each property hosts a single EV¹⁵. Figure 14 shows the currently used weekday ADMD in comparison to the ADMD generated from the modelling of 1,000 EVs based on My Electric Avenue data. Combining the two shows an increase of more than 100% to the total peak evening load, with the day time base load being higher and flatter than the previously considered morning peak. It is noted that for electrically heated properties, the 'Residential' and 'Total' loads would require revising upwards further to accommodate increased heating load.

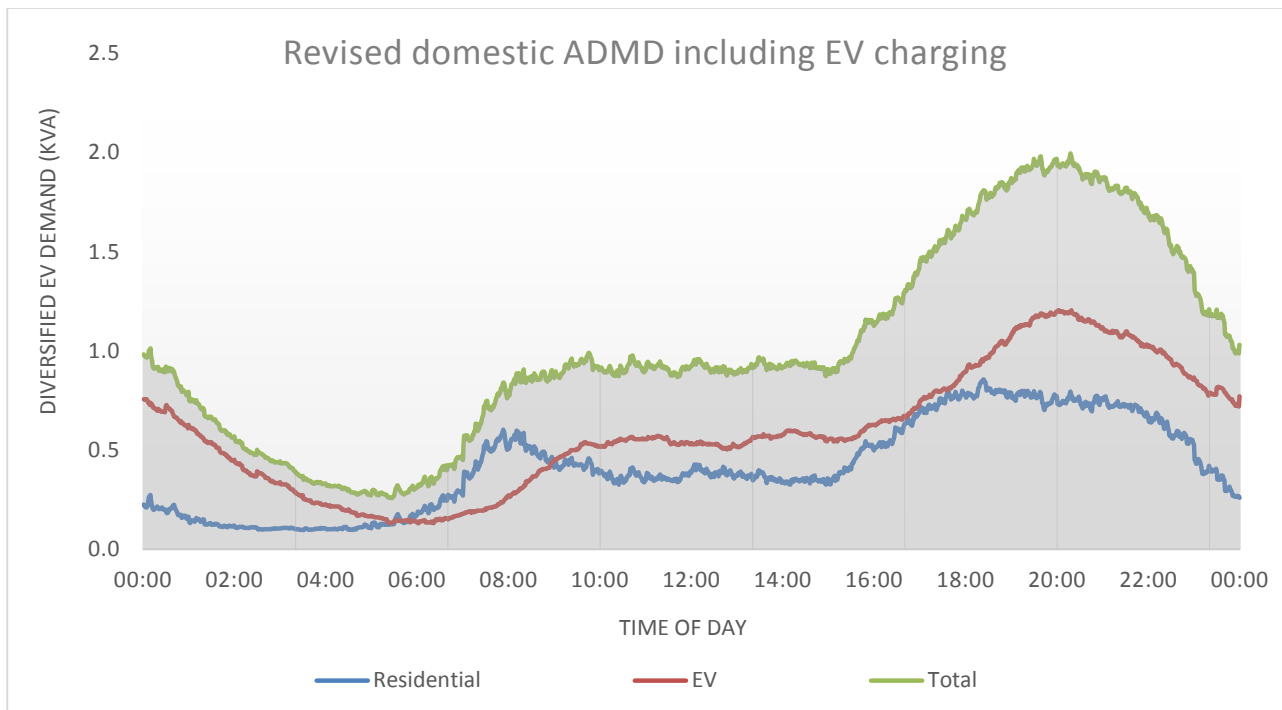


Figure 14 – Revised domestic ADMD including EV charging

Effect of different charging rates

At the time of project inception, the Nissan LEAF used in the trials (3.5kW charging and a 24kWh battery) was the only EV commercially available in sufficient quantities to meet the trial requirements. Since the start of the Project, many more makes and models of EVs have reached the market, with increased battery capacities and charge rate as standard in most cases, a trend that is set to continue with battery capacities of 90kWh already available in some of the latest models.

A simple extrapolation of the Project’s charging data from 3.5kW to 7kW has been undertaken, shown below and in more detail in Appendix III. This analysis was undertaken to demonstrate the possible effect of higher charging

¹⁵ The calculations also assume that the EVs are equivalent to those used in the trials, i.e. battery capacity = 24kWh with a charging rate of 3.5kW.

capacities. It makes the assumption that only the battery charging rate has increased and that all other factors, (e.g. journeys undertaken, state-of-charge, time-of-charge etc.), remain unchanged. Consequently, only the duration of each charge is reduced by 50%, enabling calculation of a revised probability of charging for any EV. Importantly, the load experienced by the network is determined to be higher than that from 3.5kW vehicles for most of the day, (0800 – 0000), although the total energy required remains unchanged.

Higher charging capacities will naturally increase the amount of diversity of EV load on a given circuit; this simple assessment draws out the point that the effect of diversity is unlikely to completely negate the higher load (double). It is recognised that further analysis is needed with charging data from a range of vehicles to gain an accurate view.

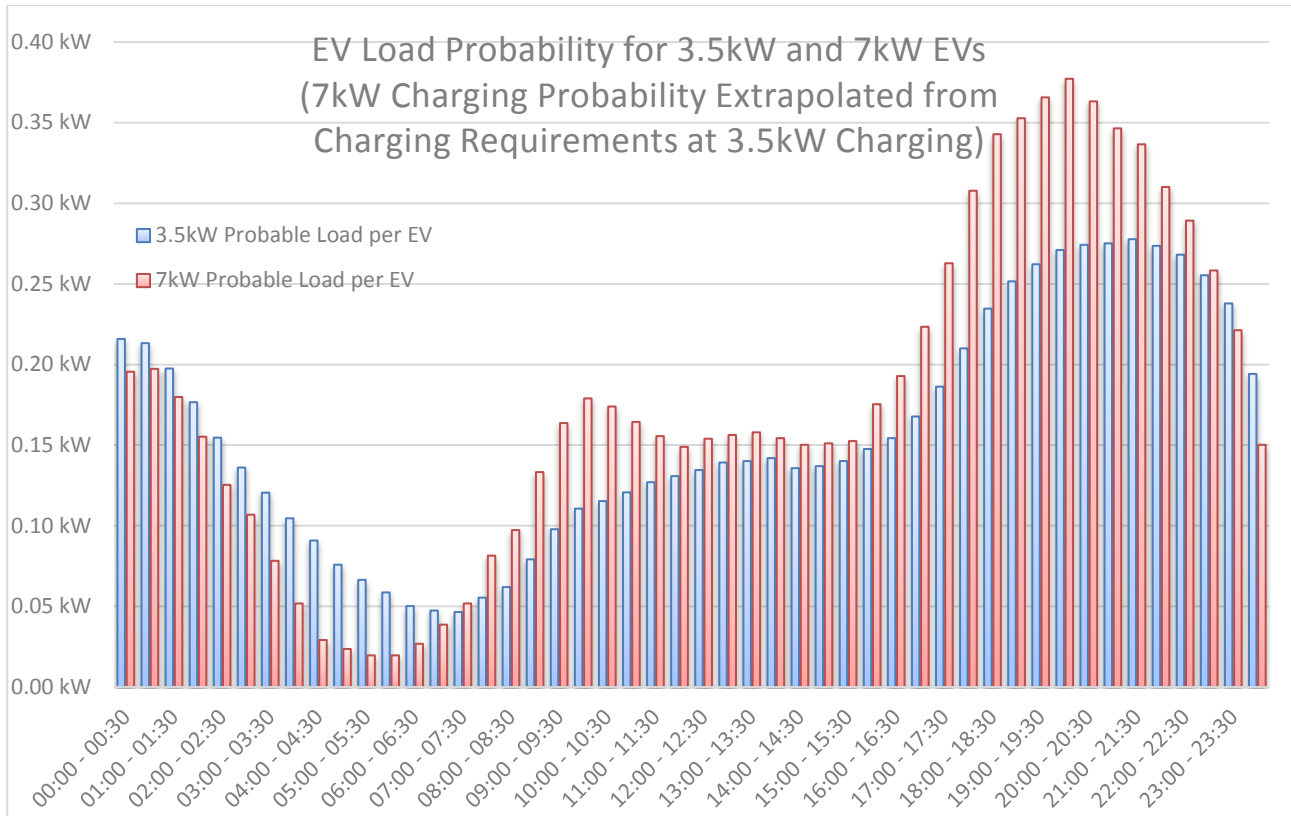


Figure 15 – Average daily load profile for 3.5kW and 7kW chargers (extrapolated from 3.5kW data)

Forecast modelling

The network modelling undertaken by the University of Manchester using the 3.5kW charger data utilised models of the Project’s trial networks and low voltage representative networks, in combination with data gathered from trial participants. This showed that over 300,000 UK networks are at risk of unconstrained EV uptake, validating the initial concerns from which the Project was conceived and supporting the need for an intervention to be developed.

As an example, analysis of the network in one cluster for each season (i.e., winter, shoulder and summer) was undertaken for every penetration level (from 0 to 100% in steps of 10%). Figure 16 highlights that the utilisation level of this feeder increases linearly with the penetration level. More importantly, it shows that the feeder utilisation level in winter is higher compared to the other two seasons. Crucially, it shows this cluster is constrained overall to an EV penetration level of approximately 30%, given that at 40% penetration level the cable ampacity¹⁶ is exceeded by 0.3% at weekends and 20% on weekdays.

¹⁶ The maximum amount of electric current a conductor can carry without overheating.

4.3 The Esprit Solution

Ability to monitor and manage load

The trials of the Esprit Technology sought to establish the effectiveness of the proposed solution in preventing, or mitigating problems on these networks. The trials on SEPD and Northern Powergrid’s networks proved the concept of Esprit is sound. The system demonstrated its ability to monitor network conditions, and trigger the curtailment and reinstatement of network load in response to changes to those conditions.

The modelling undertaken by the University of Manchester demonstrated that if Esprit were enabled on every EV connected to ‘at-risk networks,’ the system is capable of alleviating all problems caused by those EVs with appropriate control cycle and threshold settings. The example shown in Figure 16 shows the potential improvements to network load at an EV penetration level of 100% (i.e. every property owning one EV, and the Esprit trigger thresholds set to 100% and 85% of the cable rating. Further, more detailed analysis of the effectiveness of Esprit for the purposes of network protection is available in the SDRC 9.8 document and reports produced by the University of Manchester, all are available on the Project website.

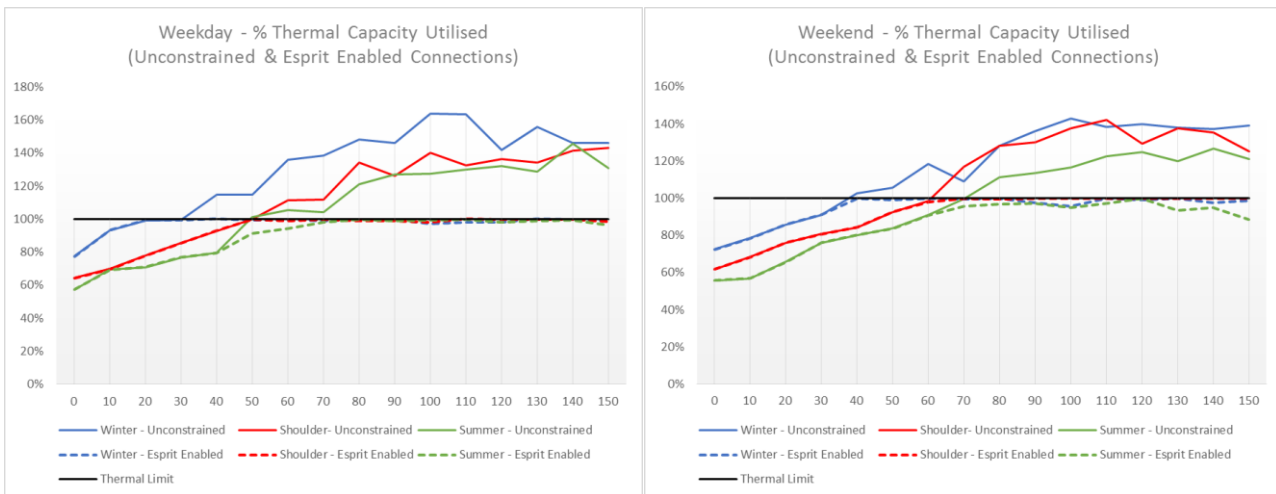


Figure 16 – Unconstrained & Esprit enabled network impacts at increasing penetration levels

Acceptability of the system

Interviews and focus groups held by De Montfort University found no statistically significant difference in opinion towards the ownership or use of EVs between the trial participants who experienced frequent and regular curtailment of their EV charging and those who experienced very little, infrequent curtailment.

When considering these outcomes together, the My Electric Avenue Project concludes that whilst EVs pose a valid risk to UK LV networks, the trials have demonstrated that the Esprit Technology can provide a viable solution, acceptable to both the DNO and the customer.

Integration of Esprit to charging points

The trial has successfully installed and integrated Esprit in one manner with charging points in domestic and commercial premises. In the trial, Esprit controls charge output by removing power from the entire charging point. However, feedback from charging point manufacturers to date has suggested that any solution which simply removes power from the entire charging point (which often includes ancillary management and communication functions) is not palatable. Instead, it was suggested that future Esprit type systems access and utilise control features already present in charging points; restricting output to the vehicle whilst maintaining power to the other functions. It is essential for collaboration between DNOs and charging point manufacturers to agree a standard approach for implementation of DSR in this area, and as a result SSEPD and EA Technology are embarking on a new project to ensure this collaboration and standardisation takes place and allows easy adoption of Esprit-type charge control in the future.

4.4 Additional outcome – recruitment

As described in Section 3.2, the approach taken to recruitment of customers to the Technical trials was both novel and successful. This success can be attributed to a number of key factors. Firstly, the Project Team was able to offer a fantastic hook to engage and recruit clusters – the lease of a Nissan LEAF Mk2 for 18 months, at a price which at the time was unbeatable in the marketplace, plus a free charging point for every household taking part. The strategic marketing strategy was critical in developing and maintaining momentum, and reaching the audience needed to both engage customers and to raise the profile of the Project on a global scale.



