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REPORT

Smart EV Managed EV Charging Use Case and Customer Impact

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Executive summary

Distribution Network Operators (DNOs) are concerned that the charging of electric vehicles (EVs) on residential electricity networks will cause overloads or a reduction in power quality below statutory limits. To mitigate this impact, DNOs will need to reinforce the network to increase capacity implement solutions to manage demands. The speed of uptake and limited visibility of EV charging on low voltage networks means that DNOs are likely to need solutions that can be rapidly deployed.

The Smart EV project is developing a specification for managed EV charging, intended as a cost-effective solution compared with traditional reinforcement techniques. Through this process, a variety of stakeholders are being consulted to better understand the implications of managed EV charging and seek endorsement of a solution. As a result of initial consultation exercises, it became clear that the customer impact of managed EV charging and the DNO use case is currently poorly understood.

This report presents details of the DNO use case, described, in summary, as using managed EV charging as a method to temporarily manage the potentially rapid uptake of EVs, including emergency power outage scenarios, allowing them more time to consider and implement longer term, permanent options. The report establishes the case that the managed EV charging solution under consideration is both proportionate to the issue, and timely in terms of developing a solution ahead of deployment need.

A range of alternative solutions are presented to give the reader a better understanding of how managed EV charging would fit into the overall solutions set that DNOs can deploy and to help stakeholders gauge what is in customers’ best interests.

To assess customer impact, a parametric modelling exercise has been conducted on six distribution circuits (feeders). Using real time-series network monitoring data and electric vehicle charging data, an assessment has been made of the customer impact resulting from implementation of managed EV charging, i.e. how often an EV owner is likely to experience having their EV charging curtailed by an external management mechanism.

The results from the modelling exercise show that the number of EVs that can safely charge from the distribution network can be substantially increased with modest amounts of charge management. The analysis shows that each charge management event would be of short duration (less than 30 minutes) and within the event, would still permit at least half the charging rate.

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1. Background & Introduction

The number of electric vehicles (EVs) in the UK is rising rapidly. In April 2017 there were 95,000 EVs (both pure electric and plug-in hybrid) in the UK[1] and by 2030, National Grid predicts that 5.8 million vehicles could be electric[2]. This growth, coupled with UK Government targets for all new cars and vans to be zero emission by 2040, and a policy drive toward smart charging[3], supports the need for managed charging to enable electricity networks to facilitate rapid EV uptake.

My Electric Avenue, a recent project run by EA Technology and hosted by Scottish and Southern Electricity Networks, estimated that EV uptake could double the peak demand on local electricity networks. The cost to customers to accommodate this increase is estimated at around £2.2 billion[4]. This would take the form of replacing electrical assets such as cables and transformers with the associated disruptive street works that this would involve. The costs would ultimately be passed on to customers through their electricity bills.

The speed of uptake and limited visibility of EV charging on low voltage networks also means that DNOs are likely to need solutions that can be rapidly deployed.

The Smart EV project is developing a specification for managed EV charging, intended as a proportionate and cost-effective solution compared with traditional reinforcement techniques. Through this project, stakeholders across automotive, utilities, EV and charging point supply chain, consumer and Government are being consulted to better understand the implications of managed EV charging and seek endorsement of a solution. Ultimately this solution is intended to benefit the customer through facilitating a smooth transition to EVs charging on local electricity networks.

The initial Consultation on managed EV charging[5] highlighted that the customer impact of managed EV charging and the DNO use case is currently poorly understood.

This report addresses these issues by presenting a set of use cases to demonstrate the circumstances under which a DNO would use managed EV charging. The results of a modelling exercise are also presented, where the customer impact of managed EV charging has been quantified using real network monitoring and EV charging data. These results will provide an analysis of how many times a person's EV charging would need to be constrained in order to avoid power outages and subsequent costly and disruptive electricity network upgrades.

