

REA POSITION PAPER

The **Interoperability** of public EV charging networks in the UK

Building on 'ad hoc' and creating the foundations for one of the best EV infrastructure networks in the world.



Table of Contents

	Welcome	6
	About this paper	7
	Executive Summary	8
1	Introduction	9-10
2	Background: EV Charging infrastructure in the UK	10
3	Interoperability of Public EV charging infrastructure in the UK	10
4	Structure, terms and Interoperability market actor	11-15
4.1	• Alternate Fuels Infrastructure Directive (AFID) and the emergence of 'ad hoc'	
4.2	• Automated and Electric Vehicles Act	
4.3	• Charging Business Models	
4.4	• Roaming platforms	
4.5	• Peer to Peer agreements	
4.6	• Enter the energy sector	
4.7	• Value Added Services	
4.8	• Building on Ad Hoc	
5	Towards common protocols and standards	15-16
5.1	CPO to MSP: proprietary protocols and independent protocols	
5.1.1	• Proprietary protocols	
5.1.2	• Independent protocol	
6	Details of Proprietary and independent protocols	16-21
6.1	• Open Clearing House Protocol (OCHP)	
6.2	• eMobility Inter-Operation Protocol (eMIP)	
6.3	• Open InterCharge Protocol (OICP)	
6.4	• The Open Charge Point Interface (OCPI)	
6.5	• Industry-led measures to achieve a more interoperable system in the UK	

7	Vehicle to charge point	21
7.1	What is the ISO 15118 vehicle-to-grid communication interface?	
8	Avoiding the potholes: the transparency of pricing example	22
9	Consider the fleet	22
10	Case Study – interoperability as enabling ZipCar’s electric growth	23
11	The Property Perspective: Understanding the value of interoperability for landowners and land managers (guest contribution from the expert team at Syzygy Consulting)	24
11.1	Landlords – a key stakeholder’s position	
11.2	Operational requirements will drive interoperability	
12	“Interoperability”: The need for a central definition	25
13	Towards a UK ID registration organisation	25-26
14	Previous Government charging strategies and support schemes	27-28
14.1	• Lessons from Plugged-in Places	
14.2	• OLEV Plug-in Vehicles Infrastructure Strategy (2011)	
14.3	• The Go Ultra Low City Scheme	
14.4	• Charging Infrastructure Investment Fund	
14.5	• The View of the National Infrastructure Commission	
15	Interoperability in Parliament: the Wiggin Bill and contactless payments	28-29
16	Approaches to interoperability in other markets	29-31
16.1	• USA	
16.2	• France	
16.3	• Norway	
16.4	• Germany	
16.5	• Netherlands	
16.6	• International Conclusions	

17	Interview process: methodology and findings	31
18	Industry perception of interoperability in the UK	31-34
	18.1 • Structure of the UK market	
	18.2 • Improving confidence	
	18.3 • Implementing AFID	
	18.4 • Implementing roaming beyond AFID and 'ad hoc'	
	18.5 • Emerging technologies	
	18.6 • Barriers to roaming	
	18.7 • Potential Government actions identified by interviewees	
	18.8 • Overall takeaways from the interviews	
19	In summary: the REA view on barriers to interoperability in the UK	34-35
	19.1 • Standardisation needed to develop energy services	
	19.2 • Incompatibility of charging networks' back office software	
	19.3 • Lack of integration with charging hubs	
	19.4 • Concern that interconnecting will be commercially detrimental for OCPs	
	19.5 • The view that customers primarily want an ad hoc solution	
	19.6 • Strong competition between charge point operators	
20	Conclusions	36
	With thanks to the contributors	37
	Endnotes	38-41

Welcome from **Dr Nina Skorupska** CBE FEI, CEO of the REA

Our energy system is undergoing profound change. The decentralisation and decarbonisation of power generation is taking place alongside rapid advancements in energy storage and a need for smarter, more efficient grids. Meanwhile, in the transport sector, historically siloed away from that of energy, rapid technology development is defining new supply chains and our industries are becoming intertwined.

Just as in energy, there is significant pressure in the transport arena to ensure that the push for decarbonisation goes hand in hand with quality consumer experiences and reduced costs. Achieving this requires industry collaboration with government, and for industry to collaborate within itself. We must ensure electric vehicles fully play their part in delivering energy system and environmental benefits – for example by providing grid services. For many stakeholders to fully decarbonise, such as fleets, steps must be taken now to ensure common systems are in place to make the transition to a zero emission future as straightforward as it can be.



This paper represents an important step towards that future as it encourages a broader industry discussion about consumer experience, about what ‘interoperability’ between networks can look like, and about how to prepare the energy and transport sectors to be increasingly aligned.

Daniel Brown, Policy Manager at the REA and report author

It is extremely important that the UK’s EV charging industry begins a discussion about what collaboration between charging networks could deliver for consumers, landowners, fleets, and others in the wider EV ecosystem. It’s also vital to begin a discussion about how interoperability between networks can be of benefit to the networks themselves. Allowing customers to roam between networks, both by embracing ‘ad hoc’ payments and going beyond it, is a key step towards achieving mass-market uptake. The breadth of interest and feedback received on this report has been very welcome and indicates willingness, and a need, for such a conversation to take place.



Clive Southwell, UK Manager at Allego and chair of the REA’s EV interoperability sub-group

Having watched the EV charging industry evolve in Europe over the last decade into the open interoperable network that now spans the entire EU and beyond, I have been baffled as to why this cannot extend to the UK. The technology and will exists to advance this conversation, and now is the time for industry to work together to deliver progress on this crucial issue. This document, the result of several months of talking, interviewing and persuading shows the breadth of support from all sectors of the Electric Vehicle value chain for the UK to take another step towards interoperability and, in doing so, move towards achieving the Government’s ambition to create truly world class charging infrastructure.



About this paper

The views expressed in this paper are those of the REA. This paper has been informed by structured interviews conducted with relevant market actors, including auto manufacturers, charge point operators, and roaming hubs, over the past six months (listed at the end). Additional informal interviews and discussions have informed this paper, including with members of the REA's EV Group. The drafting of this document was following requests by the members of the REA's EV Group members, and was debated by them at a meeting on the 30th January 2019. A list of REA EV Group members can be found here:

<https://www.r-e-a.net/membership/directory>

This paper refers primarily to public charging infrastructure in the UK (compared to domestic or workplace) and refers to payment systems rather than the interoperability of different plugs (eg CCS and CHAdeMO).



Executive Summary

The shift towards electric vehicles in the UK is gathering in pace and intensity. Propelled by a combination of technology development, supportive policy, and supply chain growth both at home and internationally, the UK Government is presently positioning itself as a future world-leader in electric vehicles, and seeks to deliver one of the best charging infrastructure networks in the world.

To deliver on our manufacturing and export ambitions in this emerging sector it is the view of the REA that we first need to build a domestic market. Key to doing so is the rollout of charging infrastructure and creating a positive consumer experience of using it.

The early movers in this sector took on significant risk and delivered a clear public good in the form of developing public charging infrastructure at multiple scales and in all corners of the country. From 2018 we have seen the number of actors in the market grow significantly – recent entrants include energy suppliers old and new, oil and gas majors, automotive manufacturers, and start-ups from London, California, and Amsterdam. Whilst the introduction of ‘ad hoc’ payments has been a useful step towards encouraging roaming across networks, for mass adoption to take hold many of these actors need to collaborate and embrace common protocols and standards. This could facilitate a superior consumer experience, open up the opportunity for integrated ‘value added services,’ and lay the framework for smarter engagement with the electricity system.

The UK is presently in a strong position to leapfrog the mistakes of, and to incorporate the lessons learnt from, other nations and propel itself into a world leadership position in relation to interoperability and developing an advanced public charging network.

This report is informed by primary and secondary research including structured stakeholder interviews. The REA has engaged over the past six months with market actors such as auto manufactures, domestic and international charge point operators, and roaming platforms. The REA concludes that the rollout of infrastructure here to date has been positive, that there is now an opportunity to bypass problems encountered elsewhere in the development of interoperability, that common standards should be embraced and that a central definition of interoperability is needed. In particular, in this report we outline:

- The benefits of a national charging network that embraces common communications systems which facilitate ‘value added services’ and ‘energy services’
- Industry-led solutions, which can be supported by Government, towards a more interoperable system
- A draft industry definition of ‘interoperability’ in the UK
- The benefits and drawbacks of the different roaming communications protocols, with a focus on Open Charge Point Interface (OCPI)

- The benefits and drawbacks of the industry adopting the ISO 15118 standard, a standard which could facilitate in-vehicle charging and smart charging
- The likely need to establish an independent organisation to facilitate interoperability, such as a Central Interoperability Register
- To truly create 'one of the best electric vehicle infrastructure networks in the world', the REA and its members believe that a conversation about 'going beyond ad hoc' charging is needed

We hope that these points can contribute to the on-going discussions, both within industry and Government, about the future of the UK's EV market, building an ever-better consumer experience, and priming the sector for greater energy sector involvement.