Figure 17 – Recruitment success: key factors

As with all other aspects of the Project, the trust and commitment of and between project partners meant that the recruitment was kept on track. This was strongly evidenced through the additional support provided to the Change Request through further in-kind contributions. Finally, the use of cluster champions from the local community to engage and liaise with their neighbours was an aspect that worked particularly well, and is an approach that should be considered and adopted where feasible in other recruitment-type projects.

4.5 Changes to TRL level of Esprit

Charging points, as with any product, have continued to be developed and enhanced over the course of the My Electric Avenue Project. In contrast to the point of bid submission, many charging points now include a level of ‘intelligence’ with built-in monitoring and communications. Such devices do not respond well to the curtailment approach trialled in the My Electric Avenue Project that of shutting down the power, as it can, over a longer period, damage the internal components.

In acknowledgement of this, and as mentioned earlier, redevelopment of Esprit is planned in collaboration with charging point manufacturers to embed the necessary functionality within the devices. The SSEPD NIA ‘Framework PIV: Management of plug-in vehicle uptake on distribution networks’ project, in collaboration with all six GB DNOs, being delivered by EA Technology, will seek to inform an ENA Engineering Recommendation (or equivalent) for the connection, charging and control of new, large, Plug In Vehicle (PIV) load to domestic properties.

The focus of this project is on the collaborative approach required to achieve consensus on a solution that can be used to facilitate the roll out of controlled PIV charging. In doing so, it will enable significantly larger numbers of PIV charging on today’s local electricity distribution networks, with sizeable reduction in reinforcement costs and customer bills/disruption. The practical output will be a functional specification to describe the system, providing vendors with the information needed to build a trial system. The Project was registered in March 2016, here: <http://www.smarternetworks.org/Project.aspx?ProjectID=1883>.

4.6 Overall summary

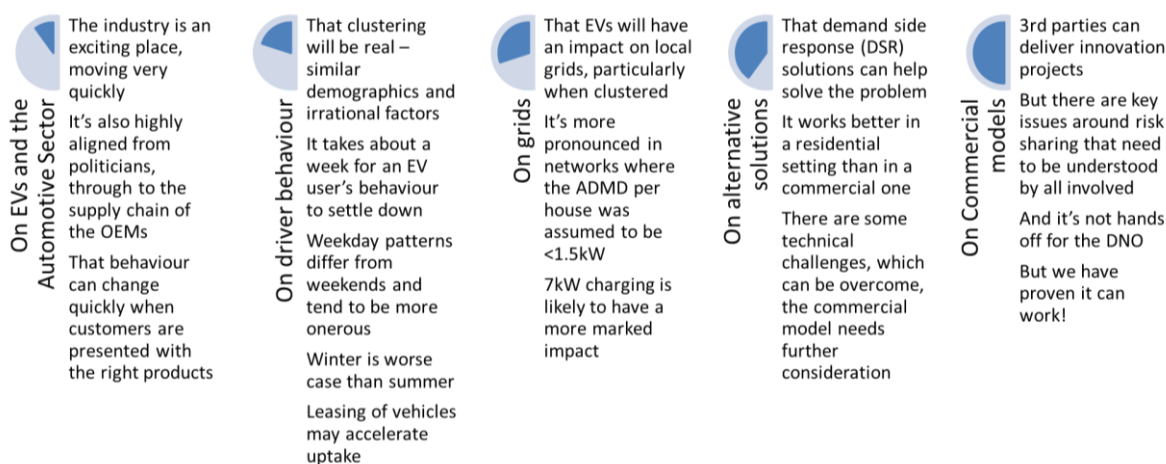


Figure 18 – Summary of key learning points presented in the Project Finale Event

5. Performance compared with the original Project aims, objectives and success criteria

Documentation published by the My Electric Avenue Project relating to each of the Project’s aims and objectives are referenced appropriately and are available on the Project website at <http://myelectricavenue.info/project-deliverables>.

5.1 Project commercial aims

The Project’s commercial aims were achieved and evidenced in SDRCs 9.1, 9.2 and 9.3, referenced in section 5.4.

Commercial Aim 1	✓
Demonstrate delivery of a LCN Fund project by a non-DNO on behalf of a DNO.	
The My Electric Avenue Project has demonstrated that a non-DNO can effectively deliver a large scale innovation Project on behalf of a DNO, across multiple licence areas operated by different DNOs. All Project outputs were achieved and SDRCs delivered on or ahead of schedule.	
Commercial Aim 2	✓
Develop a novel commercial arrangement to enable a third party to deliver a LCN Fund project on behalf of a DNO.	
To enable delivery of the My Electric Avenue Project, the Project Team created a contractual template, usable by DNOs and third parties to replicate the commercial structure of the My Electric Avenue Project. Details of this arrangement were published early in the Project and updated in the final months, to incorporate the learning realised over the three years.	
Commercial Aim 3	✓
Enable all procurement related to Project activity to be managed by a non-DNO.	
As part of the commercial arrangement implemented on the Project, all procurement activities were undertaken by either EA Technology or a Project Partner as it pertained to their area of the Project. Broadly: EA Technology procured all items relating to the Esprit equipment; Fleetdrive Electric, those relating to the EVs; and for Zero Carbon Futures, those relating to the charging points.	
Commercial Aim 4	✓
Evaluate the extent to which third party delivery accelerates deployment of LCN Fund projects.	
If this model is to be replicated companies should anticipate peaks in effort required during key periods of activity and factor in time for incident escalation, yet generally the inputs required will be less time-intensive during stable and winding down periods of delivery and so afford a level of confidence in the time-effectiveness using a third party for management and delivery of a project.	
Considering the successful management and delivery of the Project, along with the fact that the required input from the DNO has been minimal compared with other innovation projects by utilising the third party and utilising their expertise, we believe that the arrangement is successful one. It has reduced the input required by DNO staff which has allowed analysts, engineers, management and customer-facing staff to be utilised elsewhere in the business, whilst also bringing in expertise not necessarily within a DNO’s skillset and ensuring an ability to hit the ground running quicker in certain areas.	
This approach could feasibly allow several innovation projects to be run simultaneously with a relatively minor level of input required from the DNO. Whilst the costs would remain as the third party would fulfil the management and delivery aspects, with the relatively short timescales of these projects these costs would not be enduring to the DNO (such as full-time, permanent staff costs and associated overheads) and so could be considered as operational expenditure (OPEX). This is beneficial where such projects are seen as tactical delivery pieces (typically under 5 years) and so limiting the costs to a defined period of time, therefore reducing the need to expend capital on elements needed for new project delivery staff such as office equipment and furniture, IT equipment, telecoms equipment, etc. These items will have useful lives beyond the length of the project and therefore impact the	

financial statements of the DNO long after the project has completed, whereas employing a third party to manage and deliver an innovation project can ensure this is not the case as costs are processed as OPEX.

5.2 Project technical aims

The Project’s commercial aims were achieved and evidenced in SDRCs 9.4, 9.6, 9.7 and 9.8, referenced in section 5.4.

Technical Aim 1	✓
Learn customer driving and charging habits and the implications for control via the Esprit Technology.	
<p>A significant dataset was gathered throughout the Project covering vehicle usage and charging requirements for both social (non-curtailed) and technical (curtailed) trial participants.</p> <p>Trial participants were interviewed as part of the socio-demographic research to determine the extent to which they had been impacted by the Esprit Technology connected to their charging point.</p> <p>This research found that the Esprit Technology for control of EV charging was acceptable to the majority of participants in the My Electric Avenue Technical Trial. Most of the participants in the Domestic Clusters whose charging was curtailed were either not aware of the curtailment, or were not impacted by it. In face-to-face data collection, only one participant reported a significant issue with curtailment where changes to plans were required due to insufficient charge in the vehicle. The degree of acceptability of Esprit was found to be unrelated to whether or not participants experienced curtailment of charging by Esprit.</p> <p>Curtailed charging by Esprit was more of an issue for participants in the Workplace Cluster of the Technical Trial. The majority of participants opted not to charge at the workplace after curtailment began due to the uncertainty of receiving sufficient charge. This resulted from the interaction of Esprit and the flat load profile for the Workplace Cluster which caused Esprit to operate in an impractical way.</p> <p>It can be taken from this, that customers accept curtailment of their EV charging as long as they continue to have sufficient charge to undertake their essential day-to-day activities, i.e. commuting. Where this required usage is prevented, the technology is no longer considered acceptable.</p>	

Technical Aim 2	✓
Develop and trial the equipment to ascertain its ease of installation.	
<p>The deployment of Esprit across multiple clusters enabled the My Electric Avenue Project to demonstrate the effectiveness of DNO managed DSR technology in this situation.</p> <p>Where reliable PLC communications were achieved, the trials validated the Esprit functionality as being capable of responding to network conditions and curtailing the charging of EVs, causing a corresponding reduction in network load. There were instances however where the PLC communication did not perform as anticipated and analysis of this communication has been undertaken to increase the understanding relating to PLC reliability. This identified a number of factors that influence the PLC signal, details of which are provided in the PLC Communication Reliability Report issued in support of SDRC 9.8.</p> <p>The trial equipment, in the form used for the Project was simple to install when undertaken as part of the charging installation process. Modifying the equipment when required proved difficult and improvements to EV charging points over the duration of the Project will require an alternative approach for utilise the technology than trialled under My Electric Avenue.</p> <p>The Esprit equipment as installed utilised a relay to remove power to the charging point, an approach that did not cause issues with the charging points used in the trials. However, as charging points develop such that they incorporate power electronics and micro-computers, this technique cannot be deployed.</p> <p>This view is supported by problems experienced with the charging points at the commercial cluster, when curtailment was instigated the charging point responded as expected however it did not automatically resume charging once power was restored.</p> <p>Further development of the Esprit Technology is now being considered with a view to integrating the functionality into charging point capabilities, removing the need to disable power to the charging point whilst continuing to curtail charging.</p>	

Technical Aim 3 ✓
Evaluate the range of networks where Esprit can operate successfully and identify any types of networks that are inappropriate.
<p>The My Electric Avenue Project trialled the Esprit Technology on 10 LV networks, covering rural overhead lines, urban and sub-urban cable networks and a commercial location. In all cases, the technology operated successfully, within the limitations of the Powerline Carrier communication medium, monitoring the LV network and triggering charging curtailment when pre-set thresholds were exceeded.</p>
<p>The trials demonstrated that the Esprit Technology is capable of providing benefit to any network on which it is utilised, subject to the availability of reliable communications and a suitably controllable load.</p>
<p>Commercial networks were found to not be suitable for deployment of Esprit in the approach trialled, specifically, where the proportion of EV load is very low in comparison to the base load of the network. In this situation, there is insufficient variation in the non-controlled load to allow effective cycling of vehicle charging, a problem exacerbated by the largely flat profile of the load. In this situation, EV charging is largely curtailed throughout the day with insufficient charge being provided to connected vehicles.</p>
<p>Where a business was currently not utilising their full available capacity, and wished to install a significant number of charging points, the Esprit system could be deployed to balance load within connection limits.</p>

Technical Aim 4 ✓
Evaluate how often switch off routines are likely to be initiated from real life trials and extrapolation via modelling using the results.
<p>The likely frequency of switch-off routine operation varies in response to multiple factors: the feeder types, the number of properties, the mix between commercial and domestic customers, the type of properties within those categories, available capacity without EVs, the penetration of EVs on the individual network, the EV rate of charge, the EV battery capacity, and the charging habits of individuals. As each of these factors influences the control requirements of the Esprit system, it is not possible to determine a specific value of how frequently switching would occur.</p>
<p>As the factors above providing a negative effect on the network increase (baseload, EV penetration, battery capacity), the Esprit system will be required to operate earlier, and more frequently in order to protect the network. Simply put, as penetration of EVs to any LV network increases, the likelihood of customers charging simultaneously, and increasing network load to a point where the Esprit system is required to intervene increases.</p>
<p>It was found that when considering an autonomous dynamic control system, shorter control cycles provide greater benefits to the network. Combining this approach with a threshold setting lower than the cable rating demonstrated that it is possible to prevent exceedance of the LV feeder capacity.</p>

Technical Aim 5	✓
Evaluate the most appropriate length of time to switch off charging and how to cycle switches with references for battery management and customer preference and habits.	
<p>The My Electric Avenue Project liaised with EV battery manufacture stakeholders and heat pump manufacturers. Combining the information provided with the analysis of the Project data, we recommend a minimum 'on-time' of 15 minutes, with a maximum 'off-time' of 60 minutes for demand response using Esprit.</p> <p>These timings are consistent with minimising the impact on EV battery or heat pump systems whilst providing benefits to the distribution network.</p> <p>It was also found that implementing control of EV charging within the 15 – 60 window did not appear to adversely, or noticeably, impact customer preferences although some changes to charging habits were noted in the period after initiation of curtailment.</p> <p>After instigating charging control, domestic participants briefly began to make more use of public chargers but then began to return to previous connection patterns. Due to the problems found with using such a DSR system in a business environment, participants began charging at home more in preference to charging at work.</p> <p>Interviews with participants did not identify any issues with the duration of curtailment, and habits appeared to have naturally adjusted to allow for the potential for delayed charging.</p>	

Technical Aim 6	✓
From the results and extrapolation via modelling, estimate the typical and maximum thermal capacity gained.	
<p>Analysis of the vehicle usage and charging data gathered from the 200+ Nissan LEAFs participating in the My Electric Avenue Project was modelled against representative LV feeders to determine the impact of additional EV load.</p> <p>This modelling determined that 32% of LV feeders (c310,000) in the UK will require intervention at penetration levels ranging from 40% to 70%. This assumes that the properties on the affected feeder have a single EV, charging at a rate of 3.5kW, with a battery capacity of 24kWh, comparable to the EVs participating in the trials. Increasing the charging rate, battery capacity or the presence of multiple EVs at the same property will further exacerbate the issue.</p> <p>Further investigation is recommended to determine the extent at which increased charging rates and battery capacities influence usage of the vehicles and consequently their impact on the network.</p> <p>Modelling of these representative feeders with the inclusion of an Esprit type control system significantly increased the level of EV penetration that could be achieved before further intervention was required.</p> <ul style="list-style-type: none"> • The inclusion of an Esprit type system provided additional thermal headroom of up to 46% at the highest EV penetration levels, significantly delaying or removing the need for further, expensive reinforcement. <p>Voltage levels along the modelled feeders also improved from the inclusion of an Esprit type system to the network, reducing the number of non-compliant customers by 70% at the highest EV uptake levels.</p>	

5.3 Project objectives

Develop a novel commercial agreement for the My Electric Avenue (I ² EV) Project.	✓
A commercial arrangement was established between SEPD and EA Technology and subsequently between EA Technology and all partners and sub-contractors involved in the Project.	
Issue a template of the novel commercial agreement for other LCN Fund Projects interested in following the third party led approach.	✓
<p>The initial arrangement was documented and published early in the Project and then revised as planned at the end of the Project to incorporate learning realised over the three years.</p> <p>The original documentation remains available for reference on the Project website although it has been superseded by a revised contractual template, also available on the website.</p>	

Assess the initial trial of the Esprit Technology, undertaken outside of the My Electric Avenue (I²EV) Project and make recommendations where necessary to improve the design prior to implementation as part of the wider Project. ✓

The initial on-site trials did not reveal any challenges to the use of the Esprit Technology in that form. Consequently, no significant changes were identified at this stage.