[1] "Electric Car Market Statistics" http://www.nextgreencar.com/electric-cars/statistics/ Accessed: July 2016

[2] National Grid, "Future Energy Scenarios" (2016). Available: http://fes.nationalgrid.com/

[3] Vehicle Technology & Aviation Bill 2017 https://www.gov.uk/government/collections/vehicle-technology-and-aviation-bill

[4] My Electric Avenue, "Project Summary Report" (2015). Available: http://myelectricavenue.info/learning-outcomes

[5] See 'Smart EV Managed EV Charging Consultation Summary Report and Summary Presentation: https://www.eatechnology.com/projects/smart-ev/

2. Scope and Objectives

The objective of this report is to provide information on how a DNO would use managed EV charging schemes and the resultant anticipated customer impact.

The scope of the report includes:

- A description of the DNO use case for managed EV charging;
- A summary of alternative measures that a DNO could feasibly deploy to manage overloads on low voltage networks;
- Results of a modelling exercise to quantify the customer impact of managed charging for a selection of real low voltage networks.

For clarity, the report does not include:

- Consideration of the use case by other energy system participants (e.g. energy suppliers, system balancing);
- Cost benefit analysis to customers of the alternative solutions in section 5.

3. Problem Statement

Work to date on DNO innovation projects, such as Low Carbon London[6], My Electric Avenue[7] and New Thames Valley Vision[8], has highlighted the significant additional demands that EVs place on electrical networks, particularly at the local level on low voltage residential circuits. The projects concurred that each EV is broadly equivalent in energy consumption and contribution to the maximum demand of an additional domestic property being connected to the LV network.

Specifically, the risk is that EV uptake causes networks to be operated outside of their design limits, which can lead to:

- Power outages as fuses operate due to higher demand than fuse rating;
- Power outages due to cable/line faults as they are operated at higher temperatures;
- Power outages as transformers are operated above their rating;
- Supply voltages being lower than statutory limits at individual properties.

As DNOs have no control over EV uptake, network planners face a challenge to ensure that future network capacity remains adequate. Also, the uptake of EVs and their connection to low voltage networks may be rapid; potentially much faster than the investment cycles within which DNOs are obliged to operate under the regulatory regime.

The majority of low voltage networks have spare capacity to supply a significant amount of EVs. However, some networks have limited or no spare capacity, and clustering of ownership in tight geographical areas may mean that issues are experienced within the next few years. To avoid

[6] http://innovation.ukpowernetworks.co.uk/innovation/en/Projects/tier-2-projects/Low-Carbon-London-(LCL)/
[7] http://myelectricavenue.info/
[8] http://www.thamesvalleyvision.co.uk/

potential negative publicity that could affect not only DNOs but also EV uptake rates in general, it is desirable to act early so DNOs have solutions ready to deploy rapidly.

From a network planning perspective, much of the concern over the uptake of EVs lies in the amount of ‘cable miles’ of LV networks. DNOs are accustomed to reinforcing networks (mostly at higher voltages) to facilitate load growth or new connections, however, the prospect of reinforcing even a modest proportion of LV networks would be on a different scale to their conventional levels of capital investment activity. Apart from the costs and disruption that reinforcing low voltage networks would bring, this would extend lead times and ultimately limit the amount of EVs that could safely connect to the network whilst ‘keeping the lights on’.

4. Managed Charging Use Case

This section describes how a DNO would use managed charging as a means to temporarily control demand on LV networks. There are three main use cases:

- Fault Response: a network operator is responding to a fault which is caused or exacerbated by EV charging demand that prevents the network operator implementing an immediate permanent fix, as the demand may be routinely higher than capability.
- Near-term Load Growth Management: demand is measured or estimated to either exceed or soon exceed the local network capability (but the network has not yet faulted).
- Long-term Load Growth Management: Where a network operator wishes to use managed charging as a long-term measure to manage demand on the distribution network.