1. Introduction

2018 was a landmark year for the EV industry, with both significant policy proposals being put forward from Government and a multitude of commitments announced by global automotive manufacturers. The Road to Zero Strategy, a landmark document launched by Government, confirms the ambition for at least 50% of new cars to be ultra-low emission by 2030 in the UK, and for all new cars and vans to be 'effectively' zero emission by 2040. ¹ Furthermore, the Government's Sector Deal (a part of the wider Industrial Strategy) with the UK Automotive Sector demonstrates the Government's emphasis on the manufacturing of EVs and creation of high-tech jobs. The Sector Deal is aimed at maintaining the UK's position as a world leader in automotive manufacturing by increasing the industry's competitiveness and productivity to help the sector adapt to the transition to electric. ² This message was reiterated by the Prime Minister at the Zero Emissions Vehicle Summit in September 2018 ³, a global first-of-its-kind event.

Whilst supply of vehicles is a concern, increased domestic demand for EVs is needed in order to achieve the Government's ambitions to deliver the end of the sale of new conventional petrol and diesel cars and vans by 2040. A key component of this, in the REA's view, is to have more interoperability between charging networks which allows for consumers to access charging infrastructure across the country. This move should also sets up the sector so it can benefit from advanced features and for greater energy sector involvement. The introduction of 'ad hoc' payments in 2018 is a positive step but more can be done. Accommodation needs to be given to pay-as-you-go customers as well as customers who choose to enter a subscription agreement with a charging network.

Not only does an interoperable system increase the number of charge points available to drivers, it could also lead to greater visibility as to their location and status, and build confidence in the ability to charge when needed. This is important not just for those with personal cars and vans but for fleets, independent salespeople, and heavy haulage operators. Such a development does not preclude membership models, but can build on them.

Given the ambitions of the Government for the transport and manufacturing sector, and the unique structure of the UK charging market, a tailored UK-solution is needed to meet the challenge of the electrification of transport in this country. It is important, however, that we look to the experience other countries have had in implementing such a system and seek to 'leapfrog' the early growing pains that they experienced.

The charging industry is not the only sector to move from a system of largely closed networks to more open ones – the telecoms sector had a similar move, starting with closed networks based on regional coverage and transformed into what is now the ability for consumers to roam across any network in Europe using their standard mobile phone plan. Ticketing and payments in the UK public transport sector also has seen a similar change.

Rather than be an advocate for direct Government intervention, for example through legislation, the REA hopes the move towards greater interoperability between charging networks will be led primarily by industry with support from Government.

2. Background: Public EV Charging Infrastructure in the UK

The uptake of electric vehicles (EVs) has been rising steadily in the UK. The number of licensed plug-in vehicles rose to 190,000 in 2018, an increase from 3,500 in 2013.

⁴ Charging infrastructure has been growing as well, but lags behind that of the uptake of EVs. ⁵ The Committee for Climate Change currently projects that there will be a substantial need for both rapid and ultra-rapid chargers along motorways, as well as around 27,000 public chargers to meet the demand for charging by 2030. ⁶

The National Chargepoint Registry lists a total of 36 charging networks of which a handful are considered major in terms of their overall market share. ⁷ These include Pod Point, Ecotricity, Charge Your Car and Chargemaster POLAR, the latter two being part of BP Chargemaster. Ecotricity operates the majority of the UK's charging points at motorway service stations and there are also large networks with regional coverage such as ChargePlace Scotland, Plugged-In Midlands and Source London.

3. Interoperability of public EV charging infrastructure in the UK

At present, the EV charging market in the UK is characterised by large charging networks that operate vertically integrated systems with different approaches to access and payment. While exceptions exist, overall there are few cross-network agreements among UK companies. An example is Chargemaster's POLAR network which has a cross-network agreement with Charge Your Car. Chargemaster's Polar network operates a subscription service, Polar Plus, whose customers have access to Charge Your Car charge points as well as regional networks, whereas companies such as Pod Point and Ecotricity have no cross-network agreements to our knowledge.

The early movers in this market, partly supported by Government initiatives such as Plugged in Places, operate largely on membership-based models which require an app or RFID card. Since November 2018 all have introduced some measure of 'ad hoc' roaming. At present, the proprietary nature of many of the UK's charging companies back-office functions, be it own-brand or incorporated from a third-party such as Amazon Web Services, is a barrier to more open cross-network communications.

In the past 24 months the number of companies developing charging networks in the UK has increased significantly. Few of the UK networks, major or minor, are members of interoperability platforms. This stands in contrast to other countries where this is rapidly becoming the norm (as are direct peer-to-peer agreements). Examples include the Netherlands and Germany, although this has been in part driven by the sheer number of active networks in operation there. The variety of schemes for access and payments and lack of cross-network agreements results in UK consumers historically needing several cards, apps and RFIDs, and to maintain an overview of multiple memberships accounts.

4 Structure, terms and interoperability market actors

Before entering a full discussion on roaming and interoperability, it is important to define the various processes in place that guide charge point operation and the behaviour of market actors. There are three main tiers of relationships in place when a customer interacts with a public charge point.

- The relationship between the vehicle and the charge point
- The relationship between the charge point and the back office functions
- The relationship between the back office functions and the energy system / electricity supply ecosystem

Some operators manage these relationships through proprietary communications and data management systems whilst others incorporate standardised or open-source protocols.

A series of companies and roles also exist at different tiers between these relationships. For example:

- The Charge Point Operator (CPO) refers to the entity that manages the charge point
- The Mobility Service Provider (MSP) refers to the entity that offers the charging service to a customer. They often have contracts with CPOs, and in some instances CPOs also fulfil the role of an MSP. eMI3 Group has a useful definition relating to this, stating that “An EV-user can only use the Charging Infrastructure of a CPO if and when “their” MSP has a contract with that CPO to enable charging” ⁸
- Interoperability or roaming platform
- Peer to Peer agreements

Examples of a UK-based CPO which is also an MSP is BP Chargemaster, which both develops and manages charging infrastructure and has its own system for managing payments.

EV Driver is an example of a company which is only a CPO. They develop charging infrastructure and manage 14 charge points (28 sockets) in East Anglia. They work with Plugsurfing which is an MSP. Plugsurfing uses OCPI as a back-end communications protocol to negotiate roaming agreements with other networks across Europe.

These different structures may result in different approaches to interoperability from the variety of UK market actors.

4.1 Alternative Fuels Infrastructure Directive (AFID) and the emergence of ‘ad hoc’

The Alternative Fuels Infrastructure Directive (AFID) is an EU Directive that as of November 2018 (for the EV infrastructure sections) is fully implemented for new and existing charge point infrastructure in the UK. A core component of AFID is to mandate that all charge point operators need to offer customers ‘ad hoc’ access to their chargers. The provision of ad hoc access means that all new and existing public charge points must be accessible without entering a pre-existing contract.⁹ The Office for Product Safety and Standards is responsible for enforcing the regulations on behalf of the Office for Low Emission Vehicles, with a £1,000 penalty for breaching the regulation 5(2) on ad hoc access is for each non-compliant charging point.¹⁰

Pay-as-you go using a contactless credit or debit card is becoming a key means of compliance for many rapid charging developers, a solution offered by operators such as Engenie, InstaVolt and the Shell Recharge network.

REA VIEW: Whilst ensuring ad hoc access is an important move towards improving the customer experience, it is only a first step towards an interoperable system and does not result in a seamless experience of charging between networks partly due to the diversity of possible implementations. It also does not address the potential value-added services that shared communications and information between. CPOs can bring, or set up the charging network for full engagement with future energy sector products and services. Energy security, cyber security, mass EV uptake and smart charging are also issues that may be enhanced by ‘going beyond ad hoc’ that were raised in the interview process.

4.2 Automated and Electric Vehicles Act

The Act (July 2018) gives Government powers to ensure that charge points are ‘smart’ and able to respond to the needs of network operators and suppliers to manage demand. It also gives Government powers to standardise payments, ensure key charge point information is made public, and compel deployment at motorway service stations, which are important developments for the market. This may allow Government to introduce secondary legislation relating to interoperability in the future. **The REA thinks that an industry view on these issues is therefore important.**

4.3 Charging business models

Numerous factors determine why some CPOs opt for different structures to their business models. Prices for charging have evolved significantly since the early 2010s, where consumers would often pay a flat fee to use a charge point.

Fundamentally, the key parameters for a CPO that determine pricing are the length of charge duration, the rate of the charge, and the unit’s location. Some companies operate models where the rate of the charge impacts the price, others offer a flat pay-per-charge price, and some offer free charging on their private network after a customer has bought a particular vehicle. Others offer a top-up credit function where customers will put forward a certain amount of cash and to be deducted based on charging activities at a later point. Some operate a system where the maximum charge durations is set, following which a penalty will be incurred by the consumer.