The University of Manchester used the data gathered during the initial trials and technical information regarding the network to generate a model for simulation purposes. This was used to mimic the initial trial and then test the performance of the technology using theoretical loads.

Suggestions to improve the technology were made as part of the assessment, although these primarily related to functional requirements of a commercialised system that were impractical, and unnecessary for deployment as part of the My Electric Avenue Project.

Undertake a technical literature survey of the load shifting potential of EVs and heat pumps. ✓

A literature survey, augmented with correspondence with heat pump manufacturers, was undertaken to determine the effectiveness and potential impact an Esprit type system would have on heat pumps. The outcomes of this were published as part of the supplementary information for SDRG 9.7.

Undertake a socio-economic literature survey of customer behaviour with EVs and acceptance of direct control of appliances. ✓

De Montfort University carried out this review, the outputs of which informed the interviews and survey groups undertaken later in the Project.

Develop a Customer Engagement Plan (CEP) and have it approved by Ofgem. ✓

CEP submitted in March 2013 and updated in March 2014. Both iterations were approved by Ofgem.

Recruit at least 100 participants in at least seven clusters, each containing at least ten customers on the same low voltage feeder; to be achieved within 12 months of approval of the CEP. ✓

Participant recruitment was successfully achieved and reported to Ofgem in line with the SDRG requirements.

Three clusters were recruited by month nine of the Project, six months after approval of the CEP, five clusters by month 12, and ten clusters by month 15, with more than 100 participants signed up overall.

Recruit a minimum of 100 participants to the social trials to have their driving habits recorded; to be achieved within 18 months of approval of the CEP. ✓

More than 100 participants were signed up to participate in the Project's social trials by August 2014, less than 18 months after approval of the CEP.

Deploy monitoring equipment to monitor existing EV owner's behaviour. ✓

This objective was originally included due to the Project's aim to recruit existing EV users to the trials, and consequently monitoring equipment would need to be retrospectively installed at their property to monitor and control EV charging. The approach was planned as it was expected to be easier and more cost effective to achieve in comparison to recruiting non-EV drivers for this purpose.

Unfortunately, due to personal data confidentiality, the Project Team was unable to contact existing customers of Nissan or Fleetdrive Electric, requiring recruitment of new EV drivers instead.

The sign-up of more than 100 participants to the social trials provided a statistically significant dataset of monitored behaviours.

However, an EV (Nissan LEAF) was already owned by a colleague at EA Technology so monitoring equipment was installed at their home to gather data on the EV charging. This provided valuable data informing the power quality and voltage issues when considering the implementation of the Esprit Technology.

Install charging points, the Esprit Technology and monitoring. ✓

All participants recruited under the technical trials were provided with an EV charging point and an Esprit Intelligent Control Box (ICB), enabling charging to be monitored and controlled.

Determine the anticipated number and duration of switch-off events triggered by the Esprit Technology. ✓

The Esprit Technology installed in the My Electric Avenue trials was deployed with a control system that operated on a 15 minute cycle time. Based on the charging patterns seen at the point of equipment deployment, combined with the number of participants in a cluster it was anticipated that participants would be switched three or four times between 1800 and 2200. The duration of each curtailment would vary, in 15 minute segments, dependent on the number of EVs undergoing controlled charging at the time.

Collect data for the duration of the trial, to be reported upon at least every six months to the Project steering group. ✓

Data was collected from the participants' vehicles soon after delivery, continuing until the vehicle lease concluded. The Esprit equipment collected data relating to the LV network and participant charging behaviour from the point of installation, this was transmitted to a central server for later download and analysis.

It is noted that due to the unreliability experienced in the PLC system, not all ICBs were available 100% of the time, reducing the available data from that device. Vehicle charging data remained available via Nissan's CARWINGS telematics system and secondary substation monitoring equipment was also installed to ensure sufficient data was available to achieve robust learning outcomes from the Project.

During the period where trial equipment was deployed on the network, data and communication reliability reports were provided to representatives of the Project Steering Group from EA Technology and SSEPD to provide assurance that adequate, suitable data would be available for data analysis.

Interview / survey Project participants to gather their views on the trial and technology. Analysis of the data gathered to be undertaken and recommendations relating to the technology to be made. ✓

Technical and social trial participants were interviewed across the course of the Project through use of online electronic surveys, telephone and face-to-face interviews, and group discussion sessions.

The outcome of analysis of the data gathered as part of this process found that the use of the Esprit Technology was acceptable to the majority of participants. Domestic cluster participants, were either unaware of ongoing curtailment or were unaffected by it, with only one instance of curtailment of charging causing difficulty.

The use of the Esprit equipment at the workplace cluster did cause problems due to the load profile of the business; being reasonably level throughout much of the day there was very little capacity to allow vehicle charging to occur.

Recommendations to the future design and implementation of the Esprit Technology were made in SDRCs 9.7 and 9.8 combining learning from the participant responses, network modelling and trial data.

Determine the impact of EV charging on the UK distribution network and the benefits to be gained from the deployment of an Esprit type solution through creating and using network models. ✓

Modelling undertaken to simulate representative UK networks with anticipated EV uptake profiles, combining learning gained from My Electric Avenue trial participants relating to driving and charging behaviour was performed. The impact of increasing EV uptake was modelled on representative UK LV feeders both with and

without the inclusion of the Esprit Technology to determine the technical benefits available to each network type. This analysis is detailed in SDRC 9.8.

Perform a cost-benefit-analysis on both a GB and DNO licence scale for the Esprit Technology. ✓

SDRC 9.8 details the potential cost savings associated with the use of the Esprit Technology in conjunction with the anticipated uptake of EVs. The Transform Model[®] was used to compare a conventional reinforcement approach to mitigating the uptake of EVs against the use of Esprit (as DNO-led DSR) where appropriate. This analysis used the ideal Esprit settings determined by the University of Manchester as part of the network modelling undertaken to inform SDRC 9.8 and assumes that a suitably reliable communication method were implemented within the technology. The economic savings do not begin to be realised until RIIO-ED2, but have reached a potential £2.2 billion by the end of RIIO-ED4.

Estimate the likely carbon savings available from the use of the Esprit Technology. ✓

The analysis was undertaken and is detailed in the suite of documents relating to SDRC 9.8. Carbon emissions savings were calculated to be between 814 and 1,390 ton CO₂e by 2050, dependent on technology uptake.

Agree cycle times and logic for the Technology. ✓

The Project Team liaised with OEMs in both the automotive and heat pump manufacturing areas to agree cycle times that would avoid damage to the equipment in question. Details of the 'maximum on' and 'minimum on and off' periods are provided in SDRC 9.7.

Commission an independent evaluation of the Project and the Technology. ✓

Ricardo was contracted to the Project, with the remit of providing an unbiased, independent evaluation of all aspects of the Project, taking into account everything undertaken within the Project, from the Governance activities by the Regulator to deployment of equipment on-site.

Make regulatory recommendations, including integrating learning from the Project into DNO Business-As-Usual. ✓

Recommendations relating to the deployment of a similar commercial process have been provided in the SDRC 9.1 and 9.2 & 9.3 reports. Recommendations relating to the deployment of an Esprit type technology have been detailed in SDRC 9.6, 9.7, 9.8 and supporting documents. The SDRC 9.4 reports relating to the independent review provide recommendations to the industry to best deploy a similar project under business-as-usual conditions.

Make technical and commercial recommendations following learning gained throughout the Project. ✓

Recommendations have been documented by the Project Team covering learning in the areas of bid submission, future Project commercial management, customer recruitment and technology deployment. These recommendations span SDRC reports under the areas 9.1, 9.2, 9.3, 9.4, 9.6, 9.7 and 9.8.

Develop and execute a dissemination plan. ✓

The Project dissemination plan was developed in parallel with the CEP being revised and updated as required throughout the duration of the Project. Further details can be found in section 12.

5.4 Successful Delivery Reward Criteria (SDRC)

Delivery of all SDRC's was achieved through a total of 27 reports comprising the SDRC submissions (or confirmation of milestone attainment) and supporting information where required.

Table 2 SDRC Criteria Comparison

SDRC	Planned evidence	Submitted evidence	
SDRC 9.1 Document the learning from the experience of a third party leading a Tier 2 bid, including suggestions for where the process could be more open or streamlined.	SDRC 9.1.1 The provision of a report outlining key areas of learning in the identified areas, with recommendations. The report will be written such that they can be published in the public domain for an audience of: DNOs, Ofgem or other interested third parties who may wish to lead a LCN Fund project in collaboration with a DNO. Due: February 2013.	This report was submitted to Ofgem in February 2013 , and was published on the Project website.	✓
SDRC 9.2 The blueprint of the contractual arrangements put in place with the DNO for a third party lead on a LCN Fund Tier 2 project.	SDRC 9.2.1 Make available the initial contract template used between SEPD and EA Technology together with supporting guidance of the thinking behind key clauses. This will be made available to Ofgem and other DNOs as a starting point for use in future projects. Due: April 2013	A suite of four documents were published in April 2013 , comprising: <ul style="list-style-type: none"> The supporting guidance for the Project's novel commercial arrangement. The Management and Delivery Document, defining the working relationship and distribution of responsibility within the Project. A template based on the contract in place between SEPD and EA Technology. A template based on the contracts in place between EA Technology and the Project Partners and Suppliers.	✓
	SDRC 9.2.2 Review of the contract put in place between SEPD and EA Technology. A review of the initial contract developed at the outset of the Project, focusing on what worked well, what didn't work well, and what should be done differently in the future. Due: October 2015	The document published in October 2015 (SDRC 9.2 & 9.3 – An assessment of third part delivery of a low carbon innovation project), contained a review of the contracts established and the outset of the Project and made specific recommendations for improvements if such a Project structure was to be used again.	✓
	SDRC 9.2.3 An updated contract template taking into account the learning identified in the review towards the end of the Project. Due: December 2015	Following the recommendations published in the document 'SDRC 9.2 & 9.3' an updated contractual template was published in October 2015 , implementing the identified improvements.	✓

SDRC	Planned evidence	Submitted evidence	
<p>SDRC 9.3 An assessment, based on direct experience, of how a third party can effectively manage delivery on innovative projects with a DNO, and whether this allows DNOs to take on more innovation projects.</p>	<p>SDRC 9.3.1 Report detailing processes established and utilised throughout the Project including templates of any forms created and records of meetings / regular communications created as part of the process. This will include an evaluation of the collaboration between SEPD and Northern Powergrid with a third party interface. Due: October 2015</p>	<p>Due to the cross-linking between SDRC 9.2.2 and 9.3, a single report was produced containing the Project outputs relating to SDRC 9.2.2 and SDRC 9.3. This report was submitted to Ofgem and published on the Project website in October 2015.</p>	✓
	<p>SDRC 9.3.2 A framework to enable update suggestions to SSE policies and / or procedures, identified during the course of the Project will be provided. Due: October 2015</p>		✓
	<p>SDRC 9.3.3 An assessment from the participating DNO of the level of effort expended on Project Management of the I²EV task by the staff involved with the Project in comparison to previous innovation projects. Due: October 2015</p>		✓
<p>SDRC 9.4 An assessment of how the DNO and other interested parties can ensure independent validation of a third party's solution throughout a project and upon completion.</p>	<p>SDRC 9.4.1 The provision of 6 monthly independent reviews of the Project and technology with specific inclusion of improvements and adaptation to working practices incorporated by the Project Team following the previous independent review. Due: July 2013, January & July 2014, January, July and December 2015.</p>	<p>Independent reviews of the Project were undertaken by Ricardo at 6 monthly intervals. These reports, published in June and December of each year of the Project, highlighted strengths and weaknesses in the approach the Project was following and in the technology being trialled along with recommendations for improvements. A response to each review was written by EA Technology and SEPD which was then submitted to Ofgem with a summary (due to document size) of the review. The complete independent reviews, as well as the responses from EA Technology and SEPD are available on the Project website. Delivered: July 2013, January and July 2014, January, July and December 2015.</p>	✓

SDRC	Planned evidence	Submitted evidence	
<p>SDRC 9.5</p> <p>Sign up and secure involvement of sufficient customers in the trial to adequately test the Technology.</p>	<p>SDRC 9.5.0</p> <p>Customer Engagement: submission of the customer engagement plan and data protection strategy for Authority approval.</p> <p>Due: February 2013</p>	<p>The customer engagement plan and data protection strategy were submitted in February 2013 approved by Ofgem in March 2013.</p>	<p>✓</p>
	<p>SDRC 9.5.1</p> <p>Technology trials: Establishment of the cluster groups to trial the solution.</p> <ul style="list-style-type: none"> • Sign-up of 3 cluster groups (September 2013) • Sign-up of 5 cluster groups (December 2013) • Sign-up of 100 customers in at least 7 clusters with at least 10 customers in each of the 7 groups (March 2014) <p>Sign-up of 10 cluster groups (August 2014)</p>	<p>All recruitment requirements pertaining to the Technology trials were completed ahead of schedule.</p> <p>Three clusters were recruited in September 2013; five in October 2013; and ten in March 2014.</p> <p>The final distribution of participants met the requirement for at least 100 customers, recruited across at least seven clusters with at least ten participants in each cluster.</p>	<p>✓</p>
	<p>SDRC 9.5.2</p> <p>All cluster funding allocated due to successful establishment of clusters.</p> <p>Due: August 2014</p>	<p>All funding to be used for the establishment of clusters was allocated on the completion of customer recruitment to the technology trials with confirmation of this issued to Ofgem in August 2014.</p>	<p>✓</p>
	<p>SDRC 9.5.3</p> <p>Social trials: Sign-up a minimum of 100 EV drivers to have their driving habits recorded.</p> <p>Due: August 2014</p>	<p>More than 100 new EV drivers registered with the Project, granting My Electric Avenue permission to gather data from their Nissan LEAF relating to their driving and charging patterns.</p> <p>A short report confirming achievement of this was issued to Ofgem in August 2014.</p>	<p>✓</p>
<p>SDRC 9.6</p> <p>An assessment of the public acceptance (or otherwise) to DSR of EVs using this sort of technology.</p>	<p>SDRC 9.6.1</p> <p>A report documenting the finding from the socio-economic analysis on the public reaction to the technology.</p> <p>Due: October 2015</p>	<p>This report was submitted to Ofgem and published on the Project website in October 2015.</p>	<p>✓</p>