The technical solution being proposed is detailed in a draft Engineering Recommendation produced by the Smart EV project[9]. In summary, the solution is based on three main aspects:

- An EV charger capable of receiving a signal from a local controller. The proposal is that all new EV chargers installed in a domestic setting, after a specified implementation date, include the ability to receive and act on this signal;
- A local controller that has remote communication facilities and can implement charging profiles based on the Open Charge Point Protocol (OCPP) open standard. This would only be installed at the customer premises by the DNO when necessary;
- A central system, owned and operated by a DNO, to receive network monitoring measurements and convert these into OCPP signals for individual chargers when it is necessary to de-load low voltage networks.

The proposed Engineering Recommendation also specifies the facility to connect third-party charge management controllers, so giving customers the option to engage in demand response markets.

4.1 Fault Response

This use case is driven by a fault that is caused or aggravated by EV charging demand, pushing loads above circuit capability. It could manifest as a fuse disconnecting load to a phase of an LV feeder, but could be associated with a cable fault if the cable has been operated above its design temperature for a period of time.

Customers would experience an outage and the network operator would send an emergency crew to attempt to restore power. In responding to the outage, in many instances the power can be restored quickly by replacing the fuse. However, if the connected load routinely becomes greater

[9] https://www.eatechnology.com/projects/smart-ev/

than the fuse rating for a period of time due to EV charging demand, then the fuse will operate again leading to further outages.

In this case, a network operator would wish to initially ask customers to disconnect load, particularly EV chargers, to allow them to safely restore power. In order to maintain supplies, managed charging would be implemented by installing local controllers at customers' premises to enable managed charging. This would be seen as an interim measure before permanent network reinforcement can be carried out.

4.2 Near-term Load Growth Management

DNOs have limited visibility of LV networks at present. Estimates of peak demand are typically obtained from modelling and/or coarse measurements from distribution transformer maximum demand indicators. It is possible this will change with the advent of lower cost monitoring solutions and the roll-out of smart meters.

A key issue is in proactively identifying networks that have limited remaining capacity and are therefore at risk of being operated over capacity. DNOs will use modelling techniques to initially identify low voltage areas most at risk. There is also the prospect of using demographic analyses to estimate where EV uptake is likely to be clustered.

There are approximately one million low voltage feeders in Great Britain, so the task to model each discrete network area is a significant undertaking that will require the development of specialist automated tools.

Areas identified as part of planning work as being close to capacity limits would be prioritised for fast-track roll-out of low voltage feeder monitoring to gain a firmer understanding of peak demand. Estimates of spare capacity would be cross-referenced with EV uptake predictions to attempt to identify the timeframe within which network assets face risk of overload.

Once network areas have been identified as facing a high risk of overload within, for example, the next couple of years, the DNO would perform more detailed studies of the network to ascertain the most cost-efficient, feasible solution. At this stage, managed charging could be implemented as a near-term interim measure to prevent the network being operated outside design limits before reinforcement could be carried out. Managed charging also creates optionality in case better solutions arise or demand changes (drops) due to adoption of other novel technologies.

4.3 Long-term Load Growth Management

DNOs are increasingly looking towards demand-side response solutions to defer or avoid expensive network reinforcement. To date this has been focused on high voltage and extra high voltage networks. As the market matures, managed EV charging could develop into an inexpensive method of de-loading network assets compared with other major upgrade options. As the UK understands customer acceptance more in the coming few years, managed EV charging may be shown, in line with initial indications, to impact customers very little for the benefits it can provide to the wider energy system.

In these circumstances DNOs consider that it would be inappropriate to access a mandatory managed EV charging system intended to provide shorter term, real-time protection of assets.

DNOs recognise that use of managed EV charging to provide long term demand management, particularly relating to high voltage assets, should be procured through a market where customers have choice and, in line with the market, are incentivised to participate.