4.4 Roaming platforms

Interoperability (or 'roaming') platforms have become commonplace in the charging market in the United States and Europe but remain less developed in the UK. A roaming hub uses proprietary protocols and allows the customers of individual CPOs to charge on other networks also associated with that hub. The hub will monitor EVSE usage and can settle payments between operators. The roaming platform does this for a fee. Several roaming platforms are in operation across Europe. They are typically associated with an automotive manufacturer – Gireve for example is partially owned by Renault and several German automotive manufacturers hold stakes in Hsubject.

These roaming platforms have played a crucial role in creating a seamless roaming experience for many consumers across Europe (and beyond). Criticism, however, has been raised of the level of data that some platforms have access to, and potentially do not share with the CPO. Criticism over their cost, and the need to use each platform's proprietary protocol, has also been found in relevant literature, in the structured interviews conducted with market actors, and in conversations had by the REA with industry stakeholders in the past months.

4.5 Peer to peer agreements

Another model of interoperability, one particularly associated with the Dutch company NewMotion and also with the company ChargePoint, is that of peer-to-peer agreements. These involve the negotiation of direct commercial relationships and agreements between CPOs to allow for a consumer to use multiple networks while using a single app or account, without the involvement of a roaming platform. NewMotion is understood to have negotiated over 200 of these agreements to date and does so via OCPI. These are argued to reduce CPO costs, allow for full data access, and reduce the potential for a CPO to be exposed to discriminating pricing that they could be exposed to on a roaming platform. ChargePoint has recently (Oct 2018) launched a roaming agreement with EVBox, based on OCPI, which enables EV drivers to roam between networks in Europe and North America. ¹¹

Whilst peer-to-peer relationships can reduce costs (compared to subscribing to a roaming hub) for CPOs, this can be offset by the potential upfront and on-going cost of employing a developer to incorporate different OCPI 'modules'. Additionally, CPOs would need to both take on the time and cost of negotiating direct commercial relationships and managing the legal relationships between networks.

4.6 Enter the energy sector

Charging is already a complex ecosystem and is expected to become more so in the coming decade as the energy sector becomes more involved, new services are incorporated, and the relationships between operators grows. Government policy such as the Road to Zero and the Smart Systems and Flexibility Plan are anticipated to facilitate more involvement from energy suppliers, aggregators, grid operators, and companies involved in the solar and energy storage market. The move by Tesla, Nissan, Renault, and as of January 2019 VW into the energy markets is indicative of this increasing complexity ¹².

'Smart charging' is expected to grow in prominence, for both domestic, workplace and public chargers, to help manage grid constraints and offer customers prices more reflective of wholesale electricity costs. Significant work is being done, partly funded by Government innovation grants, to advance the ability to roll out vehicle-to-grid and frequency response as additional grid-related services.

4.7 Value added services

Numerous charging-related 'value added services' are emerging beyond being able to top up one's vehicle with electricity. These include the potential ability to choose between charging with typical grid power or with 100% renewable power, the option to incorporate charging data (e.g. regarding charge point maintenance status, usage, price, and locations) into a vehicle dashboard or app, enhanced price transparency as customers move across networks, and the ability to manage booking a charge point in advance. Ride and car sharing, automation, and mobility-as-a-service (MaaS) are additionally anticipated to impact business models and customer offers.

Figure 1: Illustration of charge point access and value

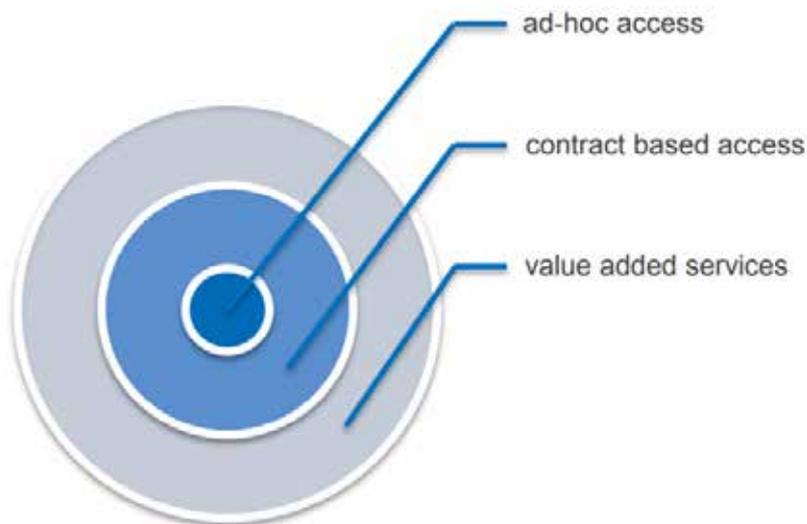


Image credit: European Sub Group to Foster the Creation of an Electromobility Market of Services (SGEMS): 2017. Link:

<http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetailDoc&id=36206&no=2>

REA VIEW: While these developments are welcome and the REA believes that these will result in an improved customer experience (as well as a more stable electricity grid), they raise a number of potential questions.

Security of digital systems could become more important, particularly as the industry begins to scale (although security issues are also in play with ad-hoc and other current forms of paying for charging). Taxation (both present and future schemes), fraud, and socialised costs incurred by electricity suppliers (such as the Warm Home Discount, grid costs) need to be considered when designing the charging network. Incorporating 'value added services' may also be beneficial to the segments of the population that do not have access to smart phones or who have physical impairments.

Standardisation of roaming communications is needed realise some of these advanced services. Standardisation of industry terminology, particularly around terms such as 'roaming', 'ad hoc', and 'interoperability' also can be improved.

4.8 Building on Ad Hoc

The Alternative Fuels and Infrastructure Directive (AFID), both at the European Union level and in its form as implemented in the UK, in the REA's view has been a success and have increased the ability for consumers to roam across UK networks. As of November 2018 this has been fully implemented for both new and existing charging infrastructure, but issues remain – for example in some situations customers are required to pay a higher rate for a charging session if they choose to pay ad hoc, or ad hoc payment still requires the downloading of an app rather than by using an RFID or contactless debit or credit card.

Fundamentally, 'ad hoc' represents a solid first step but does not equip CPOs and MSPs with the ability to fully communicate with each other, it does not set the industry up fully for value added and energy sector services, and it leaves room open for interpretation.

In order to go beyond ad-hoc payments, the REA believes that standardisation of process and protocol is needed between the different tiers of charging relationship, outlined earlier.

5 Towards common protocols and standards

5.1 CPO to MSP: proprietary protocols and independent protocols

In the discussion of roaming protocols there are two main categories, that of proprietary protocols and independent ones. The former typically refers to a centrally controlled protocol, such as those used by Hubject and Gireve, and the latter to protocols that require the CPO to independently implement and develop.

The below table outlines the difference between the protocols:

Table 1. The roaming protocols in Europe.

Protocol	Proprietary/Independent	Supports Roaming Hubs	Supports Peer-to-Peer Connection/Decentral
Open Clearing House Protocol (OCHP)	Proprietary (e-Clearing.net)	YES	YES
Open InterCharge Protocol (OICP)	Proprietary (Hubject)	YES	NO
eMobility Inter-Operation Protocol (eMIP)	Proprietary (Gireve)	YES	NO
Open Charge Point Interface Protocol (OCPI)	Independent	YES	YES

Image credit: Ferwerda, R.; Bayings, M.; Van der Kam, M.; Bekkers, R. Advancing E-Roaming in Europe: Towards a Single "Language" for the European Charging Infrastructure. World Electr. Veh. J. 2018, 9, 50.

5.1.1 Proprietary Protocols

A proprietary protocol is centrally controlled and is owned by the specific developer of each protocol. While it may be free to use, costs are associated with joining the roaming hub to which they are affiliated. Such protocols include Open Clearing House Protocol (OCHP), eMobility Inter-Operation Protocol (eMIP), and Open InterCharge Protocol (OICP). Each of these are discussed in some detail in a later section.

A clear advantage to implementing a proprietary protocol is that they allow CPOs to roam between each other with minimal up-front development cost. Additionally, due to their centrally controlled attribute, all organisations associated with that protocol would, in theory, be using the same version resulting in CPOs having the same standards and capabilities, another clear benefit. Development work on the protocol is done centrally by the controller of the protocol.

However, the over-reliance on a single hub may create more uniformity between networks but also means that there is a single point of failure, which could have cyber security implications in the future. There are also issues relating to using protocols that restrict a CPO from becoming involved with other roaming hubs.

Moreover, an additional drawback is that there are often fees associated, both upfront, standing, and for charging sessions, for the CPO who connects to the roaming hub associated with that protocol.

