The Future of **Electric Vehicle Smart Charging**

Report produced by
Engage for **Energy UK**
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With thanks and support from:

The Association for Decentralised Energy

The Association for Renewable Energy & Clean Technology

techUK For What Comes Next

Foreword

This report explores the different approaches to smart charging, an issue which is rightly at the forefront of Government and industry thinking when considering how to ensure a smooth integration of electric vehicle charging into the energy system. Smart metering infrastructure will act as the building block on which smart charging is based, providing access to information about energy usage and costs, but which does not require all aspects of smart charging to be run through the smart metering system.

Energy UK is clear in its position: mandating the Smart DCC as the enduring solution for smart charging is not the way to go. We need to avoid GB-centric solutions when the market for EVs and chargepoints is a global one; we must ensure that any solution avoids single points of failure; we should seek solutions that work for both the domestic and non-domestic sector; we must prioritise approaches that increase rather than restrict functionality; and we need to allow companies that are pushing the limits of technology to continue to do so, so that smart charging remains synonymous with innovation, customer-focus and an excellent user experience.

We recognise the difficult situation that Government is in when so much has been invested in the smart metering infrastructure, and Government's wishes for its use to be extended into other markets. Industry is effectively asking Government to put its trust in the market when an interoperable and secure EV charging system is already available. To be clear, Energy UK is by no means advocating compromising on these important objectives. With Government currently leaning towards using the smart meter system as the enduring solution for smart charging we understand that it is up to us to put forward a credible alternative that delivers against all four of Government's key principles and requirements.

We propose that Government sets out outcome-based requirements that all participants must meet to operate in the market. There are a range of international standards which already do, and can continue to form the basis of this framework, the adoption of which could be used to demonstrate compliance. Of course, work is needed to set out the specific outcomes, properly map them against standards and consider how to demonstrate compliance, and ensure that every box is ticked.

This report marks the start, rather than the end of the process. There is clearly still lots of work to be done. Industry must collaborate to pull together and pool its expertise, experience and insights, building on the significant progress to date. Energy UK and the organisations that have supported this report are committed to making the case for a secure, interoperable system that allows for continued innovation and consumer-focussed-smart charging products. The consensus and appetite for action can be clearly seen through the forewords provided by the ADE, BEAMA, the REA and techUK.

Energy UK strongly believes that we do not need to compromise on innovation or consumer uptake for a secure, interoperable smart charging technical architecture and we look forward to working with Government, our members and the rest of industry to deliver the best possible system for the consumer.

Emma Pinchbeck
Chief Executive, Energy UK

Foreword

The Association for Decentralised Energy (ADE)

Smart Electric Vehicle (EV) charging will play a crucial role in enabling cost-effective decarbonisation of the UK's transport infrastructure. The Association for Decentralised Energy (ADE) welcomes this report, which provides an important contribution to the current debate about the best approach to smart charging and demand control.

The report demonstrates the range of innovative approaches currently being utilised by flexibility providers, many of which do not utilise the Smart Meter system. Further to this, the ADE strongly supports the work that BEIS and industry have achieved together through Publicly Available Specification (PAS) 1878 and 1879, putting in place standards that will underpin an innovative, competitive and secure market by delivering the key objectives of cyber-security, customer protection, interoperability, and grid stability.

The report outlines several issues with the existing Smart Meter system, including the lack of any in-market device that allows proportional load control via the Data Communications Company (DCC), industry concerns around speed of response and granularity of data, and the potential for DCC governance arrangements to stifle innovation. More broadly, an approach focused on a specific technical solution runs counter to BEIS' broader work on smart standards. Therefore, the ADE believes that Government should avoid mandating use of Smart Meter infrastructure as the only option for control of smart EV charging. Instead, a full assessment should be made of the viability of the options outlined in the report, including systems that do not utilise the Smart Meter infrastructure and hybrid systems.

By facilitating the maximum number of viable approaches to smart EV charging, Government can ensure that consumer uptake is maximised, innovation is turbocharged, and the UK transport sector is decarbonised as quickly as possible. The ADE looks forward to working with Government and industry to achieve these goals.

Ian Calvert,
Chief Executive Officer, ADE

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The Association for Decentralised Energy

Foreword

This report is a significant and welcome contribution to the current debate within industry and Government about how to regulate and support technologies, systems and markets for smart EV charging.

BEAMA wholeheartedly supports the Government's intentions to facilitate smart charging and maximize its benefits to grid and system flexibility, to consumer choice, experience and savings, and to energy efficiency. We agree with Energy UK and its members that regulation should support new and innovative business models for EV charging without compromising the cyber security of the system.

Smart metering is and continues to be a necessary upgrade to Britain's energy infrastructure, and all domestic smart EV charging systems should be able to coexist with its architecture. And market growth depends on the interoperability of smart charging products with other services and devices in the smart energy ecosystem, especially for heating. But BEAMA's position remains steadfastly that Government should not mandate specific solutions but should empower manufacturers, service providers and consumers to engage with these challenges. This paper suggests some ways forward, and we will continue to work closely with Energy UK and its members in support of a flexible, low-carbon energy system and the electrification of road transport.

Jeremy Yapp
Head of Flexible Energy Systems, BEAMA

Foreword

Renewable Energy Association (REA)

Smart charging of electric vehicles in homes and workplaces is essential to ensuring mass adoption and enabling a wider transition to a future based on renewable energy and clean technologies. Success, in our view, looks like a secure and consumer-friendly system that reduces costs for owners and the overall electricity system and enables the uptake of technologies like renewable heat, solar PV, and battery storage.

Smart metering plays an essential role in this future low-carbon home and business environment. However, we need to make sure that the standards and processes we develop for smart charging keep those pioneering companies installing and operating this technology competitive, and that we are setting them up for success abroad.

This report highlights how this balance can be struck in a rapidly evolving environment. The Government should allow for the charging sector to meet its stated outcomes, and provide opportunities for those companies that wish to integrate with the smart metering system to do so, without being so prescriptive as reduce our competitiveness and slow adoption.

Dr Nina Skorupska CBE
Chief Executive, REA

REA THE ASSOCIATION FOR RENEWABLE ENERGY & CLEAN TECHNOLOGY

Foreword

Digital transformation is essential in the journey to electrify transport. The UK is legally committed to achieving a net zero-carbon economy by 2050. To help achieve this, sales of new petrol and diesel cars and vans will end by 2030, with hybrid vehicles permitted until 2035.

The transition away from the internal combustion engine to zero emission vehicles will be essential to achieving net zero. We have seen motor manufacturers move quickly to innovate. But a key challenge remains how to ensure there are enough low-carbon electrons available on the grid to charge the wave of electric vehicles we know are coming.

Consumer behaviour is clearly going to be critical in managing this demand and in avoiding pressure on the electricity network.

Intelligent digital technologies can intercept and incentivise consumer behaviour by supporting load control and delivering dynamic price signals to enable flexibility and unlock lower cost tariffs. National Grid ESO highlights that this demand could be significantly reduced by implementing smart charging techniques, and further reduced by adding vehicle to grid (V2G) services.

But there is a split view on how to deliver this, particularly whether smart charging infrastructure should be mandated or not, and whether it needs to sit within or outside the smart meter system. This report presents an important contribution to the debate on the role of digital tech in easing friction and enabling a seamless and frictionless experience for consumers, whilst ensuring the functionality of the grid.

What is clear is that interoperability, rigorous cyber security measures, consumer protection and cost effectiveness combined with the highest quality of service must be baked into whatever shape the future electric vehicle charging infrastructure takes.

We are at the cusp of a complete digital transformation of the energy sector. techUK will continue to provide the voice of the tech industry and look forward to working with players across the industry to showcase the potential of cutting-edge innovations and co-design solutions on this tremendous journey to net zero.

Julian David
CEO, techUK

techUK
FOR WHAT COMES NEXT

The following report was produced by **Engage** for **Energy UK**

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Engage for **Energy UK**

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ELECTRICITY | GAS | INDUSTRY EXPERTS

1 Executive Summary

There are viable options for delivering electric vehicle (EV) smart charging at home that sit outside of the smart metering (SM) system. However, work is needed to ensure that these options provide the necessary consumer and electricity grid protections at scale. In summary our report finds the following:

- Smart charging EVs at home is, in the main, conducted via the charge point operator (CPO). While we do not see this changing in the short term, viable future options could include a hybrid system or the use of the EV itself as the hub for smart charging.

- A hybrid system could combine day-to-day control via non-SM systems with a layer of supervisory control via SM in exceptional circumstances (eg serious grid imbalance) and use of the SM data flows to understand electricity demand.

- Innovation by car manufacturers has provided customers with the ability to manage their charging requirements either via a mobile device app, or through the vehicle's dashboard interface. This has given the customer a seamless end-to-end experience and is providing a viable alternative solution for 'at home' smart charging.

- Industry trials such as My Electric Avenue and Electric Nation have shown that demand control is possible and effective using Charge Point Operators to facilitate control of demand at the EV charge point, without using the SM system.

- Adequate electricity grid and consumer protections are in place today but, as the market grows, we need to consider how players and actors interact to prevent adverse effects to the electricity grid or the consumer experience.

- Implementation of draft British Standards Institution (BSI) standards PAS 1878 and PAS 1879 would help mitigate cyber security, interoperability and grid protection risks associated with non-SM system options. Consideration needs to be given to any potential impacts to the EV charging market before any decision is made to mandate these standards, or whether device-level standards (using PAS 1878/1879 as the baseline) is a more appropriate approach. Adoption of these standards should be encouraged from the outset, with a clear focus on them helping ensure that Government objectives are met in relation to of consumer uptake, innovation, grid protection and consumer protection.

- Based on feedback received from existing CPOs, Government would need to provide greater insight to the industry about its reasoning, and demonstrate how it has understood and addressed the impact on the current market participants if it continues to favour sole use of the GB SM infrastructure for Smart charging EVs in a post-PAS implementation world.

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Glossary of Terms

REFERENCE	DEFINITION
ALCS	Auxiliary Load Control Switch
APC	Auxiliary Proportional Controller
BEIS	Department for Business, Energy and Industrial Strategy
BSI	British Standards Institution
COP	Code of Practice
CPO	Charge Point Operator
DCC	Data Communications Company
DCUSA	Distribution Connection and Use of System Agreement
DFT	Department for Transport
DNO	Distribution Network Operator
DSO	Distribution System Operator
DSR	Demand Side Response
ESA	Energy Smart Appliance
ESA SAG	Energy Smart Appliance Strategic Advisory Group
ESME	Electricity Smart Metering Equipment
ESO	Electricity System Operator
EV	Electric Vehicle
EVHS	Electric Vehicle Homecharge Scheme
GW	Gigawatt
HAN	Home Area Network
HCALCS	Home Area Network Connected Auxiliary Load Control Switch
HH	Half Hourly
ICS	Industrial Control System
LCT	Low Carbon Technology
LV	Low Voltage
NCSC	National Cyber Security Centre
NG	National Grid

REFERENCE	DEFINITION
OCPP	Open Charge Point Protocol
OLEV	Office for Low Emission Vehicles
PV	Photovoltaic
SAPC	Standalone Auxiliary Proportional Controller
SEC	Smart Energy Code
SM	Smart Metering
SMETS	Smart Metering Equipment Technical Specifications
SMIP	Smart Metering Implementation Programme
V2G	Vehicle to Grid

2 Document Control

2.1 PUBLICATION

VERSION	DATE	AUTHOR
Draft Version	29th September 2020	Engage Consulting Limited
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2.2 CHANGE HISTORY

29/09/2020	Draft Version
30/10/2020	Final Draft Version
15/12/2020	Final Version

2.3 RELATED DOCUMENTS

Engage Proposal Document	07/2020

3 Introduction

3.1 PURPOSE OF THE REPORT

Energy UK commissioned Engage Consulting to consider whether domestic EV charging solutions that do not or will not use control and command signals through the existing SM infrastructure, are likely to deliver equivalent outcomes with regard to cyber security and device interoperability. And in doing so, meeting the four government objectives: grid protection, consumer protection, consumer uptake and innovation.