SDRC	Planned evidence	Submitted evidence	
<p>SDRC 9.7</p> <p>An assessment of the most appropriate integration of the Technology for different applications and suitable cycling times or reasons why this is not possible if the trials are not successful.</p>	<p>SDRC 9.7.1</p> <p>Documentation describing:</p> <p>a. Views of the OEM community of the impact (if any) that cycling of EVs or heat pumps may have on the products.</p> <p>b. Recommendations of suitable cycle times for EVs and heat pumps for demand-side response</p> <p>c. Evidence of whether this solution would be feasible or not.</p> <p>Due: June 2015</p>	<p>This report was submitted to Ofgem and published on the Project website in June 2015.</p> <p>In support of the principal report for SDRC 9.7, supporting reports, detailing additional learning relating to the analysis of voltage variations, and the effect of Esprit on cable thermal ratings and heat pumps were also published.</p>	<p>✓</p>
<p>SDRC 9.8</p> <p>An assessment of how much headroom this sort of technical solution would yield, considering different network topologies and load types.</p>	<p>SDRC 9.8.1</p> <p>Modelling to understand additional headroom available / other network benefits from using the technology.</p> <p>a) The models will assess the % of thermal and voltage headroom released.</p> <p>b) The Project will deliver an updated Solution Template specific to the Technology and any updated EV charging profiles for use.</p> <p>Due: November 2015</p>	<p>This report was submitted to Ofgem and published on the Project website in November 2015.</p> <p>In addition, the SDRC referenced multiple other documents also published at the same time, to supplement and improve the learning in the SDRC report. These are:</p> <ul style="list-style-type: none"> • PLC Communication Reliability analysis • A suite of five reports detailing the models and scenarios created for the forecasting of EV uptake and use of Esprit. 	<p>✓</p>
	<p>SDRC 9.8.2</p> <p>Potential cost and carbon emission savings using DECC published carbon intensity figures.</p> <p>Due: November 2015</p>		<p>✓</p>

6. Required modifications to the planned approach during the course of the Project

During the bid stages, the My Electric Avenue Project was designed to sequentially recruit clusters and participants, deploying vehicles and the Esprit Technology in turn. This would enable the Project Team to use the initial clusters for publicity purposes, boosting further recruitment for the later cluster. Additionally, the initial deployment of the trial technology could be ‘stress tested’ on the early recruited clusters, enabling modifications to be implemented before wider roll-out.

The funding restrictions introduced via the Schedule to the Project Direction prevented this staged deployment from occurring as planned, requiring recruitment of all customers and clusters to be achieved before use of Project Funds to deploy vehicles or trial equipment to Project participants. This required a longer, more intensive recruitment strategy to be implemented as it was necessary to recruit customers to Project clusters, and then ‘hold’ their interest whilst the remaining clusters were recruited.

Additionally, a transcription error introduced to the Final Submission Spreadsheet, during the bid submission process resulted in a shortfall of approximately £220k, this required a re-apportionment of expenditure within the Project to compensate for the reduced funds.

The Change Request, approved by Ofgem in 2015, acknowledged that the change in approach from that planned in the bid submission was necessary to achieve the recruitment targets introduced via the Project Direction and accommodate the impact of the transcription error. Increased in-kind contributions from EA Technology and Fleetdrive Electric were necessary to support this change in approach and enable effective recruitment and delivery.

7. Significant variation in expected costs and benefits

Table 3 Category expenditure

Ofgem Categories / Project Tasks	Budget (£k)	Total Expenditure (£k)	Variance (£k)	Variance (%)
Labour	£ 222.25	£ 184.40	-£ 37.85	-17.03% ^a
Equipment	£ 278.63	£ 292.55	£ 13.92	4.99%
Contractors	£ 3,532.15	£ 3,527.16	-£ 4.99	-0.14%
IT	£ 2.71	£ 2.81	£ 0.10	3.83%
Travel & Expenses	£ 3.00	£ -	-£ 3.00	-100% ^b
Payments to users	£ 276.63	£ 280.62	£ 3.99	1.44%
Contingency	£ 400.40	£ 350.03	-£ 50.37	-12.58% ^c
Decommissioning	£ 26.29	£ 25.76	-£ 0.53	-2.03%
Other	£ 7.37	£ -	-£ -7.37	-100% ^d
Total	£ 4,749.43	£ 4,663.33	-£ 86.10	-1.81%

- a) The overall level of effort required by SEPD to provide overall support to the My Electric Avenue Project was lower than anticipated, requiring less input to almost all areas of the Project.
- b) Travel and expenses costs for SEPD were spread across all on-going projects within the innovation portfolio; therefore these have been recorded within the Labour cost category.
- c) Not all of the Contingency allocated to the Project was required.
- d) No problems were experienced by the Project participants as a consequence of the Esprit trial equipment not functioning correctly. As such, there was no need for the provision of taxi's or alternative transport as allowed for originally.

Overall, the Project has delivered a more challenging recruitment schedule and a greater depth of learning than originally planned whilst underspending the available budget by more than £80k.

This was achieved despite the Project Bank Account realising significantly lower interest rates than predicted by the bid submission finance spreadsheet.

A combination of realised efficiencies, good project and risk management and increased in-kind contributions from EA Technology, Fleetdrive Electric and Nissan were necessary to make this possible.

8. Updated business case and lessons learnt on the method

The business case for the deployment of Esprit by DNOs has improved since the bid submission, where anticipated savings due to Esprit were c£740 million by 2040 in comparison to BAU methods. Use of project data into the GB version of the Transform Model[®] puts potential savings in the region of £2 billion by 2040, rising by a further £200 million, to £2.2 billion by the end of RII0-ED4 (2047), if UK DNOs choose to implement Esprit-type technologies on their networks. Details of the methodology and related assumptions informing the model's forecast are detailed in SDRC 9.8.

The business case for the use of a third party provider to deliver innovation projects has also been successfully verified. The Project was delivered for less than budgeted, with less effort required on the part of the DNO. This was achieved despite the increased complexity and associated costs relating to parallel recruitment and deployment of the equipment.

Further use of this approach to deliver innovation projects can greatly assist the industry in trialling more technologies that have the potential to further improve reliability, reduce costs and improve service to customers.

Lessons learnt relating to the deployment of an equivalent commercial approach are detailed in SDRCs 9.1, 9.2, 9.3 and 9.4 and those relating to deployment of an Esprit type technology on UK LV networks are detailed in SDRCs 9.6, 9.7 and 9.8. In all cases, the Project outputs can be downloaded from the Project website and documentation supporting the SDRCs is available where appropriate.

9. Lessons learnt for future innovation Projects

9.1 Technical trials

9.1.1 New equipment implementation

Whilst the Project Team had expected to encounter communication issues with PLC and consequently were prepared to manage them, other unforeseen challenges occurred that impacted this area of the Project. Despite testing of the Esprit equipment by the equipment manufacturer, and widespread use of the PLC architecture in other uses such as smart meters, implementation as the Esprit Technology revealed problems that had never before been encountered.

The level of communications required by the Esprit Technology was higher than previous iterations of the PLC technology had implemented, taking longer to transmit and receive commands, and requiring more of them when the system was curtailing vehicle charging. When combined with the need to transmit over the distances required, necessitating a lower bandwidth signal and hence a further increase to the transmission period, the network was unable to maintain cohesion.

In the architecture deployed as the Esprit Technology, communications from the MC automatically overrode any signals from ICBs connected to the network. During a period of high network load requiring curtailment this could result in ICBs losing their connection to the MC or each other and not reconnecting.

This behaviour had not arisen during any tests or other uses prior to deployment on the trial networks and had not been anticipated. It could have been avoided had the clusters been deployed in a manner that allowed a reasonable period of testing to be undertaken between deployment of the first one or two clusters and the subsequent ones. This would have afforded the opportunity to identify the problem and resolve it prior to deployment of test equipment to subsequent clusters.

Future innovation projects are recommended to ensure that where new equipment that has not previously been deployed or deployed on the scale required for the Project, allow sufficient time for a period of thorough testing at a simulation facility prior to the first deployment and following this, implementation of necessary improvements before initiating widespread installation.

9.1.2 Powerline Carrier Communications

PLC was found to be effective for 65% of all measurements across the I²EV participants. The implementation of PLC – using sparsely populated networks with relatively long communication distances – is not capable of delivering highly reliable communication. A number of factors have been investigated to establish their impact on PLC:

- There is an exponential correlation between distance and reduced reliability of communications for the participants where distance could be isolated. However, the certainty of this correlation is low due to the relatively low number of participants.
- The system implemented by My Electric Avenue allowed units to relay messages along the LV network. It was found that increasing the number of units relaying messages increased communication reliability and allowed communication with participants at distances of up to 300 meters.
- The presence of cable joints on the network was not commonly found to influence PLC communication reliability across the trials. However, in one instance (South Shields 1) the PLC communication reliability was found to have failed as a result of a cable joint on the network.
- PLC communication reliability was shown to improve with an increase in the number of viable signal paths. However, the results were not comprehensive for high numbers of signal paths due to the sparsity of the networks.
- There was a strong correlation between the PLC communication reliability and the load on the network. PLC communication reliability was found to reduce with increased network load.
- Interference caused by solar photo-voltaic (PV) generation was not generally found to reduce PLC communication reliabilities. However for one participant there was indication of reduced communication capability when PV generation was occurring.
- There was no correlation observed between PLC communication reliability and EV charging.

My Electric Avenue has demonstrated the use of PLC on sparsely populated distribution networks. Communication reliability was found to be slightly lower than previous projects, reflecting the sparse nature of the PLC networks and the extended distances involved. Due to the number of factors shown to influence PLC reliability, it is recommended that future projects test PLC reliability before installation and only utilise the technology where a high proportion of customers are connected. Where a very high number proportion of customers cannot be connected, it is recommended that other communications technologies be researched and deployed.

9.2 Commercial learning

9.2.1 Bid Process

Intellectual property

During the process of developing, writing, managing and submitting the LCN Fund Tier 2 bid, it was apparent that the anticipated costs significantly underestimated the level of effort that would be required to complete the bid to a suitably high standard. The experience of the bidding process demonstrated that these projects carry non-recoverable costs and significant reputational risk for a third party. Ultimately, the main driver for a third party participating in these projects is to see their product / solution established in the UK market; short-term financial gain from the project is not a driving factor.

There is a real need to ensure that this fundamental driver is recognised in the process and that the value of IP for the third party is respected. The current process gives the appearance of threatening this fundamental driver for businesses to participate. The My Electric Avenue Project Team believe that it is appropriate for a third party to share an element of the 10% DNO compulsory contribution to ensure full alignment in the delivery of tier two projects under the LCN Fund (or NIC). The exact percentage split is likely to be both project and partner specific, but should be discussed between the DNO and the third party lead early in the process and be refined as required as the project is scoped throughout the bid process. In taking on this share of the risk, it is appropriate that any discretionary reward is also shared – again the exact share of this is likely to be determined on a project by project basis.

It is noted that Ofgem provide the ability for expenditure incurred in submitting an NIC bid to be recovered (up to a maximum of £175k or 5% of outstanding funding required) if the proposed project passes the ISP stage and is eligible for developing into a full submission. The use of this does allow bid preparation costs (or a portion of) to be passed through to the third party via contractual arrangements, therefore de-risking the likelihood of non-recoverable costs from bidding.

Avoiding unintended consequences

The Project Team felt that the impact of decisions made by Expert Panel had significant, unintended consequences to the overall ability of the Project Team to effectively manage risks. In this instance, information and clarification provided as part of the consultation process, supporting the bid, did not appear to have resulted in changes to the criteria when these were set for awarding the Project. This resulted in restrictions being imposed on the Project without opportunity for engagement with the Bid Team¹⁷ prior to publication.

The lack of dialogue prior to the Direction drafting resulted in real risk of the Project becoming undeliverable. Similarly, in our view, the requirement introduced to ensure learning was robust had the unintended consequence of creating a situation where although the Project Team felt there was a desire for flexibility by Ofgem there was limited scope for movement. Although this situation was recoverable, it is reasonable to expect that if the circumstances were repeated, a perfectly valid and valuable project could be prevented from coming to fruition.

Where changes to submitted project are required as a condition of the Project award, adequate time must be allowed to fully identify the impact to costs and anticipated timelines. If these changes affect the planned expenditure, the Project budget must be increased, or decreased, accordingly.

9.2.2 Commercial delivery

Communication pathways

The indirect relationship between EA Technology (the Project Lead) and Ofgem introduced both delays in responding to queries (in either direction) and increased the potential for mis-communication.

In future innovation projects, if a similar commercial approach to that undertaken within My Electric Avenue is utilised, it is strongly recommended that consideration is given to enabling direct communication between the Project Lead and the funding organisation.

Funding restrictions

There was some ambiguity in how customer recruitment was defined between the various stakeholders with severe implications on the availability of funding essential for continuation of the Project. The result of this ambiguity was the My Electric Avenue Project believing that customer recruitment targets had been achieved, whereas Ofgem were of the opinion that they had not. Ultimately, the Project exceeded the recruitment requirements but a significant financial risk was taken by EA Technology to enable this to happen.