Finally, there is no common definition for certain EV concepts, notably 'smart charging'. This has allowed each protocol to set its own definition of 'smart charging', so care must be taken when understanding what each protocol means by using this phrase as there is no blanket definition. This limitation can be overturned through the formulation of a standard definition being generated and adopted by all protocols. However, presently there is no concrete definition but varied interpretations. This section of the report involves all forms of smart charging in its definition, ranging from simply being able to stop / restart charging during a charging session to schedule based charging in order to cover a vast array of interpretations¹³.

It must be noted that each individual proprietary protocol holds further specific strengths and weakness, as explained below, and implies association with a particular roaming hub.

5.1.2 Independent protocols

Open Charge Point Interface (OCPI) is the primary independent protocol. It is collaboratively developed by industry in 'modules' and represents a more decentralised system. Different protocol modules can be incorporated by CPOs and each module brings different benefits. It is fundamentally not owned by a single entity and is free to use. Proponents highlight that it allows companies to establish peer-to-peer relationships directly without the need for a roaming hub. Additionally, the system allows prices to be set directly while also providing companies the power to associate with exactly whomever they wish to have an agreement with.

The drawback is that, while free to use, there may be an upfront and on-going cost that must be borne by the CPO as they need to incorporate different modules themselves. There are also costs and additional time associated with the CPO needing to develop direct relationships between different operators.

One potential disadvantage of this method is that different functionality may exist between networks depending on the amount of resource they are willing to commit to incorporating the different 'modules' into their system. One network may be able to offer some advanced functions, such as pre-booking, while others who have not incorporated that module may not.

This may create a need for an independent organisation to maintain, and gradually raise, a national baseline minimum level of functionality.

6 Details of Proprietary and Independent Protocols

6.1 Open Clearing House Protocol (OCHP)

The OCHP is a propriety protocol focussing on exchanging authorisation data, charging transactions and charge point information data for roaming. The protocol is currently used with e-clearing.net clearing house and consists of 2 parts:

- One part for communication between market parties and an EV clearing house
- One part for peer-to-peer communications between market parties (called OCHP direct)

There are various use cases which can be supported by the OCHP, which are as follows (see Figure 2 for cross comparison of use cases):

- Authorising charge sessions
- Billing services – provides tariff information and charge details records for billing
- Providing charge point information
- Reservation system – allows the reservation of charge points
- Enables roaming
- Smart charging (only in OCHPdirect and is a basic form)
- Remote control of charge point (only in OCHPdirect)

6.2 eMobility Inter-Operation Protocol (eMIP)

The eMIP is another propriety protocol and is provided by the GIREVE organisation. It holds the main objective of providing open access to vehicle charging stations. The protocol has three specific goals:

- Enable the roaming of charging services by providing a charge authorisation and data clearing house
- Provide access to a comprehensive charging point database
- Provide smart charging features

The protocol holds similar benefits as the OCHP in that it facilitates connection to a roaming hub, which can lead to easier roaming, simpler connections, transparency for the EV user and less requirement for EV user private data. eMIP holds a variety of additional functionalities including a data upload service, where the CPO can send notifications surrounding the status of their units, and a data download service where the eMSP can gain information about their charge points. This facilitates the ability for operators to understand the status of their equipment. Additionally, the protocol holds a ‘heartbeat’ service which monitors the communication of all partners (CPOs and eMSP systems), enabling the ability to detect if there is a communication break or if there are any issues in the overall service. ¹⁴ This protocol additionally provides a definite smart charging functionality, promoting the use of smart chargers.

There are various use cases which can be supported by the eMIP, which are as follows (see ‘Figure 2’ for cross comparison of use cases):

- Authorisation charging sessions
- Billing services – provide charge detail records

- Provides charge point information – offers charge point information relating to tariff and parking spot details along with a charge point finder service
- Enables roaming
- Offers a smart charging functionality

6.3 Open InterCharge Protocol (OICP)

The OICP is a roaming protocol created by Hubeject in 2013. The protocol enables the transfer of roaming messages between an EMSP and a CPO and can be largely seen as a B2B platform. ¹⁵ The protocol is currently the most widely implemented communication standard between European EMSP and CPOs. There are two parts of the OICP:

- One part for the EMSP
- One part for the CPO

The protocol allows EMSPs to benefit from their solution ‘CONNECT’. This allows the EMSP to provide EV drivers with the opportunity to access any charge point, even across borders, assuming the CPO and charge point is connected to the network. The protocol ensures interoperability through the accepted standards incorporated in the network as well as the simplification of authentication and authorisation procedures. Moreover, the OICP ensures the protection of ‘sensitive’ data through the uncoupling of personal data and anonymous user data. ¹⁶

There are various use cases which can be supported by the OICP, which are as follows (see ‘**Figure 2**’ for cross comparison of use cases):

- Authorising charging sessions
- Billing services – offers charge detail records
- Provides charge point information – offers both session information and location information
- Reservation system – allows the reservation for charge points
- Enables roaming

Figure 2: Cross comparison of proprietary roaming protocol use cases (source: REA)

PROTOCOL			
USE CASES	OCHP	OICP	eMIP
AUTHORISED CHARGING SESSION	X	X	X
BILLING	X	X	X
PROVIDE CHARGE POINT INFORMATION	X	X	○
RESERVATION	X	X	X
ROAMING	X	X	X
SMART CHARGING	○		X

Figure 2: Use cases for each Protocol

X = definite use case | ○ = unclear use case (lack of definition/clarity)

6.4 The Open Charge Point Interface (OCPI)

The Open Charge Point Interface (OCPI) Protocol is an independent roaming protocol that is facilitated by The Netherlands Knowledge Platform for Charging Infrastructure (NKL), an independent non-profit organisation.¹⁷ As an interface communication software, it serves as a way to ensure compatibility between the back offices of stakeholders such as CPOs and MSPs¹⁸ which allows for different market parties to communicate with each other regardless of hardware. Main functionalities (taken from the OCPI 2.2.1 update) include:

- “A good roaming system (for bilateral usage and/or via a hub).”
- “Real-time information about location, availability and price.”
- “A uniform way of exchanging data (Notification Data Records and Charge Data Records), before during and after the transaction.”
- “Remote mobile support to access any charge station without pre-registration.”¹⁹

A key benefit of OCPI is that it is open to different business models such as the bilateral and central roaming system options available, meaning that it can support both peer-to-peer connections and roaming hubs. Hence, it has been argued that the OCPI protocol has the potential to be the “most suitable candidate for being widely adopted as the standard for e-roaming in the EU.”²⁰ OCPI has become the standard of Allego, EVBox, NewMotion, ChargePoint and the latest version available is 2.1.1. The roaming hub e-Clearing.net has also been able to connect with the Dutch roaming network eViolin via OCPI.²¹

OCPI, as an open-source protocol, is not specifically linked to one company and its development is done in a cross-industry, cross-border collaborative manner. NKL manages the process of updating the protocol. By becoming a member of the organisation companies can be part of working groups, which will collaboratively work on updating the protocol and/or adding new 'modules' to it. No privately patented material is allowed to be incorporated into OCPI, ensuring one market actor does not have undue influence over its future development and operation.

It was raised in interviews that OCPI can also assist MSPs offer 'help desk' functions. Stakeholders interviewed for this report raised concern that many networks did not have a 24/7 helpdesk offering. This could become a significant issue in the future if not widely addressed by industry.

OCPI is the roaming protocol used by Plugsurfing, an EMP which negotiates roaming agreements across Europe.

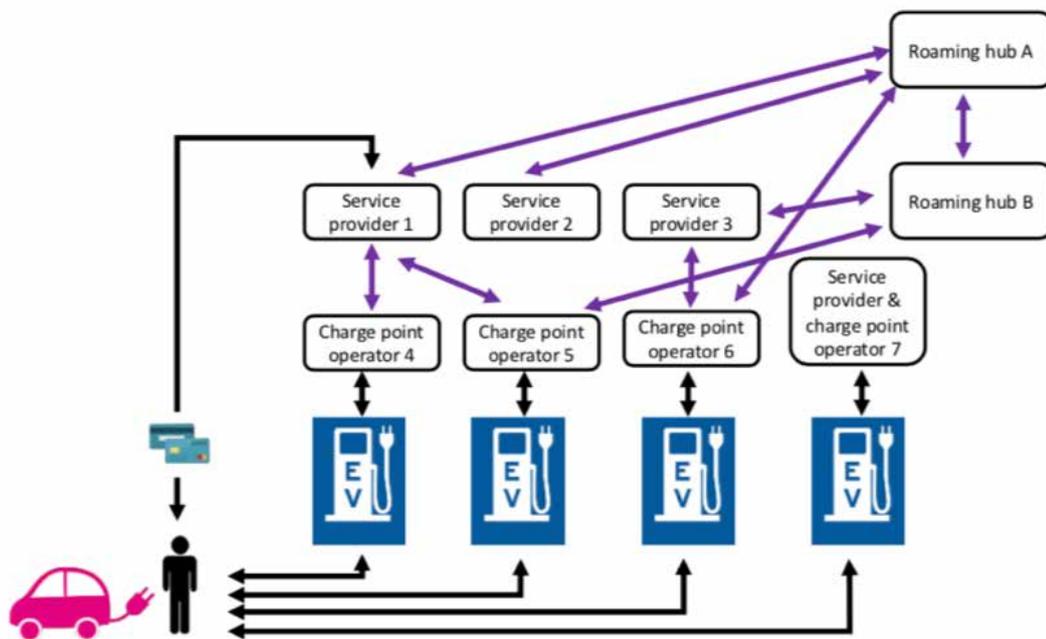


Figure 3 – A combination of peer-to-peer and roaming; two roaming hubs; Only a single protocol is used.