The report summarises how EV smart charging can be facilitated through the SM/Data Communications Company (DCC) infrastructure and assesses the benefits and challenges associated with this approach. It then looks at alternative solution options in detail and provides an assessment of the following alternatives:

- Control via non-SM system infrastructure (including the EV).
- Control via a hybrid of SMand non-SM system infrastructure.

The report outlines the additional steps to consider for each alternative approach if they are to meet the four government objectives, and to ensure the same cyber security and interoperability standards as the existing SM infrastructure.

3.2 SCOPE OF THE ASSESSMENT

Our assessment provides background information on the current UK EV market and how this is developing, as well as detailing forthcoming technical governance standards that will increase the interoperability and security of alternative solutions. We look at options for the physical control of EV charging via switching or proportional load control. We do not look at non-physical approaches, such as tariff price signals. The following table outlines the EV smart charging approach options considered within the report and details the key characteristics of each solution.

APPROACH	SUMMARY
Smart Metering System Control	This model assumes the SM system installed in the home provides the communications link to and from the charge point, and that all the data/messaging transfer protocols needed to facilitate demand control with EV charge points use the existing SM infrastructure via the Smart DCC. Current developments in the SM specifications facilitate smart control of EV chargers and other appliances (see Section 6 for more detail).
Non-Smart Metering System Control	All existing smart controlled home EV charging solutions in the UK operate without using any part of the SM system. Control is delivered using separate or proprietary communications infrastructures and back-office IT solutions. There have been real world trials – referenced later in the report – funded through Ofgem's network innovation competition (eg My Electric Avenue[1]

	and Electric Nation[2]). These trials demonstrated proof of concept of 'demand control' to avoid charging at times of network peak demand. Solutions use proprietary systems to provide communication between the charge point operator (CPO) and the charge point, with the end-user having some form of consumer interface (typically a smartphone app) to control charging their EV. Outside of trials, there are some solutions, often provided by the consumer's energy supplier in partnership with a CPO, that offer the opportunity for EVs to be charged at times when electricity prices are at their lowest. Here CPOs are free, with customer agreement, to facilitate demand control and use this to offer services into flexibility markets. Also, innovation by the car manufacturers has meant EV owners are increasingly using the functionality offered to them via the dashboard interface or app to actively manage charging times based either on their preference or system prices.
Smart/Non-Smart Hybrid System Control	There are currently no examples of smart-controlled home EV charging solutions using hybrid SM/non-SM systems in the UK. Hybrid systems could combine day-to-day control via non-SM systems, with a layer of supervisory control in exceptional circumstances via the SM (eg in cases of serious grid imbalance), and use SM to understand electricity demand. Alternatively, they could use the SM infrastructure to provide a communications link alongside a non-SM data/messaging solution.

3.3 APPROACH TO DELIVERY

To deliver this report in line with the purpose described in Section 3.1:

- We interviewed a broad range of industry participants from CPOs, energy suppliers, hardware manufacturers, automotive companies and trade bodies. During these interviews, we sought opinions on how the market currently approaches demand management, communication, security measures and current protocols for grid protection for EV smart charging.

- We used the content from these interviews, combined with our understanding of the market, to formulate, develop and assess the approach options in scope.

A full list of these businesses and the questions explored with them (as aligned with the brief from Energy UK) are in Annex A.

4 Current Landscape

4.1 ELECTRIC VEHICLE CHARGING DEMAND AND ITS IMPACTS

In excess of 31 million vehicles are currently licensed in the UK[3], the vast majority of which are powered using fossil fuels. Internal combustion engine vehicles produced around 14% of all UK greenhouse gas emissions in 2017[4].

The UK is legally committed to achieving net zero carbon emissions by 2050[5]. The transition away from the internal combustion engine to zero emission vehicles will be essential to achieving net zero. To this end, as part of the Government's 'Ten Point Plan for a Green Industrial Revolution'[6], the Prime Minister has confirmed that the UK will end the sale of new petrol and diesel cars and vans by 2030. However, hybrids that can drive a significant distance with no carbon coming out of the tailpipe will be allowed until 2035.

Of the total vehicles licensed on UK roads today, around 331,000 are plug-in EVs[7]. With rapid growth forecast for the coming decade, the National Grid Electricity System Operator's (NG ESO's) Future Energy Scenarios Report, 'Community Renewables', considers the impact of this growth on electricity demand. The report projects that unconstrained EV charging demand at peak times could rise to approximately 24GW by 2050 (see figure 1). However, NG ESO also highlights that this demand could be significantly reduced by implementing smart charging techniques and further reduced by adding vehicle to grid (V2G) techniques.

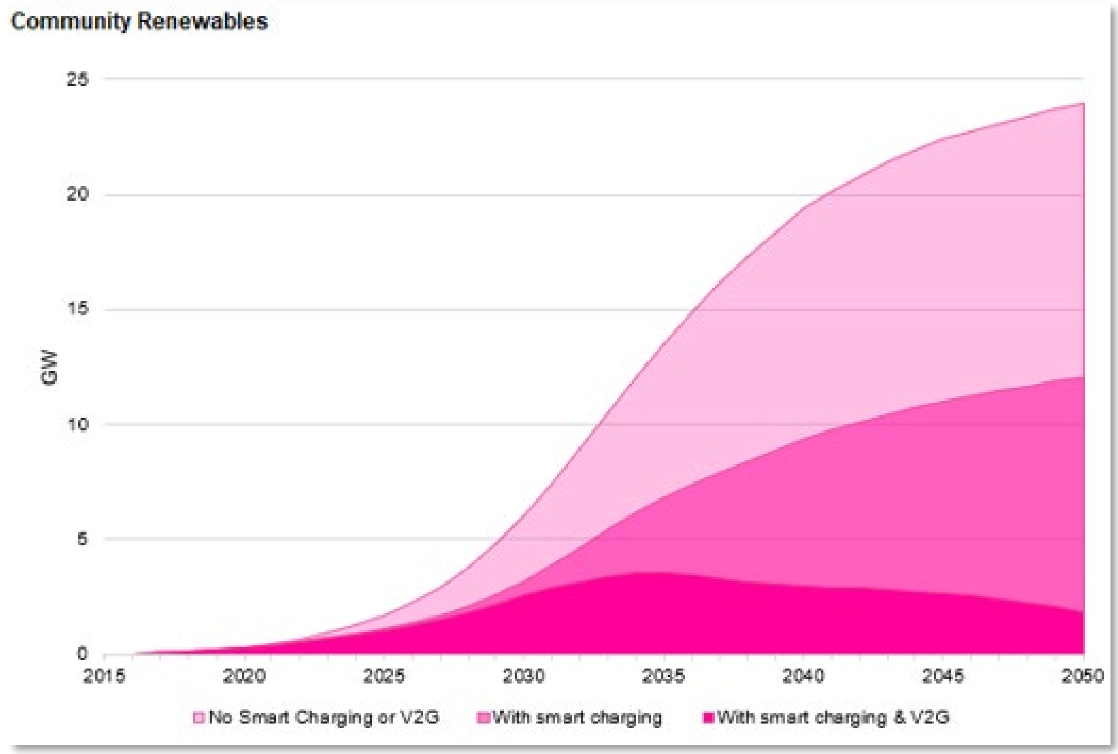

Figure 1 Projections of EV electricity demand at time of system peak. (Taken from NG ESO's Future Energy Scenarios Report, 'Community Renewables' scenario).

Evidence from trials suggests that EV owners will charge their vehicles most often at home (87% in the 'My Electric Nation' trial, with 66% only ever charging at home[8]). It is likely that many households will have several EVs, possibly sharing a single charge point. Currently, 35% of UK households have two cars or more[9] and this trend is likely to continue.

The impact of this additional electricity demand will initially be at a local level on the electricity distribution networks, where there are clusters of properties supporting unusually large numbers of EVs, or where the network is already near capacity. The My Electric Avenue[10] project found that "across Britain 32% of low voltage (LV) feeders (312,000 circuits) will require intervention when 40% – 70% of customers have EVs, based on 3.5 kW (16 amp) charging".

At an overall system level, the ESO is required to balance supply and demand across the whole of the transmission and distribution system and to guard against loss of supply. Distribution network operators (DNOs) have similar obligations across the distribution system. The purpose of this is to secure against the loss of the largest single generator unit operating on the system. Once a critical mass of EVs is reached nationally, it is possible that sharp rises or falls in EV charging demand – driven by strong electricity price signals, for example – could impact the ability of the ESO to maintain system frequency and future distribution system operators (DSOs) to manage demand fluctuations. The effects of step changes in system load were exposed vividly by the power cut event of August 2019[11]. Similar effects could equally be driven by large step changes in demand; for example, those that could be driven by simultaneous switching of large domestic loads, such as EV charging or domestic heat-pump heating systems.

The ESO's principles for managing frequency are driven by potential, worst case inbalances caused by loss of generator infeed to the grid. The potential impacts of infeed on grid frequency of loss are equally applicable to the sudden addition to or removal of large amounts of load from the grid.

ESO Future Energy Scenario projections indicate that, assuming smart charging techniques are applied, EV charging demand could top 1GW by 2025. Around this level of demand, any potential for simultaneous switching (on or off) of all EV charging becomes a serious issue for the ESO.

Potential UK network impacts can be mitigated by smart charging techniques that diversify switching times and move load away from traditional times of peak electricity demand[12]. It may also be necessary to place requirements on suppliers to prevent tariff offerings that include sharp price changes, without matching these with suitable generation.

4.2 GOVERNMENT ELECTRIC VEHICLE POLICY

The Automated and Electric Vehicles Act 2018 gives Government the powers, through secondary legislation, to ensure that all EV charge points sold or installed in the UK will have smart functionality. Government is planning to take forward these powers to help ensure these vital building blocks of a smart system are in place from an early stage[13].

In July 2019, the Department for Transport (DfT) and Office for Low Emission Vehicles (OLEV) published a consultation on EV smart charging[14] which states the Government's overarching aim is to "maximise the use of smart charging technologies, to benefit both consumers and the electricity system, whilst supporting the transition to EVs".

The consultation highlights the need to encourage consumer uptake and innovation, while avoiding negative consequences for electricity grid protection and consumer protection.

The summary of responses to the consultation[15] demonstrates significant support of the four objectives (see Figure 2):

- Consumer uptake.
- Innovation.
- Electricity grid protection.
- Customer protection.

Question 2 to 5: Do you agree with the following objectives?

	Agreed	Disagreed	Neither agreed nor disagreed	Didn't know	Total answered
Grid protection	103	5	4	0	112
Consumer protection	101	7	3	1	112
Consumer uptake	101	2	4	1	108
Innovation	100	3	4	2	109

Figure 2 Extract from OLEV's summary of consultation responses

The consultation document proposes the use of the GB-wide SM system to control EV charging as the favoured option, stating that:

> "The smart meter system could provide an enduring solution for the smart charging of EVs, and Government is confident that this system would be highly secure and interoperable. The system already exists, and smart charging demonstration projects[16] will conclude shortly."

In July 2019, Government also consulted on EV charge points in residential and non-residential buildings[17]. The intention is for every new residential building with an associated car parking space, including buildings undergoing a material change of use to create a dwelling, to have an EV charge point.

The UK government has not published its final policy positions for either of the above consultations, although a summary of stakeholders' responses to the EV Smart Charging consultation was published in May 2020[18].