5. Alternative Solutions

This section seeks to place managed EV charging in context with other solutions that DNOs can deploy to resolve capacity issues on low voltage networks. Only solutions currently available are considered, however, there are emerging technologies, particularly home energy storage that could play a part in alleviating DNO constraints. An important feature of managed EV charging is that it can be easily removed and it is a low cost solution compared with conventional reinforcement. This provides optionality in case other technologies in the future negate the need for network reinforcement. Table 1 offers a snapshot summary of the cost, pros and cons of the alternative solutions, followed by a more detailed description of each.

Table 1: Alternative solutions to managed EV charging - summary

Solution	Cost	Pros	Cons
Conventional Reinforcement	£££	Increased network capacity	Disruptive
Load Transfer	£	Inexpensive Minimal customer disruption	Solution highly dependent on network capacity
Local Generators	££	Keeps customers on supply	Pollution: noise and air Short-term solution
Disconnections	£	Quick Inexpensive	Customers off supply
Fuse Reclosers	££	Automatic	Only suitable for intermittent, short duration faults
LV Demand Response	££	Customer has a ‘say’ in and can benefit from flexibility markets	Difficulties in obtaining a meaningful response for sensible levels of cost
Storage Solutions	£££	Keeps customers on supply	Expensive

5.1 Conventional Reinforcement

Conventional reinforcement is a catch-all term for a permanent upgrade to network capacity. Typically, it would involve one or more of the following:

- Replacement of a distribution transformer;
- Installing a new cable, or overlaying an existing cable, and transferring services to the new cable;
- Installing a new transformer at a new site and re-connecting a proportion of customers to the new transformer;
- Connecting some customers to a different feeder, i.e. one with more capacity.

Particularly for reinforcement of feeders, it generally involves some disruption to the local community. Although DNOs minimise this as far as practical, road closures, civil works and short duration outages are typically necessary.

The costs of reinforcement are dependent on the scope of works but would range from a few thousand to a few tens of thousands of pounds for each feeder.

Lead time is a significant issue for conventional reinforcement; the time taken to plan, design and carry out works means that DNOs could not be expected to deliver permanent capacity upgrades in a short timescale, particularly where this involves acquisition of new sites and permissions for large excavations or cable routes.

5.2 Load Transfer

Residential network topology varies considerably dependent upon the layout of property and the vintage of the network. A fair proportion of networks are designed to incorporate Normally Open Points (NOPs) which are removable links to allow power feed from adjacent sections of network. These are normally used for maintenance purposes to allow customers to be temporarily supplied from an alternative transformer during maintenance.

Where an overloaded feeder is linked to another feeder via a NOP, and that feeder is more lightly loaded, then there is an option of reconfiguring the network to permanently move some of the customers onto more lightly loaded sections of network.

This is unlikely to be the case for the majority of LV networks, however where it is feasible, it is an inexpensive, permanent option to de-loading a feeder with minimal customer disruption.

5.3 Local Generators

DNOs frequently use diesel generators to maintain supplies to customers whilst repairing or maintaining network assets. These are typically connected at a transformer site and therefore, as they are currently deployed, would not alleviate over-capacity issues for downstream feeders.

It would be possible in some cases for diesel generators to be connected directly to feeders (downstream of the distribution transformer) in emergency situations.

It would not be in customers' interests for DNOs to resort to Diesel generators for routine support of EV charging. There would likely be issues with noise pollution and emissions from the generator. It also offsets the benefits of transitioning to a low emission transport system if Diesel generators are required to support the change. Technically, there are safety and reliability concerns. It would also lead to power quality issues – these systems are intended for (rare) outage management, not to provide capacity upgrades.

Additionally, the cost of running the generators longer term would be prohibitive compared with other solutions – the diesel costs can run into hundreds of pounds per day for a single feeder.

5.4 Disconnections

DNOs have certain rights to allow them to disconnect disturbing loads. These rights are exercised very infrequently, usually associated with the connection of loads which are counter to connection agreements and where they cause the network to be operated outside its design limits or where customers are adversely affected (e.g. voltage flicker). An example of this would be the use of pulsating electrical welding equipment on residential networks.