This figure shows one model of interoperability – EV can charge at all stations – One single protocol can allow for a focus on competing services for EV consumer and not on competition of protocols.

Image credit: Ferwerda, R.; Bayings, M.; Van der Kam, M.; Bekkers, R. Advancing E-Roaming in Europe: Towards a Single “Language” for the European Changing Infrastructure. World Electr, Veh, J. 2018, 9, 50

6.5. Industry-led measures to achieve a more interoperable system in the UK

Efforts to increase interoperability of payments systems have been made by the industry. There are existing interoperability agreements that have charge point operators with a presence in the UK as members. For instance, NewMotion, Chargepoint Genie, ESB Ecars and Last Mile Solutions are members of the French interoperability platform Gireve which enables roaming at their 605 charge points in the UK. ²²

Several new interoperability agreements with operators of charging infrastructure in the UK are being put in place as well. For instance, EVBox and Chargepoint announced in October 2018 that they have formed an interoperability partnership, the first global agreement of its kind. The agreement is based on the Open Charge Point Interface (OCPI) protocol and allows EV drivers to roam between the two networks in the EU and North America from January 2019.²³ Charge Your Car (CYC) signed an interoperability agreement with NewMotion.²⁴ ChargePoint and EVBox have signed a peer-to-peer roaming agreement, and Franklin Energy has joined the roaming platform Gireve.²⁵

The growth in interoperability agreements with charging networks in the UK demonstrates that there is a will to move forward on roaming.

7. Vehicle to charge point

Regarding the relationship between the Vehicle and the Charge Point, a standardised series of protocols is important – less so for supporting interoperability and more so for implementing smart charging, Vehicle-to-Grid, and other potential energy services in the future. The UK's EV Energy Taskforce, convened by the Office for Low Emissions Vehicles and chaired by the Energy Systems Catapult, is currently looking at barriers to smart charging and the provision of energy services and this could in the future be a stumbling block.

7.1. What is the ISO 15118 vehicle-to-grid communication interface?

ISO 15118 is an international standard that defines the communication interface between EVs and the Electric Vehicle Supply Equipment (EVSE).²⁶ It is an automated and secure data exchange between electric vehicles and charge point infrastructure for the access to charge points without an additional third medium (smartphone or RFID card), enabling in-vehicle charging (an example of which is Hubeat and Daimler's Plug&Charge solution). With Plug&Charge, the driver simply connects the car to the charging station, the authentication process take place via the connection and the charging process begins.²⁷

The adoption by UK CPOs to such a standard could be an important development for the widespread uptake of smart charging and grid services such as aggregation, V2G, and frequency response.

REA discussions with stakeholders indicate a willingness to move towards this standard but are concerned about the potential for increased market power for automotive manufacturers in the charging ecosystem. Discussions also indicate that some of the ISO 15118 functionality, particularly around smart charging, can be done by other means.

It has been raised to the REA that there is presently no IT certification body in the UK that can authorize V2G protocols – this is something that our wholly-owned subsidiary, Renewable Energy Assurance Limited, could take on.

REA VIEW: We would like to see the industry discuss the feasibility of adopting ISO 15118 within the next 5 years. Concerns have been raised that some functionality can be achieved without this standard, which is viewed in some quarters to be administratively and technically burdensome. It was also noted that no vehicles on the market at present, to the REA's awareness, are ready to work with this standard.

Any discussion about ISO15118 should be done in collaboration with automotive OEMs to ensure that an open and competitive market is maintained.

8. Avoiding the potholes: the transparency of pricing example

In the interviews the REA conducted it was raised that the UK has an opportunity to 'leapfrog' challenges and issues encountered by other nations by introducing interoperability at this stage. Tariff transparency is a topic that has been debated for some time in the Netherlands and is one such area where the UK may be able to 'leapfrog' other country's past challenges.

Early EV-roaming did not typically allow for diversity (meaning CPOs could only set a single roaming tariff across all of their network, thus greatly limiting their business flexibility). At the time, MSPs had no automated way of receiving communications regarding different roaming tariffs & transaction details from CPOs. This sometimes resulted in EV-drivers not knowing exactly what tariff they would pay at a chargepoint, or what the costs (or volume or time) of a completed transaction would be. Developing this is complicated as price signals and transaction details / summaries need to be sent in real time from a CPO to a MSP based on a number of variables (eg location, type of charge).

Once diversified roaming tariffs evolved it became important for a customer to understand what they will be charged when they arrive at a location. Greater transparency and clarity became key, and issues regarding this remain today.

It was raised that the introduction of OCPI, and/or the integration of a roaming hub, can help address this problem in the UK before it fully arises. The UK moving now on interoperability would alleviate the need to move through 'growing pains' that others had to endure regarding early roaming communications.

In the interview process it was raised that it was important to learn these lessons and build on existing technologies rather than potentially replicate the system via a UK based roaming hub or other UK-manufactured common protocol, which would be time consuming, capital intensive, and would likely slow down the movement towards interoperability.

9. Consider the fleet

One major market player that needs to be considered is fleets. Presently fuel cards allow fleets access to fuelling and facilitate direct billing to a company's headquarters. In-vehicle charging and data sharing could allow electrified fleets to replicate this model in the UK. This could be an important development, not just for heavy haulage but for travelling salespeople, contractors, ride and car-sharing companies, and vehicle leasing and rental companies as well. These all represent clear markets for charging and potentially reliable customers as deals between fleet operators and charge point companies can be negotiated on top of agreements between charging networks to allow for fleets to roam between networks.

10. Case Study – Zipcar UK pioneering the decarbonisation of transport through car sharing

With thanks to the Zipcar UK team for contributing this case study.

A significant contribution to the decarbonisation of London's transport system is being achieved by Zipcar UK by delivering car sharing, at scale, right across the capital. The benefits of car sharing are two-fold:

- It is proven to lead to positive behaviour change and a reduction in net miles driven
- The miles that are driven, are done in the cleanest, greenest fleet available to the public

Car sharing is at an all-time high in London - Zipcar has 240,000 members, with membership growing by 33% per annum. In summer 2018 Zipcar added 325 pure electric vehicles into their fleet. Within 6 months over 10,000 Londoners have tried them driving a quarter of a million zero emission miles, showing the power of car sharing as a catalyst of change.

As well as normalising EV driving in London, these vehicles are also helping the development of much-needed EV infrastructure with Zipcar's demand of over 4,000 charging sessions, helping create the business case for a number of providers entering the market.

Why interoperability?

Zipcar wants to go much further. Vision 2025 lays out an ambition for the sector to deliver an all-electric car sharing fleet for London – 9,000 electric vehicles, across a potential membership base of 800,000 members by 2025. If the infrastructure is there to support it, this Vision could deliver 120,000 fewer privately owned cars, 821 million fewer miles driven, and a saving of 160,000 tonnes of CO₂.

If this vision is to be achieved a ubiquitous, fully interoperable electric charging network is a pre-requisite. Whilst we currently have no choice but to take care of all of the vehicle charging ourselves with an in-house team, if we are to grow the number of EV's in our fleet, we will need the ability to ask our members to charge the vehicles when necessary either during or at the end of their trip. For this to be a reasonable request members need to have access to the greatest possible number of chargers and with the simplest possible experience. That is what true interoperability (full access to all networks, simplified billing, availability visibility) could achieve.

We have the ambition to be at the fore of this historic evolution in clean transportation and we already provide a clear demand for charging services. Ensuring the confidence of consumers is critical to delivering this vision, and the charging sector has an important role to play.

11. The Property Perspective: Understanding the value of interoperability for landowners

With thanks to the expert team at Syzygy Consulting for contributing this section.

11.1. Landlords – a key stakeholder’s position

Commercial real estate landlords own and operate most of the non-household private parking in the UK. This consists of parking at office, business and retail sites, therefore accounting for a considerable amount of the UK’s future charging bays. How landlords approach the deployment and operation of EV charging services will play a pivotal role in the progression of interoperability in the UK.

UK landlords have been slow to participate in the early development of the UK’s charging network, opting for short-term low-cost solutions. However, many landlords are in the process of developing and actioning strategic positions as they now understand the value potential within their portfolio that can be unlocked with EV charging services.