4.3 EXISTING LANDSCAPE FOR SMART EV CHARGING

Today EV owners typically procure a smart charger for their home around the time of receiving their first EV and some may then contract with a CPO to control their charging smartly. CPO's typically offer smart services such as optimisation of charging in terms of cost, carbon impact, range required, etc. Chargers are normally wired back to the customer's existing consumer unit via a dedicated circuit. On occasion, a new electricity supply will be required where the existing supply lacks sufficient capacity, or where the required vehicle charging position is remote from the house. Others still choose to plug their EV in to a domestic 13 Amp socket outlet, effectively taking manual control of their charging.

The UK Government offers grants to support the wider use of electric and hybrid vehicles via the OLEV[19]. The range of grants includes the Electric Vehicle Homecharge Scheme[20]. To qualify for these grants, customers must use an approved installer and have dedicated, private, off-street parking[21]. More than 1,600 installers are currently approved[22]. However, it is worth noting that around 35% of dwellings are thought not to have access to off-street parking. Government recently doubled the grants available to councils to provide on-street EV charging for people without a parking space[23].

From July 2019, all Government funded home EV charge points must use smart technology[24]. This means they must be remotely accessible, and capable of receiving, interpreting and reacting to a signal or instruction [25].

We have found no reliable data that indicates the total number of homes in GB with charge points currently installed. This is because not all home EV charger installations have received OLEV funding. Official statistics do not include charge points purchased by customers for DIY installation or procured via electricians. However, it seems likely that most EVs will have an associated home charge point, with only a small proportion relying on the simpler domestic socket outlet for (slow) charging.

Assuming that EVs are significantly more common in locations with off-street parking, then based on a population of 331,000 EVs (as noted in section 4.1 above), we estimate that there are probably some 300,000 domestic EV chargers installed in Britain. These chargers are either controlled smartly by CPOs, using means outside of the current SM system, or operate in dumb, plug and charge mode.

4.4 CONTROL OF DEMAND 'BEHIND THE METER'

Traditionally, electricity suppliers provided energy to the 'consumers terminals' on the outlet side of the meter, where the consumer's household wiring system starts. Consumers were then free to use this energy as they wished, within the maximum capacity of their connections, as determined by the rating of the cut-out fuse. Smart charging of EVs changes this.

Most electricity supply connections are subject to the National Terms of Connection[26] – a standard agreement between a consumer and the relevant electricity DNO, facilitated via the consumer's supply contract with the electricity supplier. These National Terms of Connection set out the terms and conditions that the network operator requires consumers to accept in return for maintaining the connection of the premises to its network. The document allows the network operator to de-energise or disconnect the supply in certain circumstances but does not confer rights for the network operator to control loads downstream of the meter in any other way.

Suppliers have for many years offered various tariff price signals aimed at changing customers' behaviour. The advent of 'off peak' tariffs in the 1960s first saw electricity boards exercising control of specific loads downstream of the meter. More recently suppliers have provided a broader range of tariff options, including tariffs where dynamic pricing is combined with supplier control of certain loads (water heating, EV charging, PV Generation, etc.) or offering 'free' electricity for a day.

Under the regulatory framework established by Government as part the Smart Metering Implementation Programme, only licenced electricity suppliers are allowed to send switching signals via the SM system (although they can provide switching services to third parties). Further details about the SM system are captured later in section 6. Industry parties (such as the ESO or DSOs) do not currently have direct access to control customer loads via the SM system. These parties generally procure any required flexibility services in the open market, from aggregators and others, who use switching arrangements outside of the SM system to deliver these services. However, recognising the potential impact of EV charging on the electricity networks, a Distribution Connection and Use of System Agreement (DCUSA) Change Proposal (DCP371)[27] and Smart Energy Code modification 46 (SECMP0046)[28] is currently being discussed. This aims to provide DNOs with the ability to limit or curtail EV charging under extreme circumstances where there is a risk of excessive electricity demand at a local network level.

Another possible future could see control of EV charging shifting from the energy industry to the automotive industry. While this report does not explore this possibility in any detail, its potential should not be dismissed (see Section 8). However, it should be noted, this would require significant change to the regulatory framework.

4.5 EMERGING TECHNICAL STANDARDS

Work is currently underway through the BSI Energy Smart Appliance Strategic Advisory Group (ESA SAG) to develop publicly available specifications for ESAs. This will include EV chargers[29].

A joint OLEV/BEIS statement, issued as part of a BSI letter dated 22 July 2020[30], underlines Government's commitment to this work.

> "As set out in the joint Government and Ofgem Smart Systems and Flexibility Plan (SSFP), smart, flexible energy can help drive the transition towards a future low carbon energy system, whilst bringing significant benefits for consumers, the energy network and the wider economy. A study for the Government estimates the benefits of a smart energy system to be £17-40 billion to 2050. These benefits come from avoided or deferred network reinforcements and generation build, avoided curtailment of low-carbon generation, and more efficient use of the energy system. An important component of these benefits is the provision of DSR services in UK homes. In line with the commitment in the SSFP, Government is sponsoring the British Standards Institution (BSI) to develop these industry-led standards to support the uptake of domestic Energy Smart Appliances (ESA) (including smart EV chargepoints) and facilitate the provision of domestic DSR services. Smart energy products and services represent a major opportunity for UK businesses and Government wishes to support the UK becoming a global leader in developing and implementing these technologies.
>
> Government is supporting this work to gain consensus across industry on appropriate technical standards for the smart energy sector. To all stakeholders who have engaged in the PAS development process, we would like to extend our gratitude for your positive contributions. Government will continue to engage industry in developing policy or regulation for domestic DSR products and services. Finally, Government would like to thank in advance all those who send in technical comments to BSI as part of this PAS public review."

Development of PAS 1878 is part of BSI's ESA Programme[31], sponsored by BEIS. The PAS will specify the requirements an appliance shall meet to be considered 'energy smart'. An ESA is one that can respond automatically to price and/or other signals and, as part of that response, adjust its electricity consumption and/or production. The PAS includes requirements around data interchange, cyber security and switching time randomisation, among others.

Work is also underway to produce a companion code of practice (COP), 'PAS 1879: Energy smart appliances – Demand side response – Code of practice', for DSR operation. This will define the Demand Side Response (DSR) ecosystem in which ESAs will operate, and the roles and responsibilities of the actors in that ecosystem and the relationships between them. Publication is scheduled for 2021 (shortly after PAS 1878). The draft PAS 1878 has been subject to public consultation[32], with a closing date of 2 September 2020. PAS 1878 envisages compulsory interfaces between the DSR Service Provider, the Customer Energy Manager (provider of energy management services for smart homes) and the ESA (EV smart charger, etc.), as well as optional interfaces with the SM system, other external systems and remote user interfaces. These interfaces are illustrated in Figure 3.

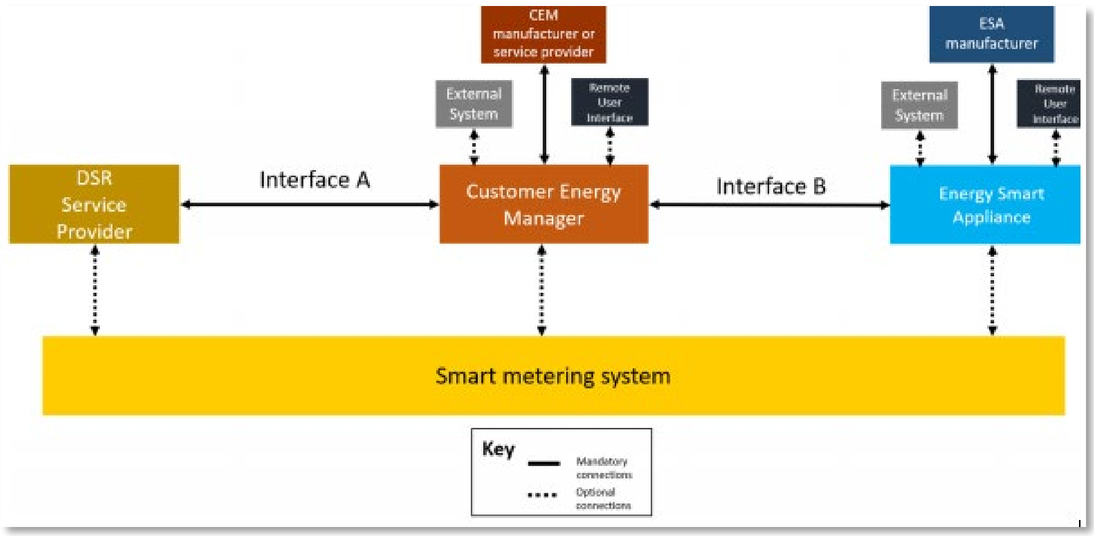

Figure 3 Diagram taken from the draft PAS 1878 (Section 5.1)

The draft PAS 1878 also draws on the European Technical Standards Institutes (ETSI) Standard 103 645 – "Cyber Security for Consumer Internet of Things"[33].

Together, the draft PAS 1878 and ETSI standard 103 645 have the potential to significantly strengthen the case for EV charging control outside, or partly outside, the SM system, particularly in the areas of cyber security, avoiding synchronised switching and automatic frequency response. Draft PAS 1878 contains significant amounts of detailed information – running to 123 pages in all, including 11 pages devoted to cyber security. However, as PAS 1878 and PAS 1879 have not been finalised yet, it is not clear whether they will be implemented in their current form, or whether adherence to them will be voluntary or mandatory. It should also be noted that PAS 1878 envisages systems that are compatible with the GB SM system, and BEIS has previously made clear that it expects PAS 1878 to ensure compatibility with smart meter technologies, specifically full compatibility with the GB SM system.

4.6 CYBER SECURITY

The introduction of significant numbers of EVs and their associated smart charge points will have a major impact on the usage of power in the home, the distribution system and wider grid at a national level. The electricity grid forms part of the UK's Critical National Infrastructure as, if it is lost for any significant amount of time, it would inevitably lead to loss of life.

Cyber attacks from external sources are rising[34]. In addition to external sources, attacks can also originate from internal sources, such as disgruntled employees and contractors.

There are multiple potential attack vectors within the EV charging ecosystem that could impact the charge point's behaviour to disrupt the usage of energy, such as an external hacking attack on any of the various components in the charging infrstructure, including the CPO, the charge point itself, or the EV and/or its manufacturer. The risks involved will need to be assessed and controls developed to ensure that the impact of smart charging on cyber security is understood and risks are mitigated.

That said, there are already multiple EV charging solutions operating across the globe as well as in Great Britain without any of these solutions adopting a single, defined set of security-based standards. We are not aware of any notable cyber security incidents relating to the various EV charging network solutions, or reports of hacking of the individual consumer data collected over those networks to date. However, all the CPOs interviewed during the research phase of this report acknowledged the growing importance of cyber security, and the need to protect the electricity grid as the number of home-based EV charging points grows.

A number of the EV CPOs already operating in the GB market noted the need for Government (via its National Cyber Security Centre) to set clear expectations around standards the industry should adopt before the uptake of EVs reaches a level where any cyber attack could have the potential to significantly impact the electricity grid.

5 Changing Landscape

This section sets out current and future developments in the smart technology landscape that are or could be deployed at scale in the domestic energy market.

5.1 VIRTUAL POWER PLANTS

With the introduction of large numbers of domestic batteries and EV with V2G capabilities, the concept of a 'virtual power plant' is being introduced to use aggregated generation, storage and/or demand to dynamically supply energy to the grid, or to reduce loads on the grid on both network scale and domestic levels.

A virtual power plant is where multiple energy sources and loads are centrally controlled towards an optimal outcome, based on machine learning and understanding of price, load and generation forecasts.