In cases where rapid uptake of EVs has directly led to a network outage, DNOs could be pushed to resort to disconnecting EV chargers to allow supply restoration; this would be until a permanent solution could be delivered which could take a few months.

5.5 Fuse Reclosers

On networks with intermittent faults, LV reclosers have the ability to restore supplies automatically. The principle is that they provide over-current protection in place of a substation fuse and following an over-current event (trip), they have the ability to disconnect the feeder phase, check the network for safety and then attempt to reconnect the supply.

These devices are intended to manage intermittent faults on networks, however, faced with the unlikely risk of frequent power outages due to EV charging, they could be applied in this application as a last resort to reduce outage duration.

5.6 Other LV Demand-Side Response and Storage Solutions

Some distribution network innovation projects have investigated the prospect of domestic scale demand-side response (DSR). As a general view, trials have highlighted the difficulties in obtaining a meaningful response for sensible levels of cost. Domestic DSR, other than related to EVs, may have a part to play in future networks when aggregated in large quantities. However, they are not currently being considered by DNOs as a tactical solution to de-load low voltage networks.

Regarding energy storage, several trials have shown the benefits to distribution networks. However, to de-load a low voltage feeder, energy storage devices would need to be deployed along the feeder and not at the distribution substation site. This presents issues finding an appropriate downstream connection point and securing the land on which to install the device. The costs are also likely to be considerably higher than managed EV charging.

6. Customer Impact

A key consideration for the implementation of managed EV charging is the expected experience of customers during operation of a system. There is considerable nervousness over obtaining the correct balance between limiting EV charging with the potential risk of impacting uptake rates, and ensuring our local electricity networks remain reliable and cost-effective.

A challenge to achieving an assessment of customer impact is that each network area is bespoke in terms of the capacity, topology, number of customers and behaviour of those customers.

In order to quantify the customer impact a modelling exercise has been conducted using data from other smart grid projects:

- Network (feeder) monitoring data obtained from New Thames Valley Vision[10] (Scottish and Southern Electricity Networks) and Customer-Led Network Revolution (Northern Powergrid);
- EV charging data obtained from My Electric Avenue (Scottish and Southern Electricity Networks / EA Technology).

[10] http://www.thamesvalleyvision.co.uk/

6.1 Modelling Specifics

The modelling simulates the operation of a managed EV charging system. The salient details of the analysis are:

- Twelve months of monitoring data at 10-minute resolution for six feeders with varying available capacities;
- Eighteen months of EV charging data at 1-minute resolution (time stamps for start/end charging);
- Analysis was conducted on the phase with highest demand;
- Comparison of loads against either the fuse rating or cable rating (whichever is lower);
- Adjusting the charging data to simulate 7kW charging rates (My Electric Avenue data only contains 3.5kW charging). This was coarsely achieved by doubling the demand and halving the duration for each event;
- EV charging demand profiles were randomly added to the feeder monitoring data to simulate future demands with various EV penetrations;
- Where the total expected feeder load was greater than the fuse or cable rating a managed charging event was created;
- Each event is an indication of the amount of demand needed to be controlled. The required demand reduction was evenly spread across all customers that were charging at that particular time (e.g. if 10kWh was required and five customers were charging during that time interval, the experience of each customer would be a demand curtailment of 2kW. If that event lasted for half an hour, the amount of energy curtailed per customer would be 1kWh);
- An analysis was conducted over a 12 month period to ascertain the number of events, the average amount of energy curtailed per event (kWh) and the maximum amount of energy curtailed during the most severe event (kWh)
- It was not possible to determine voltage excursions in this first pass analysis. The analysis is based upon overload alone.