Landlords that are developing out their own portfolio-wide networks understand that the provision of EV charging is fundamentally different to renting out real estate; charging is a service. Services need to be operated intensively to generate maximum value and remain competitive in a fast-growing market.

11.2. Operational requirements will drive interoperability

Operational flexibility is a key landlord requirement and they will seek to avoid ‘vertically integrated’ service offerings. They are unlikely to knowingly restrict their ability to procure the strongest CPO offering at the time to run their portfolio’s charging services.

On procurement of back office services, a well-advised landlord will not choose a CPO that controls the service level, nature of access, payment options and provides different rates for members and non-members. The landlord’s procurement requirements will therefore not only drive competition and innovation in CPO service offerings but naturally push the market towards interoperability.

Additionally, landlords have a keen interest in maximising the accessibility and use of their services to maximise revenue generation. From purely a business imperative, a landlord will require a CPO that is pro-interoperability with numerous peer-to-peer agreements and membership of roaming platforms as it will to open their services to a broader customer base. As landlords start to make strategic entries into charging services and build up an understanding of the operational aspect, we would expect interoperability to become a fundamental requirement.

12. Interoperability: The need for a central definition

“Interoperability” generally refers to the capability of different systems to work together. In the eMobility context it is used to describe the extent of the ability of EV drivers to use any public charging point, both in terms of the compatibility of the physical infrastructure as well as access and payment methods. It also implicitly refers to the ability for companies to seamlessly share information with each other. There are differences in how the term interoperability is used in the industry, as the following examples demonstrate: One charging company suggested: “A fully open network facilitated by **peer-to-peer roaming** where any driver has a seamless charging experience.”

EMI3: “From customers’ point of view, interoperability is the ability to use the Electric Vehicle Charging Infrastructure (EVCI) **wherever it is located, whichever EV the customer uses, whoever operates the charging Point, etc.**”

“For electric vehicle drivers, interoperability, or “e-roaming,” means that drivers can charge at any with a single identification or payment method, and that all charging stations can communicate equally with vehicles.”

One interviewee mentioned that any definition should incorporate the ability to identify a driver, for the driver to see the charge point, and for an orderly means of tracking charging sessions and expenses.

The REA believes that a standard UK-wide definition for interoperability is needed to move the conversation forward. A suggested definition by the REA is:

“A network of charge points which enables customers to access any public charging station without entering a subscription, offers non-discriminatory access for customers with existing subscription with other EMPs, facilities value added services to customers, and allows for customers to roam using a single identification or payment method.”

13. Towards a UK ID registration organisation

One barrier to interoperability identified by the European Commission’s Sub Group to foster an Electro-Mobility Market of Services (SGEMS) is the need for national organisations that maintain a public register and help define rules of uniquely identifying different objects in the EV charging ecosystem. For example, the Dutch organisation eViolin serves as the country’s ID registration organisation. It assigns a code to the different CPOs and MSPs that operate nationally.

The Sub-Committee’s final report states that “Enabling a harmonized identification registration process for electro-mobility actors and contractors, in all EU Member States, according to common and comprehensive rules, is crucial to achieve European wide access to charging networks and high quality charge point registers”. They go on to outline that only four countries are seen to have a national registration organisation including:

- Austrian Mobile Power (Austria)
- AFIREV (France)
- BDEW (Germany)
- eViolin (Netherlands)

The established ID management process facilitated by these organisations is as follows:

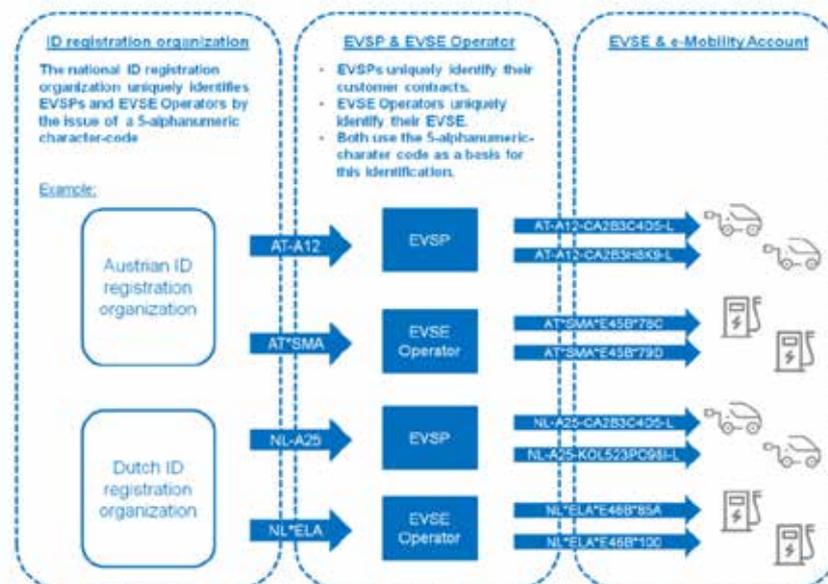


Figure 4: SGEMS Final Report, 2017. Link:

<http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetailDoc&id=36205&no=1>

Further description and visualisation of this ISO standard can be found in the ElaadNL paper Exploring the public key infrastructure for ISO 15118, found here:

https://www.elaad.nl/uploads/files/Exploring_the_PKI_for_ISO_15118_in_the_EV_charging_ecosystem_V1.0s2.pdf

REA recommendation: The REA believes that its subsidiary organisation, Renewable Energy Assurance Limited (REAL) (which manages numerous independent industry codes and certification schemes) could be in a place to be the UK's national ID registration organisation.

The ISO 15118 standard is being utilised elsewhere globally and the UK's ID registration organisation should use this standard for vehicle to charge point identification.

About REAL: <http://www.renewableenergyassurance.org.uk/>

14. Previous Government public charging strategies and support schemes

14.1. Lessons from Plugged-in Places

The Office for Low Emission Vehicles (OLEV) ran a funding scheme for electric vehicle charging infrastructure from 2010-2014 called “Plugged-in-Places”. The Government made £30 million available for funding and the programme supported eight Plugged-in Places across the UK and contributed to the establishment of over 4,000 chargepoints.²⁸

After the programme ended, OLEV released a report outlining lessons learned from the scheme. It stresses the need to have clear technological requirements for public chargepoints such as requirements related to back-office systems and the interoperability in payment model development.²⁹

14.2. OLEV Plug-In Vehicles Infrastructure Strategy (2011) set out a framework for interoperability

The Strategy challenged industry to specify, by the end of the year, the back-office requirements for a system to enable members of one scheme to be able to use the chargepoints of another. The strategy committed Government, as a first step, to develop a central system to allow the back-offices of the Plugged-In Places, and other infrastructure schemes, to communicate with each other (a central whitelist – p.43).³⁰

The strategy stated that there is a need for all public infrastructure to be interoperable in order to help the customer in implementing the strategy.

14.3. The Go Ultra Low City Scheme

In January 2016 four cities were awarded funding from OLEV. The fund consisted of £40 million for a ‘green car revolution’. Cities won the funding through a competitive bidding process. The grant is administered by ‘Go Ultra Low’ which is a jointly funded partnership between the Government and several major car manufacturers.

The key criteria in winning the fund was a step change in ULEV uptake, being an exemplar city, improving air quality, innovation, linking with other schemes and monitoring the scheme.

The four winning cities were London, Milton Keynes, Bristol, and Nottinghamshire and Derby together. Dundee, Oxford, York and the North East region were also set aside £5 million of the funding.

This was one of several early central Government schemes to encourage charging infrastructure rollout. Another was the Plugged-in Places scheme. The REA understands that interoperability-related requirements were not included as a precondition of these schemes for public infrastructure.

14.4. Charging Infrastructure Investment Fund

In Budget 2017 the Chancellor announced a new £400m initiative (comprised of £200m in public funds matched by £200m in private funds) called the Charging Infrastructure Investment Fund which would make strategic investments in charging infrastructure in the UK. It is not a grant scheme and is expected to operate on a commercial basis. As of January 2019 the Government was still considering bids to manage the Fund. The REA understands that it does not presently specify requirements for interoperability as a condition for funding.³¹

14.5. The view of the National Infrastructure Commission

The National Infrastructure Commission (NIC) published its National Infrastructure Assessment (NIA) in July 2018, which outlines recommendations for how the UK can meet the country's biggest infrastructure challenges.³² It recommends rolling "out of charging infrastructure sufficient to allow consumer demand to reach close to 100% electric new car and van sales by 2030."³³

In a follow up blog in January 2019 the NIC outlined "it will also be necessary to set minimum standards for a network of interoperable, smart charge points – something that government, industry, and Ofgem should work together to achieve."³⁴ The government will formally respond in 2019 to the National Infrastructure Strategy. HM Treasury has published an interim response.³⁵ The interim response does not address the need for interoperability, thus it remains to be seen if it will be included in its formal response.