5.2 ENERGY SUPPLIER PROPOSITIONS

Many energy suppliers are already offering innovative customer propositions to affect demand using EVs, with around a dozen time-of-use tariff offerings currently available[35]. An example is Octopus Energy's Agile Octopus tariff which provides an API (technically how apps access data) to allow other developers to obtain live tariff pricing data that supports a price-based charging control system. This allows the consumer to take an active part in the smart charging of their vehicles. Using the Agile Octopus tariff, consumers can set a schedule for charging their EV vehicle based on half-hourly pricing provided a day ahead. For the less engaged consumer, the Octopus Go tariff provides a cheap 4-hour tariff during the night the EV user can take advantage of to charge their vehicle.

It is likely that most energy suppliers will want to offer products and services to their customers that give flexible tariff options to incentivise EV load management.

5.3 BUNDLED PRODUCTS

In future electricity markets, consumers could be offered bundled packages when they purchase or lease their EV. For example, a seller could include a charger and discounted energy in return for allowing the manufacturer or retailer to use the car as an aggregated asset for Fast Frequency Response or balancing services contracts. This could build new revenue streams for the retailer or manufacturer by supporting balancing and DSR while providing consumers with cheaper energy and lower costs for installation of home charging solutions. The lower costs would also incentivise the consumer to ensure the car is plugged in and available for inclusion in these services more regularly at home. The benefits of this might be enhanced by new, post-COVID working models with more limited commuting, leading to increased time when the vehicle is parked up and connected. A recent indicator that this model is being evaluated is Tesla receiving a GB electricity generation licence.

5.4 FREQUENCY CONTROL

A potential autonomous way of protecting the grid is for the charge point to monitor the frequency of the grid locally and make local decisions after it receives a command to change mode. For example, if the grid frequency is below 49.4Hz (or other preconfigured frequency) and the charger receives a remote EV charge command, it could behave in the following ways:

- Refuse to switch on. Wait for 2 minutes and then re-try.
- Send a signed command back to the CPO for authorisation to switch on.
- Start charging but at a restricted rate.

If the grid frequency is above 50.6Hz (or other preconfigured frequency) and the charger receives an off command, it could behave in the following ways:

- Refuse to switch off. Wait for 2 minutes and then re-try.
- Send a signed command back to the CPO for authorisation to switch off.

Frequency control at charge point level is an optional element of draft PAS 1878 (see section 5).

We believe that a semi-autonomous local response to extreme frequency excursions has considerable potential to protect the grid and possibly save balancing costs. This warrants further exploration with the ESO and charge point manufacturers.

6 Smart Metering Infrastructure

This section sets out the way in which the SM system could be used to control EV charging.

6.1 SMART METERING SYSTEM OVERVIEW

The functionality of the SM system is well documented, and change is control managed formally under the Smart Energy Code (SEC) arrangements through a combination of BEIS Transition Governance and SEC Enduring Governance (under the SEC Panel). Functionality includes the capability for electricity suppliers to control EV charging and other demand/generation downstream of the customer's meter. We are not aware of these control facilities being utilised by electricity suppliers and have yet to be demonstrated with domestic customers, although two Government sponsored trials are underway:

1. **Beyond Off Street: Smart Meter Electric Vehicle Charging Trial**. This trial aims to innovate around the use of SM to design, test, manufacture and trial an EV charge point device, for off-street parking, that can perform smart charging in a context beyond the existing smart meter roll out but using the DCC infrastructure[36].

2. **Demonstration Project of EV Smart Charging using the Smart Metering System**. There are two trials within this demonstration project:

   a. **EDMI-Led Consortium**. This trial aims to use EDMI's technical solution which integrates a SMETS2 meter with an electric vehicle charge point. An auxiliary load control switch (ALCS) will be used for load control. The ALCS is a switch within a smart meter designed to manage an appliance within a property[37].

   b. **EDF-Led Consortium**. This trial is similar to the EDMI-led consortium but aims to develop a home area network-connected auxiliary load control switch (HCALCS)[38] rather than a switch within the meter to control EV charging.

The SM system consists of three main elements (see Figure 4):

- Interfaces with energy suppliers, network operators and other SM system users.
- A shared secure central SM infrastructure.
- Energy consumers metering installations.

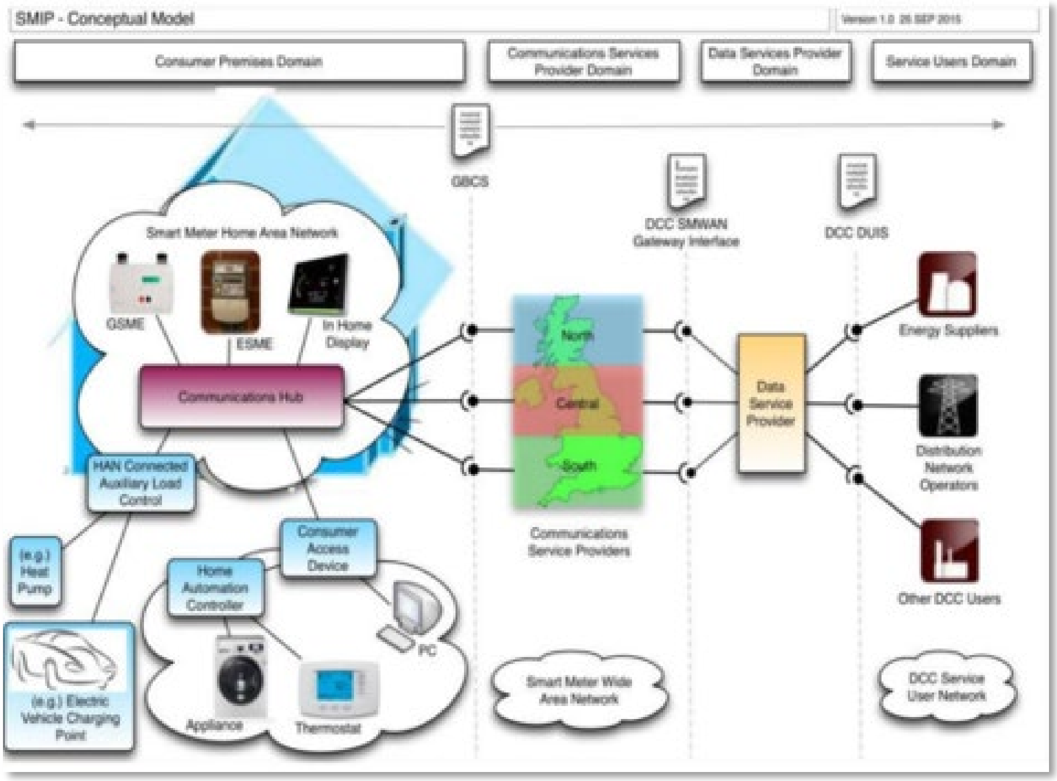

Figure 4 Conceptual model of the smart metering system (taken from the SMIP Technical Architecture Document)

6.2 SMART METERING SPECIFICATIONS

The latest GB SM specification[39] includes a new proportional control function for the electricity meter (ESME) with a built-in auxiliary proportional controller (APC), or a separate standalone auxiliary proportional controller (SAPC) device connected on the SM HAN. These devices can accept commands to limit the auxiliary load connected up to the SM system (ie limiting a particular auxiliary load to a set proportion of its maximum load, rather than limiting the overall load for the premises). The new proportional control functionality provides additional capability for an ESME with built-in APC function, or a separate SAPC device to vary the maximum input and output levels, where the input relates the energy flowing from the auxiliary load (generation) and the output relates to the energy flowing to the auxiliary load.

Enhanced proportional control functionality is intended for use in the effective management of significant loads such as electric heating systems and the smart charging of batteries and electric vehicles. The functionality allows for proportional control of that load, building on the existing specification that currently only covers on/off capability for auxiliary load. For example, the new functionality could allow an EV charger (when connected to the SM system) to be set to less than 100% power; therefore, maintaining the charging while reducing the demand on the electricity network, albeit it is likely to take longer to charge.

Industry has cited the binary nature of existing load control in SM as a barrier to its use for EVs. The Government's engagement with industry players in the EV and DSR sector has highlighted the demand for proportional load control functionality. This has now been added to SMETS2 V5. The ready availability of charging solutions (outside of SM) that do provide for proportional load control further demonstrates its necessity.

To make use of proportional load control functionality through the SM system, we believe the functionality could conceptually work as follows:

- CPOs will need to understand any change in maximum charging rate to determine whether they can draw down sufficient charge within the charging timeframe.
- An EV will be able to process the maximum input and output power that can be drawn via the EV/charger interface and determine the expected charge time.
- As this is functionality within the HAN, the EV chargers could monitor these signals to determine the charge rate being allowed; however, they would also need to understand the local conditions and priorities of supply availability from batteries, solar, etc.
- This functionality could be used at the meter level or on the SAPC to ensure that the total load in the household from the grid does not exceed the central load set by either the DNO, supplier or ESO by ensuring the auxiliary load connected up to the SM HAN is managed appropriately. However, local power availability also needs to be understood and communicated to the devices drawing load on that auxiliary load.

The DCC is currently testing this functionality in respect of the code for its central solution and it is planned to go live in November 2020. However, it is important to note that the functionality cannot be used until such devices are available in the market. An ESME with the proportional control functionality or an SAPC will still need to be designed, built, tested and deployed to take advantage of the DCC solution delivered as part of the November 2020 release. This is highly unlikely so we expect further developments from a device perspective in 2021 and beyond. Furthermore, the existing functionality on auxiliary load control and new functionality for proportional load control is only available to DCC users in the electricity supplier category. DNOs, ESO, CPOs, etc. cannot send commands to limit load on the SM HAN.

Further developments in Government's Smart Metering Implementation Programme (SMIP) are expected in coming months, supported by BEIS and SMIP, as well as a BEIS demonstration project on the ALCS and HAN connected auxiliary load control switch (HCALCS[40]). The project envisages potential communications both within and outside SM systems (see Figure 5).

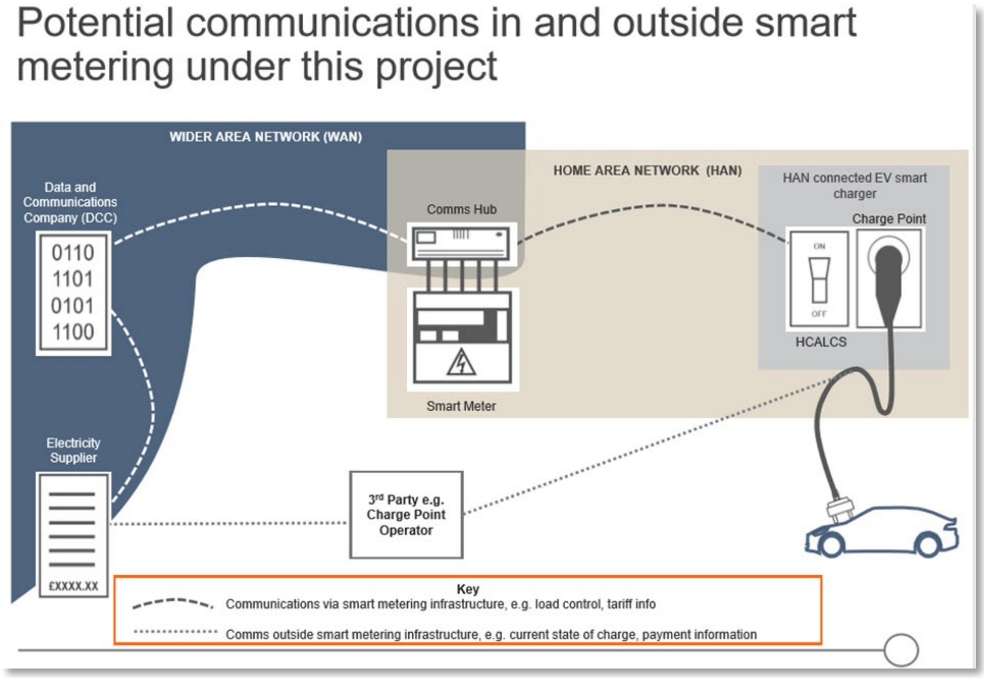

Figure 5 BEIS Diagram showing communications in and outside the smart metering project envisaged for the BEIS demonstration projects

6.3 INDUSTRY RESEARCH

As part of our research, we conducted interviews across a wide and varied segment of the Electric Vehicles Charge Point market. We found very limited support for SM systems in enabling the delivery of EV smart charging. Interviewees expressed various reservations, principally in the following areas:

- **Flexibility**. Some interviewees felt that the SM system does not have the capability to respond fast enough to enable future participation in flexibility markets such as Fast Frequency Response.
- **Data**. There is an incorrect perception that currently SM systems only communicate twice a day whereas CPOs communicate down to granular levels of seconds. Further to this, different vehicles have different algorithms so different signals are required. There is a view from many of the market participants that the SM infrastructure as it stands does not have either the flexibility or system capacity to take this into account.
- **Innovation**. Interviewees had concerns that using the SM system would stifle innovation and delay or prevent new market product offerings going forward. These concerns were based on the complexity, slow pace and cost of SM change and governance arrangements, which require SEC Modification Proposals to be submitted and assessed, before being voted upon by the Change Board and possibly going forward for determination by the Authority.
- **Cyber Security.** While the majority of interviewees felt that the rigorous cyber security requirements of operating via the Smart DCC were important, especially in terms of consumer and grid protection, they felt that the current market solutions in operation are built using similar ‘security by design’ principles (such as eliminating single points of failure, using message encryption, etc.). Many were also concerned that enforcing the SM security requirements at a device-level (for example, requiring all EV charge point devices to go through the Smart Metering Commercial Product Assurance regime) will add significant cost, and prevent or restrict innovation in the market as a whole.