This situation must be avoided in future and can be achieved by ensuring that where restrictions on the use of funding or project continuation are implemented, the criteria by which the requirement will be deemed to have been met must be clearly defined, understood and agreed by all signatories.

Assigning liabilities

There was no problem experienced by the Project Team in relation to realised liability, however the risk taken as a consequence of the funding restrictions imposed (discussed above) identified an area for consideration in future projects of this nature.

If the intention at the outset of project development is for a partnership working approach between the DNO and Project Lead, the initial agreements prior to submission of the Project Bid should include a defined allocation of future liabilities relating to the Project. A reasonable starting position for this agreement is suggested as the split agreed for the compulsory contribution.

¹⁷ The Bid Team refers to the individuals across EA Technology and SSEPD involved in the formulation and submission of the bid for the My Electric Avenue (I²EV) Project to Ofgem's LCN Fund.

10. Project replication

In order to replicate the My Electric Avenue Project, the commercial arrangements, physical components and knowledge detailed below are required. If details beyond those provided are required, please contact futurenetworks@sse.com or myelectricavenue@eatechnology.com.

Table 4 Project replication requirements

Component	Details
Commercial elements	
Principal contract	<p>The principal contract between the funding DNO and the Project Lead must specify as a minimum the:</p> <ul style="list-style-type: none"> • Project requirements or link to the Project Direction; • Clearly outline the areas of responsibility being delegated by the DNO to the Project Lead; • Detail the arrangements of risk and liability allocation; • Outline areas of responsibility and accountability. <p>Further requirements are detailed in SDRC 9.2 & 9.3.</p>
Sub-contract	<p>The sub-contracts between the Project Lead and Projects Partners and suppliers must replicate the principal contract, passing down the appropriate risks and rewards relating to the specific deliverables to the respective organisation.</p>
Management and delivery document	<p>The management and delivery document functions as the single overview source for the Project commercial elements. It details the overall project hierarchy, lines and areas of responsibility and names the key individuals in each organisation.</p> <p>Detailed explanation of this document is available in SDRC 9.2.1, Supporting Guidance for the Project’s novel commercial arrangement. Both this and the management and delivery document utilised by My Electric Avenue are available for download on the Project website¹⁸.</p>
Technical elements	
Monitor Controller (MC)	<p>The monitor controller is to be installed in the substation with access to all phases of the feeder in question.</p> <p>It must meet the following high level specification:</p> <ul style="list-style-type: none"> • Ability to monitor the current on each phases of the feeder (CTs were used in My Electric Avenue) • Capability to receive and inject PLC into all three phases of the feeder (G-clamps were used) • A micro-processor board to process the current readings and the Esprit algorithm; • Internal storage to record current readings monitored by the MC and data provided by the ICBs; • Available connection to a method of transmitting data on the feeder and connected ICBs to a central database. <p>The MC was connected to a set of dedicated measurement devices (CTs, CMTs or Rogowski Coils).</p>

¹⁸ <http://myelectricavenue.info/project-deliverables>

Component	Details
Intelligent Control Box (ICB)	<p>The ICBs were installed in series with the charging points provided to each of the technical trial participants.</p> <p>The individual units were capable of monitoring the voltage and current being drawn, and reporting this via PLC to the monitor controller.</p> <p>In addition, the ICBs contained a relay controlled by an internal micro-processor, capable of disconnecting the charging point from the supply when requested by the MC.</p>
Nortech Envoy	Each MC enclosure contained a Nortech Envoy unit that received the data on the feeders and ICBs from the MC and transmitted the data back to Nortech’s servers.
Nortech iHost	Nortech’s iHost system was utilised to access and display the data for quick analysis purposes or to download the data to the Project’s central data server.
Rail350 Monitoring Unit	Northern Design Metering Solution’s Rail350 units were used to provide an independent monitoring solution to the MC. These connected into the Nortech Envoy unit within the MC enclosure and the iHost system for data transmission purposes and access purposes. The Rail350 was connected to a set of dedicated measurement devices (CTs, CMTs or Rogowski Coils).
Current Transformer (CT) Current Measurement Transducers (CMTs) Rogowski Coils (RCs)	CTs, CMTs or Rogowski coils were utilised on a site specific basis to enable monitoring of the feeder load along each phase. The determining factor was generally the available space within the substation, specifically, which device could be fitted around the individual phases.
Charging Point	Charging points were installed at each of the premises for the technical trial participants, connected to an ICB.
Electric Vehicles	<p>The model of EV utilised in the My Electric Avenue Project was the Nissan LEAF Mark 2. These vehicles contained a 24kWh battery with a standard charger circuit rated at 3.5kW.</p> <p>In addition, the vehicles provided were all of a minimum ‘Accenta’ specification in order to enable the Nissan CARWINGS system. This provided the Project with charging and usage information of the vehicle.</p> <p>Other electric vehicles could be utilised in a future Project of this nature, but verifying that the vehicle manufacturer can provide this level of vehicular information in preference to procuring additional monitoring hardware is recommended.</p>
Esprit Algorithm	<p>The Esprit algorithm was embedded within the software within the monitor controller. The algorithm determined when and which ICBs to contact and curtail on each network, based on the thresholds determined by the Project Team.</p> <p>Any algorithm implemented must be capable of monitoring the network load in real time, tracking the devices connected to the network that the system is capable of controlling and processing the data to determine whether curtailment is required.</p>

The costs associated with replicating the commercial arrangement are inherently project specific and so cannot be expanded further here. The Project Team would direct the reader to SDRC 9.3.3, SSEPD’s evaluation of the Project’s Delivery by a third party, detailed within the SDRC 9.2 & 9.3 report for further explanation of the potential benefits.

During the bid submission process, EA Technology outlined a target cost of deploying Esprit under business-as-usual conditions of £2,000 for an individual LV feeder. The Project has generated no learning that requires an update to this estimate although it is noted that the assumptions this estimate relied upon remain in force. These assume that economies of scale are applied to bulk orders, the cost of raw materials is unchanged as would cost of manufacturing by third parties; each of these factors lie outside the control of EA Technology.

11. Planned implementation

11.1 Are the Methods ready to be implemented?

This section covers whether the Methods are ready to be implemented, as well as whether SSEPD plans to modify its Distribution System based on learning from the Project.

Commercial

Based the findings from the Project , EA Technology and SSEPD feel that the Commercial method is ready for implementation, with only minor contractual modifications required by the DNO, third party and funding body (for an innovation project) to optimise the working practice. These recommendations are detailed in SDRC 9.2 & 9.3. As a result, there are no changes needed to our Distribution System.

Technical

The outcomes have shown that whilst the Technical method is capable of monitoring and managing EV charging during periods of peak demand and was accepted by customers, it is not yet ready for BAU deployment on the distribution network. After considering the findings from the trials and understanding of current industry practices a number of areas require further work, such as communications mediums, communications and charging protocols, and integration. It left the technology in TRL 8 and so a project building on the findings and aiming to refine the issues identified will be undertaken to progress it to an operationally and commercially viable solution. Further details are listed in the below sections.

11.2 Is any further work required?

Commercial

As mentioned, awareness of contractual implications is required but otherwise the method is ready to be implemented.

Technical

The Project Team has found that whilst capable of delivering the core requirements of monitoring and managing the EV load on the networks, the operation of the system was not consistent enough for the level of resilience and reliability required for a BAU distribution network control mechanism. There were issues during the Project with the unreliability of PLC for communicating control signals, and further work is needed on the control algorithm and logic for controlling EV curtailment. As a result the following activities would need to be carried out:

1. Integration with an effective communications system to ensure that reliability reaches levels similar to other existing network control mechanisms. The communications medium should be capable of sending and receiving signals over the distances typically seen in LV circuits without the need for signal boosters or resulting in deterioration of reliability. Action required by: technology provider.
2. Refine the control software and logic to incorporate factors such as an EV's state of charge and customers' requests for minimum state of charge by certain times. This would raise the effectiveness and quality of service provided by the system and further support customer acceptance. The logic requires rethinking for commercial customers, as it is currently not practical for those with flat load profiles, however it could be decided this is simply one solution where the technology is not the most appropriate solution. Also, as reported in SDRC 9.7 the integration of real-time cable thermal models into the control algorithms would likely refine the curtailment activities and so reduce the overall impact to customers, further improving acceptability. Action required by: technology provider.
3. Integrate the technology with charging points. This would allow the communication and computing functionality of the charging point to continue operating (presently the technology cuts power to the charging point), maintaining user satisfaction and minimizing disruption to charging point technology. Action required by: technology provider; EV charging point manufacturers.
4. Agreement of a standard protocol for communicating with charging points. This would greatly improve the operability and adoptability of the solution. Action required by: DNOs; technology provider; EV charging point manufacturers; EV manufacturers; policy makers.

11.3 Likelihood method(s) will be deployed on large scale in future

Commercial

With the Project a success, and SSEPD's ability to deliver a large portfolio by effectively outsourcing its management and delivery proven, SSEPD is already in discussions with another third party looking to lead an innovation project on their behalf. With the contract templates available and reporting of the key clauses and areas to include or challenge, SSEPD believes that all other DNOs should look to adopt this approach moving forward. This is subject to all parties being satisfied that the recommended contractual changes are in place, or that they are prepared to accept the risks which have been highlighted in SDRC 9.2 and 9.3.

Technical

The rapid increase in the number of plug-in vehicles being driven in GB, combined with the clustering effect seen for adoption of low carbon technologies and load analysis from this project, means that a solution for managing peak EV charging demand will ultimately be required across a significant number of networks in GB. As mentioned, there are still refinements to be made, however once these have been made a solution that provides ability to control EV charging in response to threats to network infrastructure will certainly be utilised where it is deemed the most cost-effective and appropriate method: which is potentially on hundreds of thousands of circuits.

11.4 Recommendations on how outcomes could be exploited further

Commercial

In an effort to increase both the number of third parties leading innovation projects and the number of SMEs operating under innovation funding, Participants can raise awareness of the fact that an SME has successfully managed and delivered an LCN Fund project and request that more projects look to adopt this approach to deliver value for money for customers (fewer permanent DNO staff costs and overheads beyond the Project) and stimulate more interest in advancing the low carbon economy.

Technical

The technology was at Technology Readiness Level (TRL) 4 when we commenced an IFI project in 2012, having been previously validated in a laboratory environment. The Project then undertook the first trial of the technology on a live LV network, proving its capabilities in a relevant environment by communicating and switching loads between a transformer and several properties nearby. This progressed the technology to TRL 6 during the bid submission process for My Electric Avenue, and highlighted a number of areas requiring further work to progress towards BAU. When My Electric Avenue began in 2013 the further large scale trials on multiple LV networks successfully demonstrated the technology's capabilities in operational environments, and the system was refined and successfully qualified as being a success during 2014-2015, progressing to TRL8. The technology is now at a point where refinements to switching logic, integration with charging points and communications capabilities should allow it to make the final step into BAU and become commercially and operationally viable.

The need to clarify the commercial model that will be used to roll out this type of DSR solution is critical to support any investment in the solution, specifically the manner in which the DNO can communicate with a range of downstream chargers (of differing manufacturers) when network constraints occur.

SSEPD and EA Technology are once again attempting to progress the capabilities of the technology and its commercial viability for GB-wide deployment to aid all DNOs, and in turn GB customers, by embarking on the NIA project referenced in Section 4.5 in March 2016.

12. Dissemination of learning

Learning has been shared by the Project Team using multiple methods throughout the three years of the Project and beyond.

The Project’s dissemination strategy utilises various communication channels to embed project learning amongst the GB DNOs, to boost awareness and publicity around the Project, and to engage customers and other stakeholders. External dissemination of the SDRCs follows a planned schedule of email dissemination to a 500-strong list of relevant sector stakeholders – spanning both the utility and automotive sectors. A press release is scheduled where appropriate and shared on social media to achieve maximum coverage (Twitter and LinkedIn groups). Other core dissemination activities include:

Finale event

The Project Team hosted a finale event at The Institution of Mechanical Engineers to companies spanning the energy and automotive sectors. This event was used to disseminate key Project learning to a wide audience and help inform the sectors involved in enabling the decarbonisation of the UK’s energy and transport infrastructure.



Figure 19 – My Electric Avenue Finale Event

DNO trans-departmental learning events

The final results and learning have been shared amongst all interested DNOs following publication of the SDRCs. These events were delivered as learning workshops, with content tailored to respond to key questions or areas of interest raised in advance by the respective attendees. This approach also informed the content of the Close-Down Report, shaping it to cover specific areas. This will enable the DNO to apply project learning to support transition to a low carbon economy through knowledge transfer of electric vehicle impact on local electricity networks and need for, and options for, solutions to mitigate impact to the direct benefit of the DNO and its customers.

Industry events



Figure 20 – My Electric Avenue LCNI 2013

My Electric Avenue has been presented and represented at a multitude of industry events. These include the IPT, Cenex LCV, IET HEVC, IET Electric Vehicles, Cholmondeley Pageant of Power, amongst others. This illustrates the reach outside of the traditional LCNI area, in recognition of the import of the small yet critical overlap between the utilities and automotive sectors. Every representation of the My Electric Avenue project to these audiences has delivered learning on the impact of EVs on the networks, and developed understanding with the automotive sector of this learning.

Meetings

Ofgem, SSEPD, DECC, OLEV other DNOs – a strategic schedule of meetings has been undertaken to share learning and engage with key personnel in order to understand how best to embed learning.

Transform Model®

The Transform Model® was used as one of the investigative tools providing input to the SDRC 9.7 and 9.8 reports. Consequently, the GB dataset of the Transform Model® has been provided with the latest available information related an Esprit type technology and revised EV charging behaviours, (for 3.5kW domestic charging capability). These will be submitted to the Smart Grids Forum for consideration for inclusion to the Transform Model® as part of the next Governance Review. If the domestic charging profiles are accepted for incorporation to the Transform Model®, they will be updated into the WinDebut™ LV design software owned by EA Technology.

Project Progress Reports

The six-monthly Project Progress Reports issued in accordance with LCN Fund requirements have provided details of learning and project progress every six months.

Conference papers

Project partners De Montfort University and University of Manchester, as well as EA Technology, have presented papers at national and international events such as CIREC and HEVC.