15. Interoperability in Parliament: the Wiggin Bill and contactless payments

In November 2018 Conservative MP Bill Wiggin tabled a Private Members' Bill (under the Ten Minute Rule) relating to charge point payment interoperability. The Bill, entitled Electric Vehicles (Standardized Recharging) Bill 2017-2019,³⁶ is supported by around a dozen MPs. The Bill proposes:

"(2) regulations must require all operators of charge points to meet standardised requirements for—

- a. the method of payment or other way by which access to the use of charge points may be obtained
- b. the connecting components of charge points."

In his speech to promote the Bill, Mr Wiggin stated that an obvious solution is to "ensure that each charging point has a pay-as-you-go option that does not require a membership or key fob."³⁷

The REA believes it is positive that the issue of payment system interoperability is getting a higher profile in Parliament. A Second reading, the next stage for the Bill, is scheduled to take place on 8 March 2019.³⁸

Mr Wiggin has agreed to become a member of the All-Party Parliamentary Group on Electric and Automated Vehicles, for which the REA serves as secretariat.

Mr Wiggin's proposals, in the REA's VIEW, reflect a growing concern regarding interoperability between charge point networks in the UK and is a useful mechanism for opening up discussion on the topic. In particular, Mr Wiggin proposes contactless payments across all UK charge points.³⁹ A benefit of this solution is that it can accommodate any EV driver and offers a relatively easy way to access charging stations. An example of the benefits of contactless access is demonstrated with the InstaVolt network which, in a ZapMap survey was the highest rated public network by drivers - a significant reason for this being the 'tap and go' contactless card ease of access.⁴⁰

The REA has concerns with the Government mandating this approach, however, as this solution may be viable for rapid chargers due to their high utilisation rates, it is less practical for smaller AC chargers with lower utilisation rates and lower electricity sales. Managing a contactless system would require all operators to install this as an added expense in all charge points, it would force operators to incur standing payment charges from companies such as Worldpay which may charge a fixed rate to for the technology needed to support the payment system (potentially £30-40 per month per charger), and then would likely take a percentage of the transaction amount. An RFID system allows charge point operators to reduce their exposure to these standing charges and per-use charge. Enforcing contactless across the UK would likely result in slower deployment and increased costs to consumers.

16. Approaches to interoperability in other markets

The purpose of looking to other markets is to see how other jurisdictions have overcome the barriers to a more interoperable system. A common thread is that there is often significant coordination between state and local governments and industry-led initiatives.

16.1. USA

The state of public EV charging and the level of interoperability varies considerably from state to state in the US. California, the US's largest market for cars, leads the way in this regard. The EV Charging Open Access Act was passed in 2013 by the California Senate Energy, Utilities and Communications Committee. It states that charging stations must have ad hoc access, defined as the ability to charge without obtaining membership nor pay a subscription fee.⁴¹ However, the industry is making strides in increasing interoperability of payments. For instance, Electrify America has announced interoperability agreements with EV Connect, Greenlots, SemaConnect, resulting in a network of approximately 12,500 interconnected chargers. Argonne National Laboratory manages the Electric Vehicle-Smart Grid Interoperability Center, set up to forward the "global harmonization of standards and technology for the EV-grid interface and EV charging."⁴²

16.2 France

In January 2017, France passed a decree on EV charging infrastructure on implementing the Alternative Fuels Infrastructure Directive (AFID). It sets requirements for operators of public chargers which include that they must guarantee universal access and payment regardless of the mobility provider that requests it. It goes further than mandating ad hoc access, as it also states that this requirement is presumed to be met should the charge point operator be connected to an interoperability platform.⁴³ Furthermore, the ADVENIR programme offers a subsidy for public charging point installation that covers 40% of the cost per charge point.

One of the conditions for receiving financial aid is to be a part of Gireve's platform.⁴⁴ Consequently, now all public institutions that operate charge points are on Gireve's platform.

16.3. Norway

Norway is the market with the highest share of electric vehicles in the world. In September 2018, nearly half of all private car sales in Norway were fully electric vehicles (45.3%), setting a world record in the market share of EVs.⁴⁵ The Norwegian Ministry of Transport and Communications published its national plan for transport 2018-2029 which stressed the need for adequate charging infrastructure to encourage consumers to switch to EVs and to use them for longer journeys.⁴⁶ Enova, a Norwegian Government enterprise, provides financial support towards the installation of charge points, in which ad hoc access is a condition to be eligible for support. Public support to encourage the uptake of EVs also includes exemptions for road tolls, free public charging,⁴⁷ free public parking in some municipalities, permission to drive in most bus lanes and reduced ferry rates. Roaming platforms are not as prevalent in Norway as in for instance France or the Netherlands, however, The Norwegian EV Association provides an all-access RFID to its 60,000 members. It enables its members to use the chargers of the major charging networks all over the country without entering a subscription. This example is of interest since it is an association that is linking the charging networks.

16.4. Germany

The German government offers substantial support to promote the electromobility industry in Germany. In February 2017, the German Federal Ministry of Transport and Digital Infrastructure (BMVi) announced a nationwide funding programme, allocating €300m to expand public charging infrastructure by another 15,000 charging stations.⁴⁸ The programme enables private investors, cities and municipalities to apply for a grant that covers 40% of the hardware and network connection costs of charging stations.⁴⁹ Technical requirements to receive funding include that the charging stations must be connected to an IT backend via a current open standard such as the Open Charge Point Protocol (OCPP). Additionally, the charging infrastructure must ensure roaming for all customers so as to enable customers that have a subscription with other EMPs to charge.⁵⁰

Raised in the interview process was the security-conscious nature of the German public when it comes to card payments and contactless card security in general. It was asserted that the country has a higher security standard for RFID cards, that some members of the public outright refute the security of unmanned contactless card charging stations, and that proposals are being discussed for cash payment modules to be added to charging stations.

16.5. Netherlands

The Netherlands has been a leader in payment system interoperability. The REA understands that multiple national charge point operators came together in 2010 and signed a letter of intent around standardisation of communications and collaborating on payments. In 2012 they launched eViolin, a trade association "by charging point operators and cargo services [designed] to allow public access charging stations for commercial and technical sense in the public area" (translated).⁵¹ As a result 100% of public charging infrastructure can be used by any EV driver.^{52 53}

eViolin, as a non-profit association, maintains and keeps public a Central Interoperability Register which assigns different charge point operators a unique identification code that can be used in payment-related communications between CPOs, MSPs, and other actors. Further information on Dutch interoperability arrangements for public charging points can be found on the eMI3 website.⁵⁴

16.6 International conclusions

The takeaway from country comparisons is that compared to international markets, the UK government has been more cautious with mandating interoperability. Furthermore, in all overseas cases there has been significant coordination between government and the industry, and lessons from these joint projects can be applied to the UK market – although structural differences remain.

Overall, the REA view is that charging networks abroad have been “more proactive” in terms of joining interoperability platforms by their own initiative, but that the slower pace of uptake here may allow the UK to ‘leap-frog’ mistakes and early-adopter issues experienced elsewhere.

17. Interview process: methodology and findings

As part of the research for this policy paper, the REA conducted a number of structured interviews with charge point operators and manufacturers, interoperability platforms, automotive manufacturers, mobility service providers and other key stakeholders in the UK and abroad. The following is a list of the questions that formed the basis of the interviews.

The REA asked a number of structured questions of interviewees, which were then built on. The questions include:

Question 1: How do you view the EV charging market in the UK presently, and how does it impact your company?

Question 2: What are the barriers to a more interoperable system in regards to payments? Do you think the Alternative Fuels and Infrastructure Directive goes far enough?

Question 3: How can these challenges be addressed? What sort of solutions do you envision for a more interoperable system in the UK?

Question 4: Should the government be involved in pushing for a more interoperable system, and if so, what role should it take?

Question 5: Are there any lessons we can learn from other countries?

18. Industry perceptions of interoperability in the UK

This section summarises many of the discussions and points raised by industry stakeholders, both as a part of the structured interview process and from feedback on the draft of the report circulated to REA members.

18.1. Structure of the UK

Given that the ambitions of the Government for the transport and manufacturing sector are high, and the structure of the domestic charging market fairly unique (meaning less cooperation across networks / use of roaming platforms or peer-to-peer agreements than in other countries), a tailored UK-solution is needed to meet the challenge of the electrification of transport in this country. Many stakeholders indicated that they thought the UK market was uniquely vertically-integrated. Most stakeholders thought that the adoption of interoperability had been slower in the UK than in other markets.

Some thought that improving the reliability of infrastructure on the public charging network should be the industry’s highest priority.

Some thought this slower implementation of interoperability had put the UK in an advantageous position to 'leapfrog' other nations. Smart charging and transparency of prices were key potential areas.