Based on the interviews held as part of the research phase of this report, it is clear there are different levels of understanding of the SM system and its operational capabilities among organisations in the EV charging market. If Government is to continue to push a DCC-based solution for EV smart charging, further consideration is needed around how it might improve its wider stakeholder engagement activity to raise knowledge and understanding of how the SM system operates. Government will also need to consider how it can meet the demands of EV charging market participants more generally in order to allow continued innovation in terms of both technology advancements and customer product offerings.

6.4 ASSESSMENT OF DEMAND CONTROL VIA SMART METERING SYSTEM APPROACH

This section serves as a baseline to our consideration of the alternative EV-based demand control options set out in Section 7. It is for information only. As is the case in Section 7. The appraisal is undertaken with regard to the Government's stated requirements of any smart charging system (Section 7.1 describes these requirements).

Electricity Grid Protection

The SM system has existing protections in the energy supplier licences, Ofgem Regulatory Framework and SEC which place direct obligations on relevant industry parties to protect the integrity of the market overall. This includes the need to protect the electricity grid.

An SM-based solution benefits DSOs with direct access to relevant data provided by smart meters to help balance the GB network. This saves them having to create new or additional access routes via the CPO (or similar) and DSOs then having to link the two sets of data to enable it to be useful.

Extensive work has been done to ensure the SM system has strong cyber security. Government's security requirements for SM have been co-developed with the national cyber security centre (NCSC) and, as such, is equipped to prevent excessive swings in demand.

That said, there are no 'real world' trials of demand control via SM routes concluded yet and, as detailed in Section 6.1, it is difficult to make a meaningful assessment in relation to electricity grid protection at this stage.

Consumer Protection

The SM system has been implemented in a highly competitive retail energy market where consumer protection is embedded firmly in the relevant regulatory and governance frameworks. Despite there being no examples of EV charging demand control via the SM system to assess, it is difficult to envisage any SM system based solutions being allowed to deliver negative consequences for consumers.

If EV demand control was facilitated purely using SM system-based solutions, this would enforce interoperability between charge points (and charge point providers) and CPOs, on the assumption that all equipment used, and communications methods implemented in the overall infrastructure must meet defined standards and specifications. This would remove any technical restrictions that might influence customers' choice of EV charging service providers.

To date, CPOs have operated exclusively outside of the SM system. It seems unlikely that they would move voluntarily to operating via the SM system and, in order to facilitate this, significant changes would be required to both the regulatory framework and associated technical architecture to enable CPOs to control EV charging through the SM system (similar to the way energy suppliers can). Set against this is the protection afforded by the SM system, which many industry participants agree provides a formal regulatory oversight, as well as governance arrangements designed to protect consumers.

Consumer Uptake

It is noted that, because of delays to the progress of the smart meter rollout, as at 30 June 2020, only 32% of domestic meters are smart meters operating in smart mode. However, SM is approaching critical mass and Government plans are for all domestic premises in the UK to have smart meters by mid-2025.

The overall benefits of utilising the SM system to increase consumer uptake, particularly for those market participants already operating SM equipment, is that it will use the existing SM infrastructure already installed within the home to deliver the necessary communications to/from the EV charge point, and should deliver cost efficiencies in its delivery that can be passed on to end-users.

However, these benefits are unlikely to be seen by those that operate purely in the EV charging market using non SM-based solutions. That said, many of the non-SM EV charging solutions in existence already utilise (or plan to utilise) the consumer's existing broadband/WiFi connection as a means of connecting the EV charge point to the CPO; therefore, there are clear arguments that similar cost efficiency benefits may be available to non-SM solutions too.

It may also be the case that for those customers who have previously refused to take a smart meter, they may be incentivised to do so if they see benefit relating to their EV usage. We see little argument to suggest that the exclusive use of either the SM or non-SM routes would leave sizeable customer cohorts unable to access the benefits of smart EV charging.

Although strictly outside the scope of this report, it is worth noting that the SM infrastructure does not extend to the higher capacity electricity connections typically used by larger commercial and industrial customers and public charging infrastructure, so could not provide a demand control option for these.

Innovation

At the time of writing this report, there are no published trial results for demand control using the SM system (as referenced in Section in 6.1). Therefore, it is difficult to accurately assess the innovation capability of the system. However, change to the SEC and associated SM infrastructure is typically costly to deliver and slow to implement, and would likely prove daunting to OEMs/CPOs unversed in SEC procedures.

SM is currently being used to manage the load on electrical heating systems so the capability to use half-hourly or block tariffs is already available The system's built-in event and alert capability also provide users with options to trigger innovative communications or pricing signals that incentivise consumers to change behaviour.

Based mainly on the feedback received from CPOs (which reflects CPOs' understanding of SM capabilities and associated governance arrangements that dictate the speed and cost of change), they have concerns that any dependency on the SM system would inhibit their freedom to innovate and deliver competitive products and services. We are also conscious that any change to SM systems needed to accommodate innovations in EV charging control is likely to be slow and expensive, given the associated governance processes and the extent of development and testing work required.

7 Assessing Smart Charging Solutions Against Objectives

This section of the report presents the assessment of the various alternative routes to EV smart charging. In Section 6, we showed the extent to which an SM-only solution would meet the Government objectives set out in detail in Section 7.1 below. Having done so provides useful context when considering the alternative options. At the end of Section 7 we have provided a summary of our assessed options in table form.

7.1 GOVERNMENT OBJECTIVES

The following high-level analysis examines options for EV charging demand control that do not entirely rely on the SM system through the lens of Government's objectives[41] to encourage consumer uptake and innovation, while avoiding negative consequences for electricity grid protection (including cyber security) and consumer protection (including interoperability). Additionally, we consider in Sections 7.2 and 7.3, where relevant, whether the options support interoperability and cyber security. We call this out where required within the assessment against the four Government objectives.

Electricity Grid Protection

Electricity grid and network protection will be enhanced if:

- EV charging behaviour that is already shifting load away from network peaks (thus avoiding the need for reinforcement) continues and increases as the home EV charging market matures.
- Switching times are prevented from being synchronised precisely across large numbers of chargers at the same start/finish times thus avoiding large step-changes in demand.
- Control of charging is achieved by many, distributed, partly autonomous devices. This avoids single points of failure that could have widespread consequences.
- The potential for hostile actors to interfere with the electricity system by manipulating EV charging is mitigated effectively to avoid cyber-based risk.
- EV charging solution providers are free to offer services helpful to the local DNO and/or to the ESO on a commercial basis.
- Potentially, the smart meter has final control of the load being drawn from the distribution network for EV charge points. This recognises that the regulatory framework currently only allows the electricity supplier to control this.

Consumer Protection

Consumer protection will be enhanced by:

- Customers having access to choose from suppliers and tariffs, charge point providers, vehicles and providers of aggregation services at all levels of the market.
- Customers' having the freedom to change electricity supplier is not compromised by them changing their electric vehicle, charge point or CPO.
- Having interoperable charge points so that customers can change CPO without having also to change their charge point. Note that this may be subject to contractual constraints or considerations – eg where a charge-point has been bundled with a tariff or wider EV package, there may be break clauses if the customer wishes to break the contract early.
- Underpinning clear regulatory requirements and relevant obligations on industry and market players who provide products and services to consumers.

Consumer Uptake

Consumer uptake of EVs will be encouraged if arrangements for home smart charging:

- Are priced attractively.
- Are not overly complex.
- Have clear benefits.
- Make it simple, attractive and flexible for potential EV users to charge their vehicles at home.
- Do not present barriers in terms of cost, risk, ability to charge when urgent, etc.
- Allow users to have a broad variety of charging control options available to them, ranging from simple 'plug in and charge', through to various energy cost/carbon optimisation apps and fully integrated control of the home energy ecosystem, which may include a variety of LCTs, V2G, etc.

Innovation

Innovation will be encouraged if:

- It is easy to develop, test and trial new ideas without onerous regulatory hurdles and market costs.
- Obligations to deliver consumer protections are clear and simple.
- Risk of technical or regulatory obsolescence does not present a significant barrier to market entry.
- Innovations developed outside of the UK are considered on an equal basis to homegrown innovations (recognising the need to adhere to relevant UK regulatory controls and standards).
- There is stability in policy and regulation that gives clear and reliable foresight into revenue streams and opportunities to innovate.

7.2 DEMAND CONTROL VIA NON-SM ROUTES

This section looks at EV charging delivering demand control via routes that are completely independent of the SM infrastructure or systems, as is the case today in the nascent market for EV-led demand response. Signals sent by such routes may originate from a 'traditional' CPO or from the car and/or its driver (see Section 7.3 for discussion of the latter).

In this and following sections we use diagarams (such as figure 6 below) together with a table setting out the the associated 'actors' and their roles.

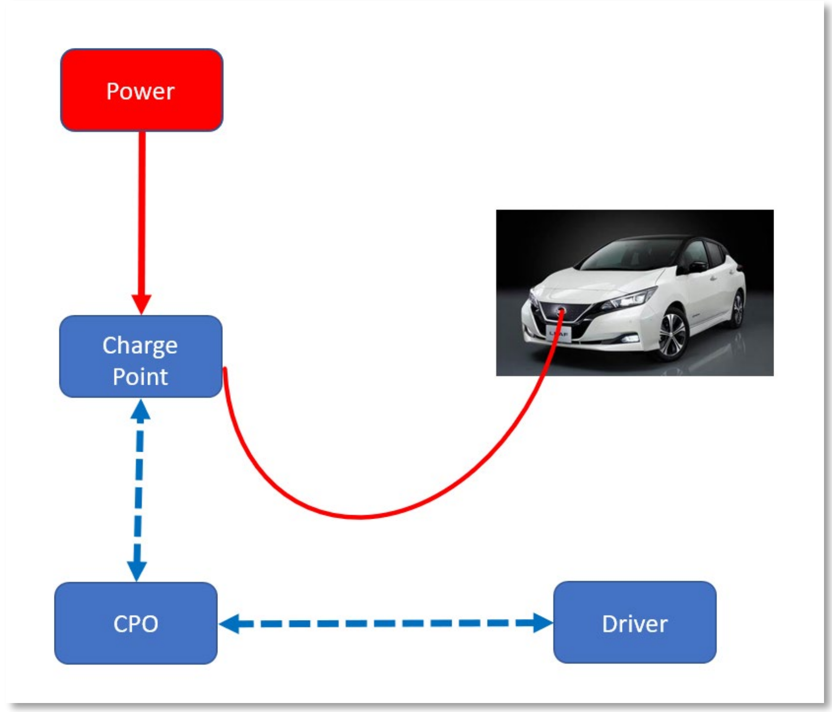

Figure 6 Simple schematic of demand control via non-SM routes

The Actors

ACTOR	ROLE
Network Operator	Managing the local and national networks.
Energy Supplier	Managing the customer's power supply contract.
Charge Point Operator	Provider of, and controller of power to the EV charge point.
The Electric Vehicle	Receives charge from the charge point.
The Driver	Signals charging requirements to the CPO.