6.2 Notes on Modelling Accuracy

The modelling conducted is considered to be the best available in light of the real-world data sources used; however, it is intended as a guide to the degree of customer impact of managed charging. This section briefly describes some of the more significant assumptions and limitations of the modelling:

- EV charging data was obtained solely from My Electric Avenue which only studied use of Nissan LEAFs and had an unconventional trial recruitment method. Other EVs and users (different vehicle range, mainstream customers etc.) are likely to produce different charging profiles;
- Only the feeder has been modelled and not the distribution transformer (which typically supplies multiple feeders – usually between one and six). Using managed EV charging for distribution transformer constraints is also desirable for DNOs;
- The charging rates have been extrapolated from 3.5kW to 7kW using a very basic assumption of double the demand and half the duration.

Nonetheless, the modelling presents the first view using real data at 10-minute resolution of how networks will cope and how managed EV charging could be used by DNOs. This is a significant step forward from using averaged data where it is difficult to understand the inter-day variation of demand.

6.3 Results

Six low voltage feeders were modelled with different characteristics in terms of number of customers and network capacity. EV charging profiles were added to the feeder demand and any overloads were classified as managed EV charging events. The table below describes:

- Max Feeder Utilisation (%): the maximum demand recorded for each feeder expressed as a percentage of the network capacity (feeder rating or able rating – whichever is lower);
- EV penetration (%): the percentage of customers with EVs;
- Number of managed charging events: over the twelve month modelling period, the number of distinct managed charging events. Overloads in two or more consecutive 10-minute time periods are classed as one event;
- Average duration of event (mins): the average duration of managed charging events seen by each customer. This is different to the average duration of events as only a proportion of customers are charging their vehicles during each event. The modelling was conducted at 10-minute resolution, hence the minimum duration is 10 minutes;
- Average deferred energy (kWh); this represents the average amount of energy displaced by each managed charging event. For example, a 7kW charger curtailed by 20% for 20 minutes would be equal to 0.47 kWh (7 x 20% x 20/60);
- Maximum energy deferred (kWh): during the most severe managed charging event, the greatest amount of energy deferred.

On analysis of the results below, if we consider Circuit 2, which the modelling suggests would experience four overloads a year with a 50% EV penetration. Per year, a customer could expect to have 0.92kWh (4 events x 0.23 kWh) of charging delayed by 18 minutes on average. For perspective, an EV owner covering 10,000 miles a year would require around 3,000 kWh of energy to re-charge their vehicle.

Considering recharging an EV after a 50-mile round trip, with a 7kW charging rate, the vehicle would be fully re-charged after approximately two hours. With managed charging to save four potential power outages, on these four occasions, the re-charge time would be extended by two minutes.

When penetrations of EVs reach 100%, the analysis shows that the number of breaches rises dramatically, often above 200 events per annum, although the average amount of deferred energy per event remains low.

Table 2: Modelling result figures for a year of data

Circuit Identifier	Max Feeder Utilisation no EVs (%)	EV Penetration (%)	Number of Managed Charging Events for the network	Maximum Number of Managed Charging Events per customer	Average duration of event (mins) per customer	Average deferred energy per customer per event (kWh)	Maximum energy deferred (kWh)n per customer
Circuit 1 (Suburban)	70	58	4	4	10	0.08	0.17
		100	23	20	15	0.55	2.02
Circuit 2 (Suburban)	52	50	4	4	18	0.23	0.45
		100	207	88	25	2.02	3.29
Circuit 3 (Suburban)	18	69	1	1	10	0.06	0.06
		100	194	119	18	0.10	0.15
Circuit 4 (Rural)	71	17	5	5	30	0.75	1.45
		100	251	92	23	0.1	1
Circuit 5 (Urban)	68	17	10	8	24	0.65	2.35
		100	256	89	32	1.03	11.64
Circuit 6 (Rural Substation)	47	23	4	4	19	0.35	1.04

6.4 The Message to Customers

The Smart EV project will produce a customer messaging strategy to facilitate customer understanding and buy-in to EV-network demand response tools. The aim of the strategy is to support customer acceptance of the solution as proposed under the draft Engineering Recommendation (see s.4), supported by the outcome of the customer impact modelling as detailed in section 6. It will deliver recommendations to DNOs on best communication approaches towards customer engagement in EV demand management.