Events

Progress, learning and results from the Project have been shared annually at the LCN Fund, now LCNI annual conferences since 2013, with My Electric Avenue presenting findings to the largely DNO audience.

Newsletters

Project newsletters have been sent out to 500 stakeholders on a quarterly basis and may be accessed on the Project website¹⁹.

PR

Key media including the BBC, Independent, Guardian, energy and automotive press have attended press briefings for key project events such as the launch in 2013, and a dedicated press briefing in advance of the Project's finale event in December 2015.

Press releases

Press coverage has been achieved in over 300 media, covering sector, trade (engineering, automotive, energy), national and international press. Press releases are sent out through Newspress (5,000 recipients) and utility / energy sector press contacts list of c.50.

Social media

International coverage through strategic use of Twitter and LinkedIn.

Newsletters to trialists

The Project Team has engaged extensively with its customer trialists to invite feedback on the customer experience through technology installation, vehicle deliveries, and decommissioning. Any feedback has been passed on to relevant project partners or contractors to support continual improvement in process and design of pertinent project stage.

Webinars²⁰

The Project Team has hosted a series of webinars focusing on both the network and automotive perspectives. One of the automotive sessions provides an insight into EV charging and driving behaviours, based on over 200 real customers, perceptions of EVs and of controlled charging. The prior research into this webinar included a survey of the automotive sector and supply chain (charging point manufacturers etc.) for their views on remote control of EV charging. These views were then fed back to the DNO and automotive community through the webinar. The University of Manchester supported a project webinar on the Esprit Technology as a means to manage EV demand. The webinars have been a key tool in reaching a wide audience, inviting and utilising feedback from customers and industry, whilst providing excellent value for money.

Videos²⁰

A series of EV test drive videos, using real customers, galvanised recruitment at the start of the Project.

¹⁹ <http://myelectricavenue.info/news>

²⁰ <http://myelectricavenue.info/media-library#overlay-context=faqs>

Filmed interviews²⁰

These have included Robert Llewellyn interviewing project lead EA Technology and partners for an edition of Fully Charged, Energy News Live's coverage of the final EV cluster, and more recently in September 2015, EA Technology were interviewed²¹ by Robert Llewellyn at Cenex LCV2015. This films support ready access to project learning cross-sectorally, and with electricity network customers on a global scale.

Top Ten Tips Series²²

This series, covering topics from customer engagement, novel commercial arrangements and trial installations, to data monitoring and data management, has been lauded by Ricardo, the Project's independent reviewer, as an exceptional output for the Project. Accessible and readily transferable across project portfolios and sectors, these 'how to' snapshots enable uptake in learning and are testament to My Electric Avenue's pioneering approach to learning dissemination. The Tips have been disseminated via LCNI conferences and others e.g. Cenex LCV2015.

Cross sector liaison

My Electric Avenue may be unique amongst LCNI projects in that it has engaged directly and deeply with the automotive sector and others, gaining traction in reputation as an authority on the issue that EVs pose to electricity networks. The Project Team is seen as the 'go to' source of learning in the utility-automotive sector overlap. Meetings have been held with SMMT, LowCVP, OLEV, BEAMA, Northwest Automotive Alliance, Nissan, Tesla, Institution of Mechanical Engineers, Industry and Parliament Trust amongst others.

Customer liaison

Tailored newsletters have been sent to clustered customers on the trial programme on a monthly basis, informing customers of project progress, learning, and inviting feedback. A dedicated video for customers was produced in November 2015, to thank them for participation and reveal the final project learning and results. The cluster champions were invited to the final event on 3 December. Customers have always been at the heart of the My Electric Avenue project, and it is anticipated that the learning will further disseminate via the ripple effect through conversation, press and social media to support understanding of the impact of EVs on the local electricity networks, and to embed the findings that there are solutions available to support both the networks and automotive sectors in the transition to a low carbon economy. It is imperative that customers are on board with this message and My Electric Avenue has recognised this and acted in support of this from the outset.

Applied new learning

Following completion of all recruitment-related Successful Delivery Criteria (9.5) in August 2014, other projects being considered by local councils and engineering consultancies were looking to My Electric Avenue for advice on how best to engage with the public.

²¹ <http://www.nwautoalliance.com/news/event-review-cenex-low-carbon-vehicle-event-2015-and-why-you-need-to-book-now-for-next-year/>

²² <http://myelectricavenue.info/top-tips>

13. Key Project learning documents

All of the below documents are available to download on the Project website (www.myelectricavenue.info), with direct hyperlinks provided for each report.

Summary Report

A brief report summarising the key Project Outcomes and Learning.

<http://myelectricavenue.info/sites/default/files/My%20Electric%20Avenue%20%28I2EV%29%20-%20Project%20Summary%20Report.pdf>

SDRC 9.1 – Learning from the bid submission process

A report outlining the key learning realised from the bid submission process.

Recommendations were made to improve future bids for innovation funding, irrespective of whether or not DNO or third party leads the submission.

Further recommendations were made that are specific to bid submissions similar in commercial scope to the My Electric Avenue (I²EV) Project.

http://myelectricavenue.info/sites/default/files/My_Electric_Avenue_%28I2EV%29_-_SDRC_9_1_Learning_from_bid_process_v_1_For_Issue_0.pdf

SDRC 9.2.1 – Initial contractual templates

This SDRC consisted of several files, including the initial contractual templates under which the My Electric Avenue Project was established. The contractual template has since been revised as part of the contract review towards the end of the Project but the originally published document remains available for reference purposes on the Project website. However it is deliberately not included in the suite of documents published at Project Completion due to it being superseded by SDRC 9.2.3.

- Supporting Guidance for the Project’s novel commercial arrangement:
http://myelectricavenue.info/sites/default/files/SDRC%209.2.1.%20Supporting%20Guidance%20for%20the%20I2EV%20%28My%20Electric%20Avenue%29%20Novel%20Commercial%20Arrangement%20-%20Issue%201.0_0.pdf
- Management & Delivery Document:
<http://myelectricavenue.info/sites/default/files/Annex%201%20-%20I2EV%20%28My%20Electric%20Avenue%29%20Management%20and%20Delivery%20Document%20-%20Issue%201.0.pdf>
- Initial contract template:
<http://myelectricavenue.info/sites/default/files/Annex%202%20-%20I2EV%20%28My%20Electric%20Avenue%29%20-%20Principal%20Contract%20Template%20-%20Issue%201.1%20-%20Superseded.pdf>
- Task Order Template:
<http://myelectricavenue.info/sites/default/files/Annex%203%20-%20I2EV%20%28My%20Electric%20Avenue%29%20-%20Supporting%20Guidance%20-%20Task%20Order%20Template.pdf>

SDRC 9.2 & 9.3 – Commercial learning report

This report details the learning focussed on the commercial elements of the Project. Specifically, it includes:

- A review, undertaken towards the end of the Project, of the contract established between EA Technology and SEPD and published under SDRC 9.2.1. This focussed on what worked well, what didn't, and subsequent recommendations for improving the commercial arrangement for future projects. These recommendations were then incorporated and published under SDRC 9.2.3;
- Details of the processes established throughout the Project to enable effective Project delivery;
- Templates of specific forms and reporting methods utilised through the Project;
- A framework process and associated templates to enable suggestions relating to the update of SSE policies and / or procedures to be submitted and processed. These can be implemented into business-as-usual processes by other DNOs as well;
- An assessment from SEPD of the level of effort expended on Project Management of the My Electric Avenue (I²EV) Project in comparison to other innovation projects.

<http://myelectricavenue.info/sites/default/files/My%20Electric%20Avenue%20%28I2EV%29%20SDRC%209.2%20%26%209.3%20Issue%20v2.3.pdf>

SDRC 9.2.3 – Updated contract template

An updated contractual template, based on the contract implemented between EA Technology and SEPD at the start of the Project, incorporating the changes identified through the duration of the Project.

This template is intended to be utilised as a starting point for future innovation projects implementing a similar commercial arrangement to the My Electric Avenue Project.

<http://myelectricavenue.info/sites/default/files/My%20Electric%20Avenue%20%28I2EV%29%20SDRC%209.2.3%20-%20Principal%20Contract%20Template%20-%20Issue%202.1.pdf>

SDRC 9.4 – Independent Project reviews

A collection of the six independent reviews of the Project undertaken by Ricardo and the Project Team's responses to the recommendations made.

The reviews encompassed all levels of the Project, from Ofgem's governance procedures to the site-work documentation. Constructive recommendations provided where appropriate to improve the outputs or effectiveness of My Electric Avenue and future Projects.

- Month 6
http://myelectricavenue.info/sites/default/files/SDRC%209%204%201%20I2EV%20%28My%20Electric%20Avenue%29%20Month%206%20Independent%20Review%20Issue%201.0_0.pdf
- Month 12
http://myelectricavenue.info/sites/default/files/SDRC%209%204%201%20I2EV%20My%20Electric%20Avenue%20Month%2012%20Independent%20Review%20v1.3_0.pdf
- Month 18
<http://myelectricavenue.info/sites/default/files/SDRC%209%204%201%20I2EV%20My%20Electric%20Avenue%20Month%2018%20Independent%20Review%20v1.2.pdf>
- Month 24
<http://myelectricavenue.info/sites/default/files/SDRC%209%204%201%20I2EV%20My%20Electric%20Avenue%20Month%2024%20Independent%20Review%20v1.1.pdf>
- Month 30
<http://myelectricavenue.info/sites/default/files/SDRC%209%204%201%20I2EV%20My%20Electric%20Avenue%20Month%2030%20Independent%20Review%20Issue%201.pdf>
- Month 36
<http://myelectricavenue.info/sites/default/files/SDRC%209.4.1%20I2EV%20%28My%20Electric%20Avenue%29%20Month%2036%20Independent%20Review%20Response%20Issue%201.0.pdf>

SDRC 9.6 – Socio-economic analysis

Analysis of the public acceptance of the implementation of Esprit or similar DSR technology, specifically related to the effect on the use of EVs.

This analysis compared the experiences of trial participants on the technical trials whose vehicle charging was affected by the Esprit Technology with those on the social trials whose charging was not changed in any way.

<http://myelectricavenue.info/sites/default/l²Eves/MEA%20SDRC%209%206%20Issue%202.pdf>

SDRC 9.7 – An assessment of technology integration

An evaluation of the most appropriate methods of integration for Esprit or similar style technologies depending on the end application, e.g. EVs or heat pumps. This SDRC was delivered through a suite of four reports, covering:

- The capability of the Esprit Technology to integrate with the distribution network;
http://myelectricavenue.info/sites/default/files/86002_8_R_SDRC%209.7%20Issue%202.pdf
- The benefits Esprit can provide to network voltage levels;
http://myelectricavenue.info/sites/default/files/86002_8_R_Flicker%20Analysis%20SDRC%209.7%20Issue%204.pdf
- The impacts Esprit may have on heat pumps;
http://myelectricavenue.info/sites/default/files/86002_8_R_HeatPumpImpactEsprit_Issue%20%20non-confidential.pdf
- The benefits Esprit can provide to cable thermal ratings.
http://myelectricavenue.info/sites/default/files/86002_8_R_Cable%20Thermal%20Rating%20SDRC%209.7%20Issue%204.pdf

SDRC 9.8 – An assessment of achievable network benefits

This report draws on analysis of the data gathered throughout the Project from the Nissan LEAFs driven by the trial participants and the Esprit equipment installed across the trial locations.

This analysis informed and refined network models to enable the derivation of:

- Estimated thermal and voltage headroom achievable through the use of Esprit;
- Potential financial and carbon savings through the use of Esprit;
- An updated solution template, applicable to Esprit, for the Transform Model[®].

<http://myelectricavenue.info/sites/default/files/My%20Electric%20Avenue%20%28I2EV%29%20SDRC%209.8%20Issue%201.4.pdf>

Additionally, a report expanding learning related to the effective use of PLC was generated to inform the primary SDRC 9.8 report.

<http://myelectricavenue.info/sites/default/files/PLC%20Communication%20Reliability%20Report.pdf>

Network modelling reports

A suite of five reports delivered by the University of Manchester providing:

- Details and analysis of the models created and used for the purposes of analysing the Project data;
 - WA1: http://myelectricavenue.info/sites/default/files/UoM-EA-Technology_MEA_Deliverable1.1-1.3v01.pdf
 - WA2: http://myelectricavenue.info/sites/default/files/UoM-EA-Technology_MEA_Deliverable2.1-2.3v03.pdf
 - WA3: http://myelectricavenue.info/sites/default/files/UoM-EA-Technology_MEA_Deliverable3.1-3.4v05.pdf
- Analysis of the data generated by the models, enabling estimation of the potential benefits Esprit can provide to the networks.
 - WA4: http://myelectricavenue.info/sites/default/files/UoM-EA-Technology_MEA_Deliverable4.1-4.2v03.pdf
 - WA5: http://myelectricavenue.info/sites/default/files/UoM-EA-Technology_MEA_Deliverable5.1-5.2v04.pdf

Top Ten Tips Series

The My Electric Avenue Project has produced a series of ‘Top Ten Tips’ covering a wide range of topics to benefit future projects based on the learning generated. The series comprises:

- Customer Engagement
- Procuring Partners
- Novel Commercial Arrangements
- Customer Recruitment
- Trial Installations
- Data Management
- Database Management
- Data Monitoring
- Trial Decommissioning
- Managing EV Uptake

<http://myelectricavenue.info/project-learning>

Project progress reports

The project progress reports, issued to Ofgem at six month intervals, summarising progress and key developments:

- January 2013 - June 2013
<http://myelectricavenue.info/sites/default/files/12EV%20Project%20Progress%20Report%20June%202013%20%28public%20version%29.pdf>
- July 2013 – December 2013
<http://myelectricavenue.info/sites/default/files/12EV%20Project%20Progress%20Report%20December%202013%20Public%20Version%20Issue%201.2.pdf>
- January 2014 - June 2014
http://myelectricavenue.info/sites/default/files/12EV%20Project%20Progress%20Report%20June%202014%20%28non-confidential%29_1.pdf
- July 2014 – December 2014
http://myelectricavenue.info/sites/default/files/12EV%20Project%20Progress%20Report%20December%202014_0.pdf
- January 2015 - June 2015
<http://myelectricavenue.info/sites/default/files/12EV%20PPR%20June%202015%20v1.0%20-%20Complete%20%28non-confidential%29.pdf>
- July 2015 – December 2015
<http://myelectricavenue.info/sites/default/files/12EV%20Project%20Progress%20Report%20December%202015%20Issue%201.1%20redacted.pdf>

Esprit White Paper

A Technology White Paper setting out EA Technology’s vision for Esprit, based on the key finding from My Electric Avenue.