Control of EV charging via non-SM routes will involve:

- **An EV charge point installed at the user's home and connected to their domestic electrical wiring installation**. Around 40 charge point manufacturers provide charge points for residential applications, with most companies providing two power ratings which are permitted under the Homecharge Scheme: 'Standard' and 'Fast' AC charging. For Standard AC charging, the rating is 3.5kW or 7kW with a single phase. Fast AC charging it is 7kW or 22kW using either a single of three phase supply.

- **A CPO that is either a 'traditional' CPO or the connected EV**. A CPO in the traditional form provides the hardware and software platform to charge the EV with reference to a charging schedule based on customer requirements. In some instances (with customer agreement), the CPO can have control of demand management on behalf of the customer, with the customer having the ability to override the charging schedule in time of need. Further to this, new innovative software companies are coming to market with services that manage EV charging automatically on behalf of the customer, for example, optimisation for 'greener' and/or cheaper charging.

- **A means of communication between the charge point and the CPO.** Typically, this communication is carried over a mobile network or an internet connection. This form of communication provides the CPO with the ability to receive real-time data on the charge point's performance, send necessary firmware (software) updates and provide the customer with the functionality of real-time charging data via a smartphone. This activity does not typically require any additional telecommunications infrastructure; however, its limitations bring challenges in areas with poor data and broadband connectivity.

- **An interface between the customer and the CPO (such as a smart phone app or internet web portal).** This typeof interface gives the customer information about the charge point's energy usage, costs, carbon intensity, etc. and allows them the ability to control their charging requirements (eg charge immediately, charge at cheapest time, charge at the lowest carbon time or fully charge by .....) by sending data to the CPO in real time

There are innovative, integrated businesses operating in the world of EV smart charging already using non-SM routes. An example of this in the UK is Octopus Energy who are pioneering an end-to-end EV offering. Their offering incorporates the ability to lease the EV, have a charge point that provides smart charging capability and a flexible energy tariff that allows charging of the vehicle based on attractive energy costs utilising renewable power. This is a model that is likely to grow in popularity as consumers look for a one-stop-shop for car ownership and reduces the CAPEX expenditure required to install a charge point independently.

Assessment of non-SM option against Government requirements

Consumer Uptake

To date, delivery of demand control via non-SM routes is the solution used for all EV home charging in GB, including for large-scale trials such as EATechnology/SSEN's My Electric Avenue[42] and WPD's Electric Nation[43]. Demand control may be used to simply optimise the energy costs of EV charging or may have wider uses, such as mitigating demand peaks on the local network or providing demand side services to the ESO.

These trials have already provided some evidence that the delivery of demand control via non-SM routes is likely to be acceptable to many home EV charging users:

- Learning from My Electric Avenue includes:

"……. use of the technology did not cause significant inconvenience or unacceptable loss of service to EV users, with the majority declaring themselves comfortable or very comfortable with Esprit being able to curtail their charging."

- A key finding of the Electric Nation trial was:

  "Trial data shows that Time of Use incentives appear to be highly effective at moving demand away from the evening peak – particularly when supported by Smart Charging (with an app), which makes it simple for the user."

While the evidence of consumer uptake from these trials is not conclusive (since they focussed on a relatively small number of 'early adopters'), it is nonetheless encouraging in terms of likely future uptake of demand control via non-SM routes. It is also the case that non-SM solutions continue to demonstrate growth in terms of installation numbers, adding some evidence that consumer uptake is not influenced by the technical delivery mechanism of their chosen EV charging solution.

Innovation

Our discussions with CPOs revealed their strong preferences for control solutions that do not rely on the use of SM infrastructure, and this remains the predominant approach in the UK. These preferences seemed to be founded mainly on the flexibility these approaches deliver (in terms of cost and speed to delivery, and their ability to continue to innovate), and a wish to develop and operate products and services suitable for application across a range of different countries and to control their whole value chain. No operators interviewed stated the desire to develop or offer services that depend on the SM system for their delivery.

In summary, CPOs stated that use of non-SM routes:

- Removes any dependency on smart meters (and the associate SM infrastructure) and the need to partner with an energy supplier or to become a Smart DCC User to access SM-based services.
- Removes any SM system technology or infrastructure constraints (notably cost and speed of delivery/implementation constraints) that may affect the CPOs current or future solutions.
- Provides flexibility in terms of timing and speed of change.
- Facilitates provision of time-critical services, such as 'fast-frequency' response.

Based on our interviews, it is not clear whether businesses who only act as CPOs have seriously considered, or have considered and dismissed using the SM system, or if they are fully conversant with the functionality it currently offers or may offer in the future. There may be an opportunity for Government, along with the SM community to reach out to CPOs (and other relevant market participants), to ensure they clearly understand how the SM system operates, what it can and may be able to offer in the longer-term, and how they might be able to influence this to meet their needs. That said, a lot of energy suppliers, such as Bulb, OVO and Octopus Energy, are offering or trialling smart charging capabilities as part of their end-to-end customer offerings. An assumption would be that these businesses are very familiar with SM, its capabilities and potential use case for EV smart charging. Yet, after careful consideration, at least at this point, they have decided that delivering EV smart charging capability is best delivered outside of the SM system.

In the light of the above, and the significant number of service providers and product offerings available to EV consumers, there is evidence to suggest that demand control via non-SM routes is already encouraging innovation and competition. There is also evidence that it is enabling and delivering quick response to market needs, and allowing innovators to access and 'stack' various future revenue streams. As noted above, control via non-SM routes is the method currently used by all CPOs in their business as usual applications.

From the innovation perspective, it is important to consider the forthcoming introduction and implementation of PAS 1878. While providing CPOs with clear design standards (which many agree will provide clear benefits in terms of 'device-level' standards), it may also be the case that PAS 1878 will also provide the necessary building blocks to improve areas such as cyber-security standards and general interoperability for equipment and communication methods.

Electricity Grid Protection

Large scale trials, such as My Electric Avenue and Electric Nation, have successfully demonstrated the ability of demand control via non-SM routes to shift electricity demand away from peak times, to avoid potential local network overloads, without any negative customer acceptance of such load shifting. We note that non-SM routes are the only option to have demonstrated this.

Also, further trials are also underway such as Project SHIFT, a partnership between UKPN, Kaluza, Octopus Energy and ev.energy, is looking at how smart charging presents opportunities to lower EV running costs while also reducing the impact of EV uptake on the grid.

At present, DNOs generally prefer to procure flexibility services through third party aggregators and other intermediaries rather than seeking direct control.

To evidence this, in 2019, UK Power Networks secured some 18MW of flexibility services through open market tenders to support its networks. Western Power Distribution is also active in the flexibility market with its 'Flexible Power Portal' that enables procurement of flexibility services for its networks. Independent flexibility marketplaces, such as Piclo Flex[44], have also emerged to help industry parties procure flexibility services via competitive tendering. In June 2020, UPKN became the first network operator in the UK to award contracts for smart charging to provide network flexibility[45].

However, SSE Networks is seeking the right to restrict or curtail EV charging in extreme circumstances to protect their network at a local level via the SEC (SECMP 0046) and the DCUSA (DCP371).

While trials have already shown it is possible to facilitate demand control that is beneficial to the local DNO and/or to the ESO, it is important to recognise they have done so with the full agreement and co-operation of the trial customers.

It is essential that any future solutions that feature demand control have the informed agreement of the customer, and that the customer shares in any benefits arising from provision of services. This may be an area in which a more formal, standardised framework could benefit customers.

To fully meet the electricity grid protection objective it will be important that:

- Demand control via non-SM routes can demonstrate that switching times can be prevented from synchronising precisely across large numbers of EV chargers.
- Control of EV charging can be achieved by many distributed, partly autonomous, devices.

- The potential for a hostile actor to interfere with the electricity system by manipulating EV charging has been addressed effectively.

However, the consultation draft of PAS 1878 includes functionality for both randomised offsets of switching times and frequency response, which have the potential to contribute to electricity grid protection.

From a cyber security perspective, finalisation and publication of PAS 1878 will provide greater clarity on Governement's expectations in terms of the standards required to ensure the electricity grid is adequately protected. Based on the feedback received from interviewees, many operators in the EV charging market appear to be suggesting a willingness to adopt appropriate security standards the Government specifies; therefore, the early adoption of PAS 1878 would be highly desirable, and likely to be favoured and adopted by the market as a whole.

Consumer Protection

EV charging solutions delivered via non-SM routes have already facilitated competition by delivering a wide choice of both charge point providers and CPOs. There is nothing to suggest that future solutions delivering demand control will reduce the choice of providers or operators.

However, it has yet to be demonstrated that customers can freely change CPO without having also to change their EV charge point due to the clear lack of device-level interoperability. The typical average price of a new smart charge point is around £900 for a typical 3kW slow AC charger. However, with current grants and financial support available (such as the OLEV installation grant of £350) this price could be brought down to around £550 on average.

From an interoperability perspective, there are already examples of EV charge point providers using different, bespoke equipment that is suitable only for their own solution. Any lack of technology interoperability at the device level is likely to be unhelpful to the consumer experience as it effectively restricts choice of CPO, assuming the costs associated with replacing the EV charge point being a significant barrier to switching CPO.

With the OLEV grant likely to have a sunset date as EV uptake gathers pace, any continuing absence of interoperability would make switching CPO both prohibitive and inconvenient for consumers. It is important to consider the ongoing developments in the standards/PAS space as these will be key to addressing any interoperability risks and protecting consumers.

Concerns around interoperability are common to all three options, and would be overcome if Government follows through on the proposal, made in the smart charging consultation, to mandate interoperability at the device level.

From a cyber security perspective, ensuring that the CPO's solution does not introduce new or additional security vulnerabilities to consumer-owned/provided communications channels (such as the customers' broadband/WiFi connection), protecting consumer data will be an ongoing consideration for the CPO community.

7.3 CONCEPTUAL FUTURE APPROACHES

This section details two possible future approaches to demand control EV home charging. One using the electric vehicle's charge control capabilities, the other using a hybrid of SM and non-SM routes. As before, these options are assessed against the Government's four objectives.

7.3.1 DEMAND CONTROL USING THE ELECTRIC VEHICLE

A possible alternative solution to EV demand control outside of the SM system is to use the charge control capabilities of the electric vehicle itself.

All lectric vehicles have the facility to charge from 'dumb' charge points, or even standard domestic socket outlets.

This section focuses on the current capability of EVs to provide an interface for the driver to manage their charging requirements. It also looks at the potential, in the future, for the EV to become a 'CPO on wheels', capable of controlling vehicle charging, reacting to external inputs (from an ESO or DSO, for example) and providing a range of flexibility services.

As things stand today, almost all vehicles have the capability to communicate with the manufacturer via a built in mobile network. It is these communications that make the vehicles smart and the mobile phone app functional; for example, providing the capability to conduct range checks, send navigation data and record location etc. For EVs this includes the functionality for the driver to input their charging requirements and instruct the car to control its charging by turning on an off charging circuits. However, EVs do not yet have all the capabilities required to take on the role of CPO to communicate with flexibility providers or (in emergency situations) with the ESO or DSOs, for example.