The modelling results under s. 6.3 have simulated the impact on customers of managed charging. A number of key messages to customers can be drawn from these findings. These messages will be evaluated and refined through a series of qualitative focus groups in order to inform the customer messaging strategy. Table 2 summarises the messages that will be presented to the customer focus groups.

Table 3: Key messages to customers

#	Key messages	Origin / evidence base
1	Electric vehicles – both pure electric vehicles and plug-in hybrids - are on the increase, with prices coming down, range increasing and the second hand market for EVs starting to emerge. This is great news for consumers: • More vehicle choice • Lower running costs • A better driving experience • Better air quality and so ultimately better health outcomes • Lower CO2 emissions • Economic opportunity (new jobs) through Government funding for new technology and product development.	EV market
2	Distribution Network Operators (DNOs) – as distinct from energy suppliers – are under a regulatory obligation to make sure that our local electricity distribution networks can facilitate the forecast uptake in EVs – so that EV drivers and their neighbours are not inconvenienced by any unplanned work that may be required to reinforce their local underground electricity distribution cables as a result of EV charging at times of high demand.	DNOs
3	Government forecasts predict around 40 million electric vehicles (EVs) on UK roads by 2050. As the electrification of transport becomes more widespread, localised clustering of demand is likely to have a greater impact on electricity networks. Research[11] shows that **the additional demand from an EV is equivalent to an extra house on the network**. This extra demand would mean approximately 30% of GB low voltage (LV) networks would require reinforcement by 2050, representing a present day cost of £2.2bn to UK customers. There's a great opportunity to avoid costly and disruptive reinforcement if DNOs can 'work ahead of need' and put in place a managed EV charging solution to avoid this.	My Electric Avenue
4	'Smart', or 'managed' charging will help the overall customer experience when it comes to either themselves or their neighbours owning and charging EVs. A simple technology is being developed that will enable a DNO to manage an EV's charge on the infrequent occasions when it	Smart EV

[11] My Electric Avenue: http://myelectricavenue.info/

	would otherwise mean that there's a powercut due a fuse blowing on the low voltage network. It only takes one such event to trigger a costly and disruptive (roads being dug up) reinforcement event.	
5	Managed charging has the potential to avoid increased customer bills in the future, if network reinforcement can be avoided with a simple yet effective solution. Reinforcement may be necessary in some cases to facilitate EV uptake – but if DNOs can plan for it in a timely fashion, significant cost savings will be made.	My Electric Avenue
6	Smart EV modelling shows that when between 40 – 70% of people have EVs, who are living within one or two streets of one another, a number of those EVs may need to be managed by the DNO to avoid power outages when a number of those EVs are charging all at once. Each instance of managed charging would only last between 10 – 20 minutes, and so would be unlikely to effect the ability of the charger to complete its charging session. So if an EV is being charged for a number of hours overnight, and charging was managed for 10-20 minutes within this period, the owner is still likely to have a full charge by the next morning, and would not notice any difference.	Smart EV

7. Conclusions

The work presented in this report describes the intended use of managed EV charging by DNOs in Great Britain. The desire by DNOs is to have the rights to deploy managed charging systems to respond to power outages and power quality issues.

Also, where the DNO can justify the pro-active implementation of managed charging to protect against imminent overload, likely to be advised from network modelling and uptake analyses, they seek the rights to use managed charging.

A modelling exercise undertaken on six typical low voltage feeders, using real network and charging data, has shown that the customer impact would be very low with penetrations roughly around 50%. As penetrations reach 100%, the impact is higher but still is unlikely to impact on customers' ability to undertake subsequent journeys.

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