<http://myelectricavenue.info/sites/default/files/Esprit%20White%20Paper%20Issue%202.pdf>

Method Statements

Method statements detailing installation and decommissioning for the Project’s trial equipment.

- Esprit MC (GMT)
<http://myelectricavenue.info/sites/default/files/Esprit%20Installation%20GMT%20Method%20Statment%20v%202.0.8.pdf>
- Esprit MC (PMT)
<http://myelectricavenue.info/sites/default/files/Esprit%20Installation%20Method%20Statement%203.1.5%20PMT.pdf>
- Esprit ICB
<http://myelectricavenue.info/sites/default/files/ICB%20Method%20Statement%206.3.pdf>
- Rail350 GMT
<http://myelectricavenue.info/sites/default/files/Esprit%20Rail%20350%20Method%20Statement.pdf>
- Rail350 PMT
<http://myelectricavenue.info/sites/default/files/Esprit%20Rail%20350v%20PMT%20Method%20Statement.pdf>

14. Peer Review

Western Power Distribution (WPD) agreed to undertake the peer review of the My Electric Avenue Project's Close-Down Report providing a commented version and brief notes on key observations on 11th March 2016.

These comments and recommendations have been incorporated into this final version, and both EA Technology and SEPD are grateful to WPD for their undertaking of the peer review.

The letter from WPD containing the brief notes on the overall report is included in Appendix IV. They have since confirmed that they are satisfied the final version of the report addresses their points (Appendix V).

15. Contact details

The following contacts are best placed to provide access to the Project's learning and/or documentation.

SEPD

Richard Hartshorn, Communications and Outputs
Manager

55 Vastern Road, Reading, Berkshire, RG1 8BU

e-mail: futurenetworks@sse.com

tel: 01189 534 163

web: www.ssepd.co.uk/innovation

EA Technology

Tim Butler, Senior Consultant, Smart Interventions

EA Technology, Capenhurst Technology Park,
Capenhurst, Chester, Cheshire, CH1 6ES

e-mail: timothy.butler@eatechnology.com

tel: 0151 347 2173

web: www.eatechnology.com

Appendix I The Esprit Technology

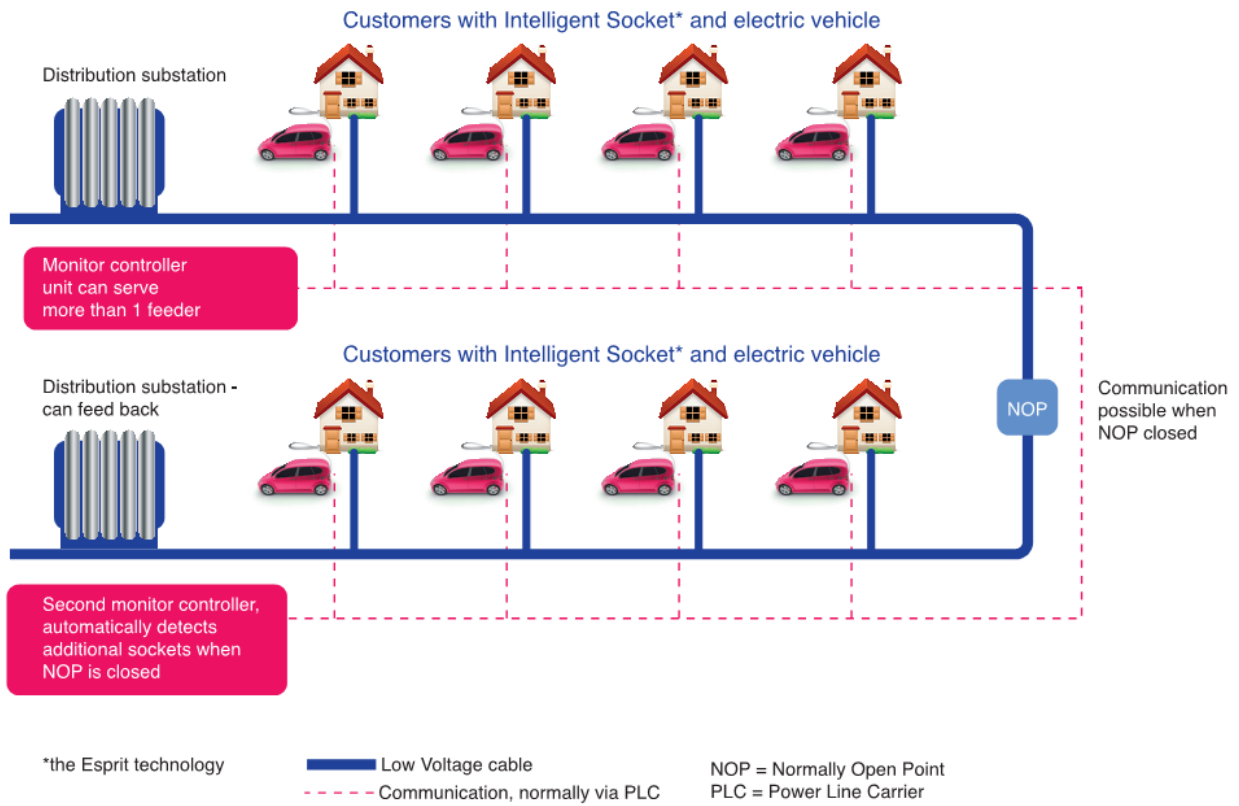


Figure 21 – Overview of the Esprit Technology

Appendix II Further information on technical trials

Technical Trial Equipment Installation (reference section 3.3.1)

Monitor Controller (MC)

The function of the MC was to monitor the LV feeder phase currents and issue switching commands to each Intelligent Control Box (ICB) to protect the local network from overload. The switching priority of ICBs was determined by an ICB charging priority table, calculated by the MC control logic algorithm at the end of every switching cycle and based on the energy drawn by each ICB in recent hours. The MC was located within an 11 kV/400V substation, with one for each EV technical trial cluster.

The monitoring enabling technology consisted of Current Measurement Transducers (CMTs) (Rogowski Coils (RCs) or Current Transformers (CTs) and Voltage Measurement Terminals (VMTs) located on the LV feeder phase conductors and busbars respectively. In the technical trial, the MC voltage measurement terminals consisted of either bus bar mounted G-Clamps, Service Insulation Piercing Connectors (SIPCs) for Overhead Lines (OHLs) or split ring voltage terminals. The communication enabling technology consisted of a Nortech Envoy Communications Hub (ECH) and Power Line Communication (PLC) injection points, which doubled as the MC VMTs. The ECH allowed data to be uploaded to an iHost website, which allowed monitoring of Esprit performance, participant charging behaviour and the uploading of trial data. The PLC injection points enabled PLC signals to be sent along the LV feeder cable, both to and from the ICB units.

For ground mounted and pole mounted installations, the MC and ECH were housed in wall or pole mounted IP66 rated enclosures, as shown in Figure 13. Installation of the CMTs and VMTs was straight forward in ground mounted substations with open busbars, as ease of access to bus bars and phase conductors was available. In one of the ten substations used in the Project, the bus bars were shrouded and a network outage was required to remove the busbar shrouding and fit the CMTs and VMTs. This was carried out ahead of the MC enclosure installations. Where installation of a metal enclosure introduced a touch potential hazard, a Class II MC enclosure was used to eliminate any risk of electric shock.

Installation on the rural OHL cluster involved the design and fabrication of a bespoke mounting bracket to allow pole mounting of the MC Enclosure. SIPCs were used as VMTs, with fuses housed in a IP66 rated box, situated as close to the SIPs as possible. Care had to be taken to allow enough cable length for the CMT and VMT leads, as the final position of the MC enclosure was not known before installation. The equipment was installed by an OHL team, who found no issue with installing the test equipment under their normal working practices.

Rail350 current monitors were installed to support the monitor controller phase current data collection. This was required due to the MC phase current data output ceasing due a bug in the MC firmware but they are recommended to be used as standard in future innovation projects.

Ten Off the Shelf (OtS) current monitors, of the Rail350 type, were procured and wired at EA Technology during January 2015. Preparation and deployment of these devices took place in a short amount of time, with installation across all ten EV trial cluster occurring within 3 – 4 weeks.

The Rail350s remained in place for the remainder of the test trial period and in all but one instance performed without issue.

In general, preparation and coordination of the substation teams was straightforward, with minimal on-site issues. Some lead time issues with method statement approval from the funding DNO SEPD were encountered, primarily due to the bespoke nature of the work and the unfamiliarity of the I²EV team with SEPD internal working practices.

Intelligent Control Box (ICB)

The ICB's role was to accept and implement switching commands from the MC and report back information on the charging history of the EV to the MC. Each ICB was located between the consumer unit or distribution board and the Charge Point (CP) within the participant's premises.

The approach taken to the ICB installation was very different to that of the Monitor Controllers. Because of the geographical spread of the MEA EV trial clusters, any installation work needed to be carried out and completed within a 2 to 3-day window for each EV cluster, to minimise travel and accommodation costs. To achieve this, a large amount

of coordination time and effort was expended by the Project Partner, Zero Carbon Futures in order to ensure access to all participating properties on a cluster LV feeder in one visit to the cluster.

Due to the bespoke nature of the ICB units, provision of briefing and training to the electricians was essential. This allowed the electricians to install the equipment in the minimal amount of time and to the standards required by the Project. Electricians were supervised during the first three cluster installations and then allowed to install unsupervised for the remaining EV trial clusters. Documented evidence of installation was a Project requirement for all installations, with forms being provided to electrical contractors in each instance, supplemented by photographic evidence of a successful, and professional looking installation.

In general, documentation control for the initial ICB installation proved challenging, due to the number of different electricians used and the initial misunderstanding of the importance of document control, when installing prototype test equipment, on the part of the electricians. This situation improved with experience throughout the trial.

PLC Support Equipment

Three EV trial clusters faced PLC attenuation issues, due to long cable lengths (for PLC signals) between communicating devices. This issue was alleviated through the use of 'Repeater Units' (RUs); devices that pick up an attenuated PLC signal, from the MC or an ICB, and retransmit the PLC signal at an increased transmission strength.

Installation of RUs was technically possible in domestic properties, if a resident of the property was connected to the correct phase and willing to host the unit. Unfortunately, this approach did not prove possible due to lack of suitable volunteers and consequently street furniture was required for the deployment of the necessary RUs. Only one site, Wylam, had accessible street furniture, which therefore led to a lower cost and shorter lead time for installation.

The remaining two EV trial clusters required street furniture to be developed and commissioned, each using a different method; one utilised a Smart Link Box (SML) and the other an In-Ground Retractable Power Pillar (IGRPP). In-ground housing was selected due to issues of low acceptability by the residents of the specific cluster in respect to the visual impact of an above ground housing, despite its temporary nature. Lead times in the development and procurement of in-ground housing took many months, though on-site installations were completed without issue.

Technical Trial Equipment Operation (reference section 3.3.2)

ICB Recall and Reinstallation

The switching behaviour of the ICBs was reported to the MC by each ICB and depended on a good connection to the LV network. Some deployed ICB units communicated poorly with the MC throughout the technical trial's initial months and were subsequently investigated to ascertain the cause of the problem. Upon inspection, one ICB was found to have a wiring fault affecting the communications with the MC.

To mitigate the risk of other potential faults existing, all ICBs were bypassed whilst a redesign was developed to simplify the installation process; avoiding the need for the electrical contractor to access the ICB internal circuits and reducing the likelihood of future problems. Spare ICBs procured at the outset of the Project were the first to be remanufactured and were deployed to replace units in the Marlow cluster. These replaced units were subsequently remanufactured to adhere with the new design specifications before being deployed to another cluster; this process repeated until a staged refurbishment of the units was completed throughout the Project. The redeployment utilised the lesson learned from the initial ICB roll-out and was successful, with none of the initial problems relating to either the documentation or installation resurfacing.

Power Line Communications

Several examples of PLC issues occurred throughout the Project. The causes of these issues can be grouped into two main classes; 'network related' and Esprit 'design related'. Examples of network related causes are: network topography; high cable joint impedances at the PLC narrow band frequency; harmonic disturbances and communication path lengths.

Network related causes are not introduced by the design of the Esprit Technology, but are caused by features associated with the LV network which were largely outside of the Project Team's control. The only remedial action taken to address a network related cause of PLC issues was the installation of repeater units. No in-depth analysis of the effect of the repeater units on PLC communications was carried out however onsite observations of PLC

communications between the MC and ICBs, showed an immediate improvement after energisation of repeaters in the two of the EV trial clusters in which they were installed.

It was never envisaged that PLC would be perfect throughout the trial, due to the low number of ICBs on each cluster. Despite the low saturation levels of repeater units, communication within the Esprit networks appeared operational for extended periods, before a rapid deterioration occurred with no obvious instigating factor. Resetting the MC and ICBs resolved the issue for a period before the deteriorated occurred again.

Extensive investigation, including the establishment of a test cluster at EA Technology offices in Capenhurst and making controlled changes to MC settings on site, eventually identified the problem as a problem inherent with the use of PLC in this situation.

In order to achieve successful communication at extreme ranges the speed at which the individual signals can be transmitted had to be reduced, a process implemented automatically by the PLC architecture employed by the Esprit Technology. ICBs outside of effective range with the MC would instead register with a closer ICB that would relay the signals. This worked as expected until the MC began to initiate curtailment and charging initiation commands.

These signals took longer to transmit and be verified under real network conditions and were further impacted as network load increased, exactly when the system needed to operate. As part of the embedded control software, the MC signals were classed as higher priority within the network than signals from the ICB. This resulted in signals from all ICBs having less opportunity for successful transmission, ultimately leading to the PLC network to collapse.

The results of this investigative testing revealed that the frequency (i.e. number of PLC signals sent per minute) at which the MC issued commands to the ICBs was too high. Reducing the control cycle and frequency of communication from all devices within the PLC network improved the reliability.