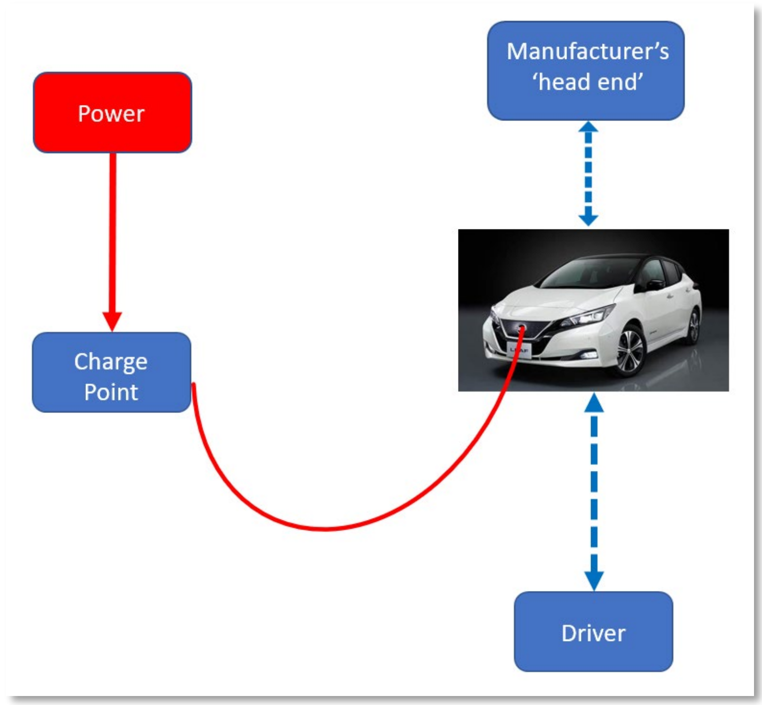

Figure 7 Simple schematic of demand control using the EV (with charge point in 'dumb' mode)

The Actors

ACTOR	ROLE
The Electric Vehicle	The EV manages its charging in accordance with the driver's requirements.
The Driver	Inputs charging requirements via the car's dashboard interface or via an app.
The Manufacturer's 'Head End'	Allows the manufacturer to monitor the vehicle and enables various driver applications.

The automotive industry is likely to seek to control more elements of their customer experiences. In the case of electric cars, this may include the driver's charging experience. It is also likely that manufacturers will want the facility to monitor and supervise their vehicles' charging – particularly if they have ambitions to participate in electricity flexibility markets or retain ownership of the battery in future.

To do this, the car will need the capabilities required to take on the role of CPO. This will probably include the facility to communicate with flexibility providers, and with the ESO or DSOs (in emergency situations) probably via the manufacturer's 'head end' system.

In the future, the charging ecosystem may look more like the illustration in Figure 8.

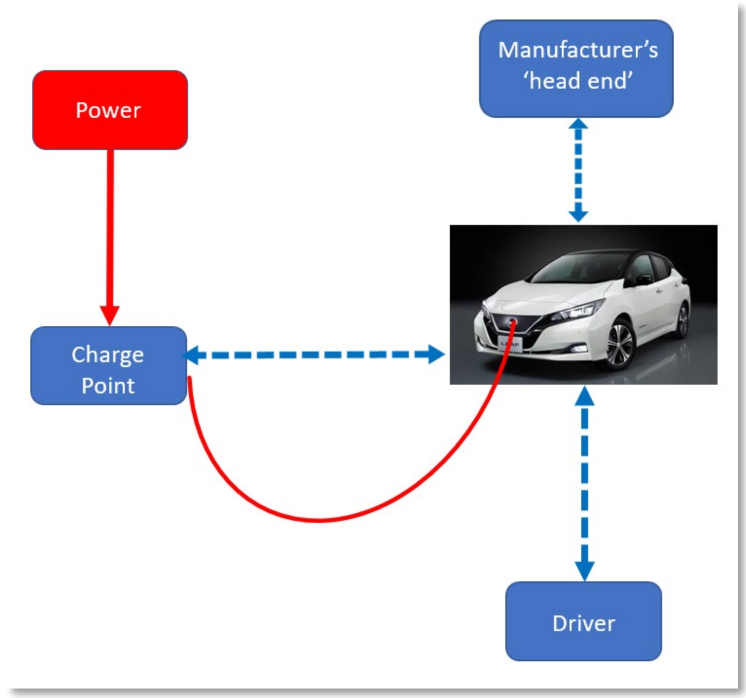

Figure 8 Possible future schematic of demand control using the EV (with the car in the role of CPO}

The Actors

ACTOR	ROLE
The Electric Vehicle	Manages its charging in accordance with the driver's requirements and any flexibility service or emergency network requirements, by controlling the charge point in the role of CPO.
The Driver	Inputs charging requirements via the car's dashboard interface or via an app.
The Charge Point	Receives and carries out instructions from the car (in the role of CPO).
The Manufacturer's 'Head End'	Monitors and supervises the vehicle's charging, overlaying any flexibility market or (emergency) networks requirements.

EVs already feature powerful computing and communications that provide the technology and functionality to allow EV owners to schedule and control the charging of their vehicle, either via an app or using the vehicle's dashboard interface and charge control system. However, development of this scenario is at an early stage as car manufacturers start to understand the opportunities that the transition to EVs provides to their business models. Furthermore, the automotive industry recognises that moving to a model where the car is the sole vector for delivering demand management of EV charging could present challenges in the management of the energy system.

EV smart charging through the vehicle could be refined further to encompass communication with the charge point. This will be made simpler if PAS 1878 is adopted widely, standardising charge point interfaces.

There are several developments in the market in this space:

- Octopus (a large energy supplier) with its Agile Octopus tariff already provides an API to allow other developers to obtain live tariff pricing data that supports a price based charging control system.[46] and this is already being used to control charging.[47][48] Using the Octopus Agile tariff, consumers can set a schedule for charging the vehicle based on half-hourly pricing provided day ahead and for the less engaged consumer the Octopus Go tariff provides a cheap 4-hour tariff during the night which the EV user can take advantage of to charge their vehicle. This innovation provided by Octopus, is a transition model for what EV control of demand control could look like.

- Tesla has recently obtained a GB electricity generation licence with the aim of developing virtual powerplants using its 'Autobidder' real-time trading and control platform, which aggregates distributed energy resources to balance supply and demand between its customers.

- In Germany, Volkswagen has created an energy supplier called Elli under the Volkswagen umbrella. The purpose of this company is to provide its customers with an end-to-end experience where they can purchase an EV, charge point and smartphone functionality to actively manage demand and charge the vehicle using renewable power.

Assessment of vehicle-led option against Government requirements

Electricity Grid Protection

EVs currently use a rectifier and charge manager to regulate the electric current entering the car's battery to avoid damaging it. The charge manager could also enable control of the demand being drawn from the home charge point for other reasons, such as network protection. This could ultimately mean that the smart charging features of home chargers become redundant as the car takes control.

This type of smart charging control would be effective irrespective of the connection to the network (eg changing from a remotely controllable dedicated charging point to a conventional 13A socket without any load control, which EV drivers who feel overly managed will likely do). However, using the car as the sole demand manager would ultimately mean unconstrained access to the energy network to charge. Therefore, further consideration is required to understand how EVs are integrated into the DSR framework to ensure that demand requirement can be managed at times of network stress.

From a cyber security perspective, car manufacturers already have stringent protocols in place to ensure vehicles are safe from external attacks. This is strengthened by the fact that vehicle manufacturers have to comply with ISO 27001 and the recently created World Forum for Harmonisation of Vehicle Regulations framework on cyber security and software updates. Furthermore, two new international standards are being developed: ISO 21434 "Road vehicles—Cyber security engineering"[49] and ISO/AWI 24089 "Road vehicle – Software update engineering"[50], which will further strengthen the cyber security credentials of vehicle manufacturers.

Consumer Protection

There are already stringent legislative and regulatory obligations on vehicle manufacturers that require them to ensure they provide a vehicle that is of satisfactory quality, fit for purpose and as described. With the addition of the new standards, it is safe to assume that there will be sufficient consumer protections in place relating to the car itself.

Using the vehicle as the delivery mechanism for smart charging would also give the consumer a single point of contact to resolve any car and/or charging related issues often via the car's own connectivity that provides voice, diagnostics, location and connection data.

From an interoperability perspective, it is important to track the ongoing developments in the standards/PAS space as these will be key to ensuring interoperability and protecting consumers.

Consumer Uptake

To date, while EV owners may be able to utilise the functionality and capability of their vehicle to control when it charges, charging control is facilitated by the charge point in all the current solutions operating in the market. In future, many drivers are likely to look favourably on using their vehicle as an interface for smart charging. This makes the process simpler and means the driver does not have to engage with other smartphone or web apps to understand and control their vehicle's charging.

Using the car's interface to control its charging would enhance the overall ownership experience for many EV drivers; thereby, encouraging consumer uptake.

Consumer uptake could be enhanced further if the car could take control of all its charging needs at home, at the destination and en-route.

Innovation

The automotive sector is constantly innovating to provide the customer with new functionality and technology (often by way of firmware updates for existing customers and new models) to ensure it is keeping up with technological advances. This will be the case for innovative solutions to be developed for flexibility services and the likely interface between the car and the smart home as homes transition to become 'prosumers'.

From an interoperability perspective, in a similar vein to the non-smart meter option, the introduction of PAS 1878 will provide standards the charge point and car interface have to follow as it becomes a demand manager. However, it has slightly less risk of stifling innovation due to there being more flexibility for vehicle manufacturers to constantly innovate their product designs outside the constraints of the smart energy/DSR market. That said, vehicle manufacturers will have to ensure they work closely with the energy market so that any new products provide the stability and rigour to conform with the standards.

As the number of EVs grows, their potential to provide flexibility to the energy system – either by altering their charging times or by providing V2G storage capacity – will become increasingly valuable. However, further consideration will be required to understand how EVs are integrated into the DSR framework. This will then require the automotive sector to consider whether it will need to enter the energy market as direct participants or if it will prefer to do this via established energy industry players.

7.3.2 DEMAND CONTROL VIA HYBRID (SM/NON-SM) ROUTES

This section looks at control of EV charging via hybrid (SM/non-SM) routes that depend partly on SM infrastructure or systems.

We are not aware of any current examples of hybrid control of home EV charging, whether in trials or business-as-usual deployments in the industry. That said, while hybrid control could be in different forms or models conceptually, we envisage this consisting broadly of a system for day-to-day control of charging that is outside of the SM system.

The SM system, as described in Section 6, will facilitate auxiliary load control via the SM HAN, using either an ESME with built-in ALCS functionality or HCALCS. Or, in future, an ESME with built-in APC functionality or an SAPC connected to the SM HAN.