This issue was corrected by upgrading the MC firmware at each trial cluster. The firmware update process was easily carried out via a visit to each EV cluster substation. The update to the firmware introduced a simpler Esprit control logic algorithm enabling a reduction in the number of required communication signals.

Unfortunately, when this update was rolled out onto the EV trial clusters, a software bug resulted in MCs occasionally not reporting the load on the network phases. Data continued to be provided confirming the successful curtailment and reinstatement of EV charging however so Rail350 units were installed to provide phase current monitoring in the event the MC stopped reporting.

Ancillary Phase Current Monitoring

Before any MC firmware updates were implemented, the MC reported back near real time phase current readings with high reliability. The near real time collection of EV cluster phase currents was extremely important to the Project and, due to the EV penetrations levels, the DNOs who owned the LV networks (SEPD & NPG). As a consequence, after the firmware update to rectify PLC communications issues, the Rail350 units (including: wiring, Modbus connections, supporting mounts and CMTs) were wired and deployed in a very short time frame. Of the ten units that were installed, one unit failed after 8 months. This was located at the Lyndhurst EV trail cluster. This unit was replaced in August 2015 during a routine site visit. This unit is shown in Figure 22.



Figure 22 – Rail350v enclosure and double dagger bracket (for OHL pole mounting) front and rear view as used on the Lyndhurst EV trial cluster

Appendix III Implications of 7kW Charging

Whilst the data gathered by the My Electric Avenue Project is specific to 3.5kW charging, a simple extrapolation to 7kW charging can be undertaken using the available data as a starting point. It is necessary to consider however, that a number of assumptions are required in order to make use of the 3.5kW charging data in this way. These are detailed below.

1. That the vehicle battery capacity is unchanged at 24kWh.
2. That vehicle theoretical maximum range remains unchanged at c100 miles from a fully charged battery, dependent on individual driving habits.
3. That the owner's use of the vehicle would remain unchanged (journey lengths, number of daily trips etc.).
4. That the owner's charging habits are unchanged.

It is recognised that higher charging capacities will lead to greater diversity of EV related network load; this simple analysis was performed to take an initial view on whether the increased diversity negates the higher loading of each individual charger.

Assuming therefore, that the only variable to change from the charging data recorded by the My Electric Avenue Project is the charge duration, this analysis is undertaken by using the start time of recorded 3.5kW charging events, and halving the duration to extrapolate charging at 7kW. More than 28k charging events for the 6 month period January to June 2015 were used to calculate the probability of any individual EV charging in any 30 minute time period. This probability was then used to determine the probable load introduced to the distribution network by any EV within each 30 minute period.

Figure 23 shows the probability of charging for both the recorded 3.5kW charging and the extrapolated 7kW charging. It can be seen that likelihood of charging still forms the morning and evening peaks but due to the increased charging rate, the probability of charging falls quicker than realised during the trials.

Figure 24 demonstrates the load that can be anticipated from any individual EV based on the probability of charging at 3.5kW and 7kW. Whilst the probability of charging occurring at 7kW is lower throughout the day, based on the aforementioned assumptions, for 16 hours a day the required load still exceeds that required for 3.5kW charging but the total energy required remains the same.

It is noted however, that the assumptions required to enable this extrapolation are not expected to occur in real-world situations. As EV manufacturers continue to develop the vehicles, battery capacities are increasing, the efficiencies are improving and the charging rate most commonly installed as standard is now 7kW, with some manufacturers offering capabilities in excess of this.

As the rate of charge and the realistically achievable range increase, the frequency at which each car is used is likely to increase accordingly, whilst also becoming viable to those with usage requirements currently outside capabilities of many EVs. The steadily falling cost of EVs, with an increasing selection across multiple manufacturers is also supportive an anticipated increase in probability of higher rate charging in the future.

Ultimately, this analysis demonstrates that increasing the rate of charge does not remove the potential issue with EV charging on LV networks, indeed the anticipated increase in load requirements over much of the day is worse than that expected for 3.5kW charging.

Increasing the charging capability provides greater opportunity for use of EVs as greater travel ranges can be achieved in less time whilst increasing the battery capacity makes EVs suitable to a wider demographic. Both of these effects will serve to increase the demand on the electricity network by EVs, drawing increasing quantities of energy for longer periods of time.

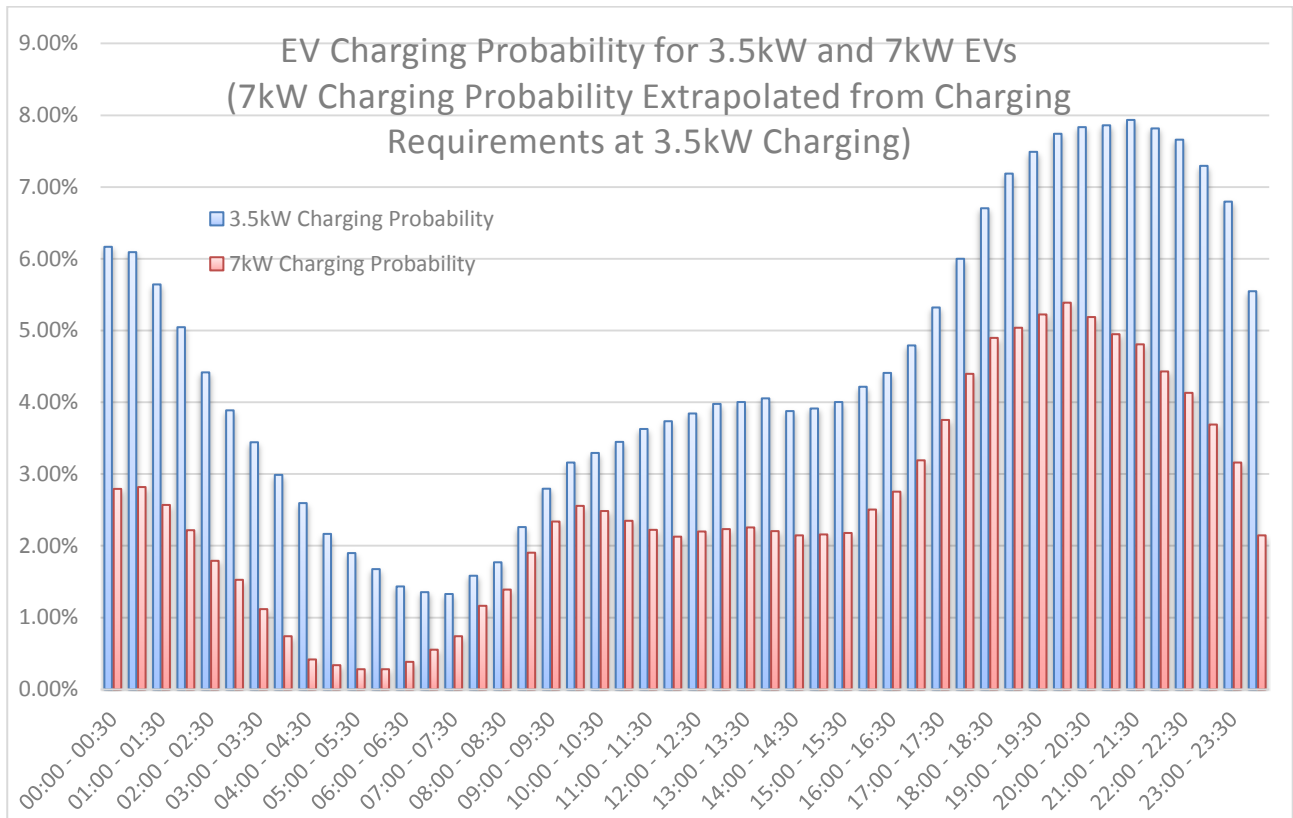


Figure 23 – Comparison of charging probabilities between 3.5kW and an extrapolated 7kW charging capability.

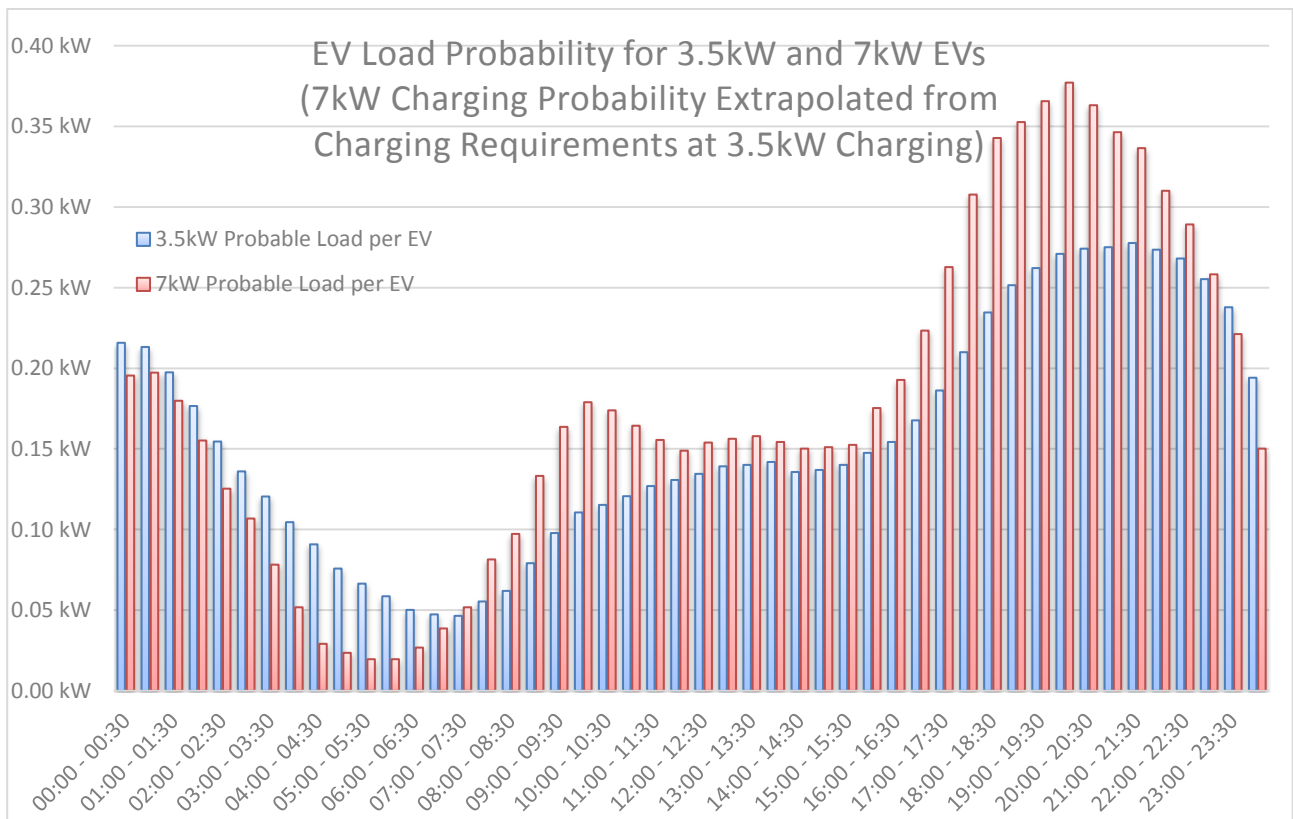


Figure 24 – Comparison of demand between 3.5kW and an extrapolated 7kW charging capability.

Appendix IV Letter from WPD following review of the initial issue of the Close-Down Report



Attn: Richard Hartshorn

Ben Godfrey
Innovation and Low Carbon Networks Engineer
Western Power Distribution
Pegasus Business Park
East Midlands Airport
Castle Donington
Derbyshire
DE74 2TU

Telephone 07894258687
bgodfrey@westernpower.co.uk

<i>Our ref</i>	<i>Your ref</i>	<i>Extension</i>	<i>Date</i>
My Electric Avenue Closedown Report			11 March 2016

Dear Richard,

Thank you for sending across the draft Tier 2 closedown report for I2EV – Innovation-squared: managing unconstrained EV connections (My Electric Avenue). We welcome the opportunity to provide feedback on this project and actively participate in the peer review process.

Having reviewed the current documentation, I am pleased to summarise the following comments on the draft:

- The documentation is presented in a clear and readable format, with easily identifiable headings to structure the information.
- The rationale for undertaking the project is well justified and identifies a recognisable problem seen on distribution networks.
- The scope, objectives and work carried are adequately described and the outcomes of the project are defined in enough detail to understand where this may be applied across other networks. The range of networks where the technology could operate successfully could be defined in more quantitative terms to validate the benefits stated.
- The need for further development work in order to achieve replicability is highlighted but the limitations of the project with respect to slow charging could be recognised stronger, as this will affect the level of replicability.
- Performance of the project compared to the SDRCs is presented well and evidenced effectively.
- Modifications within the project timescale and cost variances are explained to a sufficient degree.
- The statement that the conventional load ADMD is 1kW per electrically heated property should recognise other ADMDs used by other DNOs.
- Others DNOs may be able to realise the benefits of multiple innovation areas through the deployment of parallel projects without the help of third parties and internal resourcing these projects is not an unfeasible approach.



- It is stated that the acceptability of the customer to curtailment has been demonstrated, but there is also reference to majority of participants opting not to charge at the workplace after curtailment began due to the uncertainty of receiving sufficient charge.
- The predicted potential financial savings of £2.2 billion would require complete customer acceptance of the technology and do not take into account the economic value of the deferred power.

I am also enclosed my marked up comments as an attachment for more specific notes on the documentation.

Yours Sincerely,

Ben Godfrey

Appendix V WPD response following updates to close-down report

From: Godfrey, Benjamin R. [<mailto:bgodfrey@westernpower.co.uk>]
Sent: 25 April 2016 15:09
To: Hartshorn, Richard
Subject: RE: My Electric Avenue closedown report for DNO peer review

Richard,

I can confirm that WPD are satisfied that our points have been addressed in your final report.

Many Thanks,

Ben Godfrey
Innovation and Low Carbon Networks Engineer
T :01332 827447
M :07894258687
bgodfrey@westernpower.co.uk
www.westernpowerinnovation.co.uk

Western Power Distribution

Pegasus Business Park
East Midlands Airport
Castle Donington
Derbyshire
DE74 2TU

www.westernpower.co.uk