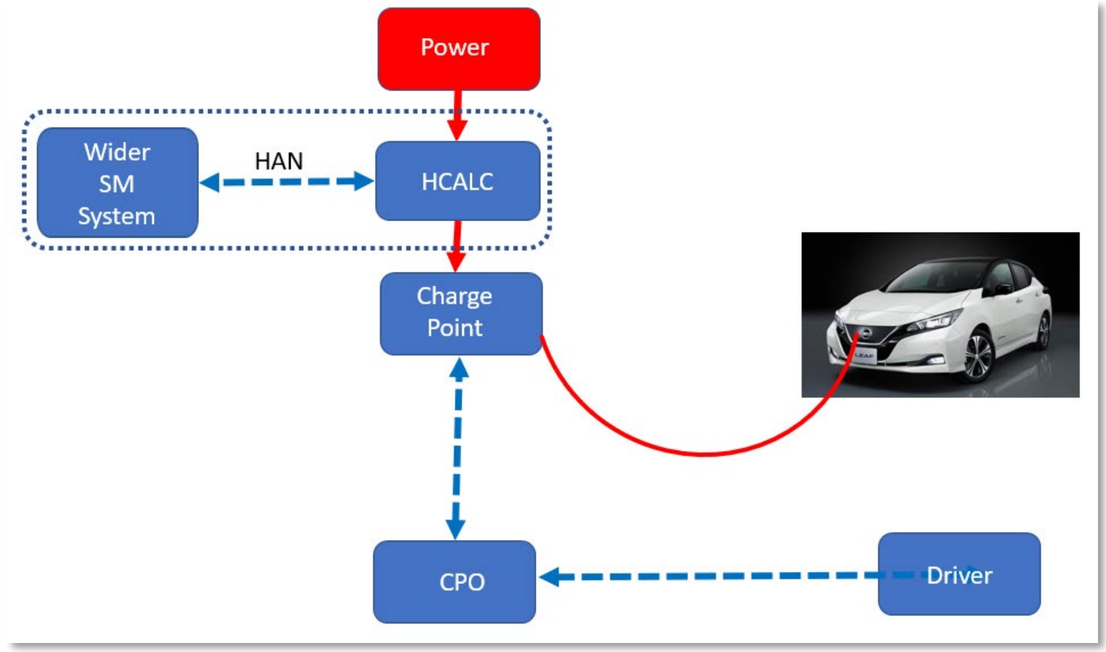

Figure 9 Simple schematic of demand control via hybrid (SM/non-SM) routes

The Actors

ACTOR	ROLE
Network Operators	Managing the local and national networks.
Energy Supplier	Managing the customer's power supply contract.
Charge Point Operator (or EV in a 'car as CPO' scenario)	Demand manager for the EV charge point (constrained using the SM system where appropriate in this conceptual hybrid solution)*.
The Electric Vehicle	The EV may signal its state of charge to the charge point, or its role is passive in this scenario.
The Driver	Signals charging requirements to the CPO.

* Current regulations mean that, if the SM system was to be used in this way, only the energy supplier is permitted to send demand management signals to the HCALC.

In normal circumstances, when no supervisory intervention is required via the SM system, the CPO will receive the driver's requirements and send instructions to the charge point as normal. However, in exceptional circumstances, the SM system can be used to send an instruction to block or reduce the flow of power to the charge point.

Assessment

We have assessed both the SM (see Section 6.4) and non-SM (see Section 7.2) options already in this report. The extent to which this option meets Government requirements is largely what has been stated in those previous assessments, which we will not repeat here. However, the fact that a hybrid option by definition allows a best of both worlds approach warrants further exploration in a number of specific areas, including innovation and interoperability.

In summary:

- In all normal circumstances, the hybrid solution would operate in the same manner as the non-SM solution and attract the same assessment.
- In rare, abnormal circumstances, the hybrid solution would operate in the same manner as the SM solution and attract the same assessment.

7.4 SUMMARY TABLE OF ALTERNATIVE OPTIONS

REQUIREMENTS	DEMAND CONTROL VIA NON-SM ROUTES (7.2)	DEMAND CONTROL VIA HYBRID (SM/NON-SM) ROUTES (7.3.1)
Electricity Grid Protection	Trials have successfully demonstrated the ability of demand control via non-SM routes to shift electricity demand away from peak times. From a cyber security perspective, the early adoption of PAS 1878 would be highly desirable based on the security standards it sets out.	Using the car as the demand manager would ultimately mean unconstrained access to the energy network to charge; therefore, further controls may need to be put in place to ensure that demand requirement can be managed at times of network stress. Car manufacturers already have stringent cyber security protocols in place to ensure that the vehicle is safe from external attacks. Vehicle manufacturers have to comply with ISO 27001 and the recently created World Forum for Harmonisation of Vehicle Regulations framework on cyber security and software updates.
Consumer Protection	EV charging solutions delivered via non-SM routes have already facilitated competition by delivering a wide choice of both charge point providers and CPOs. There is nothing to suggest that future solutions delivering demand control will reduce the choice of charge point providers/operators.	There are already stringent legislative and regulatory obligations on vehicle manufacturers that require them to ensure they provide a vehicle that is of satisfactory quality, fit for purpose and as described. It is important to consider the ongoing developments in the standards/PAS space as these will be key to

	It is yet to be demonstrated that customers can freely change CPO without having to also change their EV charge point. The typical average price of a new smart charge point is around £900 for a typical 3kW slow AC charger. There are examples of EV charge point providers using bespoke equipment that is suitable only for their own solution. Any lack of interoperability will be unhelpful to the consumer experience by restricting the choice of CPO and placing cost barriers to change CPO.	addressing any interoperability risks and protecting consumers.
Consumer Uptake	Demand control via non-SM routes has proved acceptable to many home EV charging users. Trial studies showed Time of Use incentives as highly effective at moving demand away from the evening peak, particularly when supported by smart charging (with an app).	Charging control is facilitated by the charge point in all the current solutions operating in the market. However, in future, drivers are likely to look favourably on using their vehicle as an interface for smart charging.
Innovation	CPOs are constantly innovating to develop and operate products and services that are attractive to customers. They have a strong preference for products that are applicable across a range of different countries. CPOs typically seek to control their whole value chain and prefer to avoid or limit reliance on third party infrastructure, such as the SM system.	The automotive sector is constantly innovating to provide the customer with new functionality and technology to ensure it is keeping up with technological advances. This will be the case for innovative solutions developed for flexibility services and the likely interface between the car and the smart home as the homes transition to become 'prosumers'. The introduction of PAS 1878 will provide standards which the charge point and car interface has to follow as it becomes a demand manager.

8 Conclusion

There are viable options for delivering EV smart charging at home that sit entirely outside of the GB SM system. However, work is needed to ensure these options provide the necessary consumer and electricity grid protections at scale.

The SM system currently plays no part in the control of home EV charging but has the capability to do so. Smart home EV charging is, in the main, conducted via CPOs using bespoke systems and communication channels between the CPO and EV charging point. We do not see this changing in the short term, but there are certainly viable medium-term options such as a hybrid (SM/non-SM) approach and/or using the EV as the control hub for smart charging.

A hybrid system could combine day-to-day control via non-SM systems, with a layer of supervisory control via the SM system in exceptional circumstances (eg serious grid imbalance), thus, ensuring the protection needed for networks and customers.

Industry trials, such as My Electric Avenue and Electric Nation, have already shown that demand control using CPOs alone is possible and effective from an electricity networks perspective, at least on a small scale, and is entirely acceptable to end users.

We have identified resistance to proposals to make use of the SM infrastructure to facilitate demand control of smart charging. This is despite clear signals from Government that this is its favoured approach as the market increases.

Innovation by car manufacturers has provided drivers with the ability to manage their charging requirements either via an app or the dashboard interface, giving them a seamless, end-to-end experience. This innovation has created a credible alternative solution for managing EV charging demand. However, the automotive sector recognises that any future solution will require collaboration between the transport and energy sectors to ensure that necessary protections are in place for managing the electricity grid in times of stress.

Our assessment of options makes it clear that the potential for innovation is high across the board, but alongside that is the potential for complexity. There are a number of things for industry to continue to support or consider for the future, all of which will help in steering towards a universally acceptable and low-risk solution design.

Implementation of draft BSI standards PAS 1878 and PAS 1879 will help mitigate many of the (perceived) current risks associated with solutions that sit outside of the SM system. Adoption of these standards should be encouraged from the onset, with a clear focus on the standards being in place to help ensure the Government's objectives of consumer uptake, innovation, grid protection and consumer protection are met. Implementation of these standards will also mitigate risks associated with technical, functional and end-to-end cyber security. To get the best out of the PAS standards, further industry work is needed to:

- Consider the requirements for regulating this area and establishing the necessary regulatory oversight and/or enforcement, thus, ensuring the delivery of the intended benefits from these standards.
- Assess whether compliance with PAS 1878 in its entirety is necessary or whether a more balanced approach is appropriate.
- Assess whether compliance with the standards should be applied prospectively to newly installed equipment only or retrospectively to all equipment.

It would also be beneficial for Government to reach out to the smart charging community to ensure there is a good understanding of how the SM infrastructure works today and could work in the future, and how CPOs might benefit from the SM infrastructure if any hybrid-type solution option is taken forward.

More work is also needed to ensure that customers can change their appointed CPO without the need also to change their EV charge point. This might include things such as:

- Standardising key terms and conditions of customer/CPO contracts.
- Standardising arrangements for communication and co-ordination between the old and new CPO during handover.
- Standardising communications with other interested parties during handover (eg energy supplier, DSO, aggregator, etc.).
- Standardising procedures for the handover of control from one CPO to another, including the state of a charge point on handover (eg fully operational with old settings, reset to 'factory settings', reset to industry standard default settings, etc.).
- Ensuring proper treatment of customer data during handover

Work should be initiated to gauge the appetite of the ESO (and future DSOs) for semi-autonomous, local frequency response, as described in Section 5.4

In addition to the above, work will be needed to ensure the increasingly large range of players within the home energy space do not interact in ways that might disadvantage individual players or customers. It is too early to anticipate the detail of what might be required here, but our expectation is that arrangements should aim to ensure that players are held harmless to others actions of which they are not aware. An illustrative example of this for the hybrid option might be a CPO who has contracted to provide a demand increment at a set time, but is prevented from delivering this by a DSO action via the SM system, which restricts EV charging demand.

Finally, and importantly, thought must be given now to how to ensure a consistent and high level of customer protection. Such work might be co-ordinated via an existing trade association, such as Energy UK, or may warrant a new, dedicated customer protection organisation for EV charging given how widespread it will become in the coming years. Any such work should include players from the automotive industry as well as the electricity sector.

Annex A

INDUSTRY CONSULTATION

LIST OF COMPANIES INTERVIEWED	
Centrica	Kaluza/Ovo Energy
EDF Energy	Shell Energy
Nuuve	Bulb Energy
Pod Point	Sero Homes
EO Charging	Moixa
Alfen	Utiligroup
Enel X	SMMT
Ford	REA
Flexitricity	Ihomer
SSEN	BEAMA

The list of interview questions were as follows:

1. Do you currently have any tariffs suitable for or targeted at EV users?
2. Do you provide a charging solution as part of this tariff or stand alone?
3. At what granularity does any tariff you would expect to be taken up by EV users operate, Daily, Half Hourly, less than Half Hourly (please specify), other (please specify).
4. Does your charging solution manage demand i.e. does it switch on / off energy consumption for the connected EV? If so, does it do this via the SM infrastructure, or alternative means?
5. Is this demand management 'fixed' i.e. pre-determined by a tariff/calendar or dynamic i.e. triggered by signals from an external source?
6. What communications infrastructure i.e. broadband, 4G etc is used to transmit your dynamic signals?

7. What security measures have been put in place to ensure these signals cannot be utilised by a hostile actor? (Please contact us if you would prefer to discuss this over a secure service such as Egress or face to face)

8. What protections and mitigations (such as offsetting) does your charging solution contain to ensure energy infrastructure is not overwhelmed by demand surges either locally or nationally? (if 'yes' please provide detail on how)

9. How would these protections work in conjunction with competitors' solutions to manage 'last mile' network load and wider grid frequency fluctuations where low pricing signals trigger demand?

10. Do you have any data that you feel would be useful in demonstrating consumer needs for smart charging and specifically how loads are currently being managed safely?

11. For the longer term, would you anticipate using the SM infrastructure to control EV charging, or alternative means? (if so, what means?)

12. Have you any concerns about taking on new domestic customers who already have EV charging equipment and services provided by their previous supplier?

13. If you provide EV charging equipment/services to your customers, what arrangements have you put in place to accommodate any subsequent change of supplier?

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