It was raised that from a cost perspective, it is almost easier to own charge points in the UK than in other countries and it is more straightforward to install them than in other countries. It was raised by several stakeholders that the overall coverage of public charge points in the UK was 'fantastic' or 'very good' and that the industry received more negative press than was fair. It was mentioned that the most successful business models for charging were yet to be determined, but several were in play.

It was raised that consumers should have easier access to real-time status updates of chargers. One company's internal research indicated that of the 18 major companies operating in the UK, 9 actually had implemented 24/7 customer assistance. Information sharing and pooling could address this. Several stakeholders believed that the market was likely to move towards increased 'bundling' of products and services, which could compete with the drive for interoperability across networks.

18.2. Improving confidence

Most stakeholders indicated that a key component of increasing demand for electric vehicles in the UK is improving public confidence in the type, availability, and accessibility of charging infrastructure available to them. Accessibility is a significant barrier in the UK, with operators historically maintaining membership-only closed networks that require multiple apps or payment cards, which required relationships with numerous charge point operators, to move around the country.

Most stakeholders indicated that a more interoperable and consumer-oriented payment system for public charge points would support vehicle manufacturer confidence. Several stakeholders indicated that vehicle availability and manufacturing levels were a more important industry problem, with interoperability of public charging infrastructure farther down the list. Greater utilisation of existing networks could allow for operators to invest in legacy infrastructure. One issue raised was that the variety of payments (both prices and methods of payment) is an incremental barrier to EV adoption. The charging market is not homogenous for a consumer to navigate. Consumers are often required to have greater knowledge about the energy system than the average person.

It was raised that some networks are already able to offer some 'value added services' such as variable tariffs to fleets using existing back office functions. Some mechanisms were also already in place for companies to share data on the status of their networks with public-facing apps such as ZapMap.

18.3. Implementation of AFID

It was widely raised that the mandating of 'ad hoc' access was a positive step in the UK and a key first move, although not the final move, towards an interoperable network. Some concern was raised that the reason why implementation in other countries looked different or went beyond ad hoc, was that a significantly smaller number of charge point operators were active in the UK market at the time of consultation, with only two responding at the time.

Issues with AFID raised include the fact that 'ad hoc' contactless payment terminals on every station does not ensure equitable roaming as operators can still charge more for non-members, and credit card companies can take a percentage.

18.4. Implementing roaming beyond AFID and ‘ad hoc’

It was raised that for some, enforcing any interoperability beyond AFID is not necessary and any central government regulation relating to this could be extremely disruptive to the existing business. It was raised that some customers solely want contactless readers and have not shown interest in more advanced systems. It was raised that some companies will resist Government-led initiatives to mandating interoperability beyond ad hoc. Numerous companies made the point that Government mandating a single interoperability outcome would significantly detrimental to the market. It was raised by most stakeholders that there were benefits to roaming beyond what ad hoc offered.

18.5. Emerging technologies

It was raised that consumers in the future will want to access ‘value added services’ and the electricity system will continue to push to introduce things such as smart charging and Vehicle to Grid (V2G). It was noted that the UK was a R&D leader in V2G. It was mentioned that automotive manufacturers will likely seek to offer an in-vehicle charging service in the future.

18.6. Barriers to roaming

Key barriers identified that are restricting UK CPOs (Charge Point Operators) from adopting roaming agreements without government intervention are:

- A lack of commercial willingness rather than technical issue (although some CPOs might require back-end upgrades to become more seamlessly integrated with other CPOs)
- Concern that increased roaming could put downward pressure on prices
- Concern about access to customer data from charging sessions in a more interoperable system, and to what degree the CPOs get value from that
- The ability to set the price. Some CPOs feel that the MSP (Mobility Service Provider) will have too much influence over the price if they allow for roaming. The fear is that CPOs will be forced to reduce the price
- Hardware may be a barrier for incumbent charging companies to fully adopt this vision of interoperability, particularly those that have taken on legacy assets partly funded from early Government initiatives

18.7. Potential Government actions identified by interviewees

- An approach could be to mandate a minimum level of roaming through the backend for all CPOs. An early version of OCPI as a minimum is a potential minimum standard that could be introduced
- Another less compulsory approach could be to require publically funded charge points (eg those funded from the Charging Infrastructure Investment Fund, or the Home or Workplace Chargepoint Schemes), to meet certain specifications relating to backend communications and roaming
- The two options can be combined. For instance, all new charge points must comply within a certain time to certain backend communications requirements, whereas existing charge points are given a longer timeline to comply

- The Government can take a lead on building the language about interoperability and to be clear about the definitions
- Several stakeholders communicated that central government intervention might not be required and that the industry will move towards more information sharing on its own. The onus therefore being on industry to respond

18.8. Overall takeaways from the interviews

- A key issue for the consumer is a lack of clarity and consistency. The consumer is expected to know more than the average person about electricity and methods of accessing charge points
- Greater interoperability was identified by some as a means of speeding up EV deployment
- The variety of payments (both prices and methods of payments across networks) is also an incremental barrier
- Paying for charging should be as simple as using a contactless card (ad hoc), with more sophisticated measures for those who would wish it
- Concerns about the added expense of some roaming platforms, as well as the ability for a CPO to access consumer usage data from their equipment if a roaming platform is involved in the transaction
- An agreed upon definition of “Interoperability” is needed
- There should be a minimum standard of back office function – OCPI has repeatedly been raised as a potential standard function that encouraged innovation without being overly prescriptive

19. In summary: the REA view on barriers to interoperability in the UK

In this section the REA outlines its view on challenges to increasing interoperability of payments systems in the UK, derived from interviews, member feedback, and secondary research.

19.1. Standardisation needed to develop energy services

Standardised communications are particularly important between the vehicle and the charge point, an issue which the common adoption of the ISO 15118 standard may alleviate. This issue may become more acute as chargers and vehicles are further incorporated into the energy services sector, providing smart charging, vehicle to grid, or ancillary services to the grid. This could also lead to an increase in the number of market actors.

19.2. Incompatibility of charging networks’ back office software

The maintenance of proprietary back-office networks and lack of common communications protocols between networks is possibly the main barrier to the adoption of cross-network roaming agreements. The widespread adoption of OCPI, which is an independent protocol, could allow for both CPO integration into roaming hubs and direct peer-to-peer agreements, increasing choice for CPOs.

Several UK market actors are likely not able to incorporate OCPI, or incorporate into OCPI, without significant investment in changing their back office to do so. Some may also require hardware upgrades to facilitate this, including the possibility of RFID cards. This could be disruptive to their businesses; Government support may be necessary to facilitate these actors moving towards more open systems.

The common use of roaming protocols in the UK will be increasingly important for operators who wish to offer transnational roaming to their members / customers. Local authorities could address this by including provisions for interoperability in their tenders for charging points.

19.3. Lack of integration with charging hubs

There has been little CPO cooperation with roaming hubs in the UK to date, partly due to the business model of operators, their backend and / or hardware setup, and the early stage nature of the UK charging market.

19.4. Concern that interconnecting will be commercially detrimental for CPOs

There is a perception amongst some market actors that greater interoperability between networks could be commercially detrimental. Discussions equally, however, indicate numerous companies that see greater interoperability facilitating EVs become mainstream.

19.5. The view that customers primarily want an ad hoc solution

It was raised in the REA's research phase that a majority of EV drivers are happy with an 'ad hoc' pay as you go solution to roaming and that more does not need to be done. The REA realises that this may be the case from existing surveys but customers may react positively to innovation in the sector, for example relating to the energy sector or value added services, in the future.

19.6. Strong competition between charge point operators

A key barrier that was raised was extremely strong competition between UK market actors in the early stages of market development (which the UK is presently in). It was raised that this highly competitive nature resulted in hesitancy for companies to collaborate in regards to interoperability, but that as the market matures such pressures may be reduced. Pressures may also be reduced by greater automotive OEM manufacturing and deployment of vehicles, which would expand the market and potentially give space for companies to further invest or upgrade their networks.

20. Conclusion

The UK's electric vehicle charging sector is rapidly evolving and Government support to date for the development of a national charging network has been useful. The implementation of 'ad hoc' charging in the UK through the Alternative Fuels and Infrastructure Directive has been successful, and there is much to be said for the reach of the charging network that has been deployed in the UK to date.

To achieve the Government's goal of creating one of the best EV infrastructure networks in the world, however, a conversation about additional services, about cooperation between networks, and about future energy services is needed. Industry needs to develop solutions, potentially through individual networks adopting common roaming protocols such as OCPI, that strengthen their business cases. Direct Government intervention to force companies to adopt particular protocols or business models is not warranted, but support to foster collaboration between networks and for any industry-led schemes would be welcome.

There are clear lessons to be learnt from other countries, both those in Europe and elsewhere, about the benefits and challenges of fostering interoperability and the drivers behind its development. What we should take from these lessons is not that the UK needs to follow what has been done elsewhere but that the early-stage discussions about this topic in the UK prime us to 'leapfrog' challenges and problems encountered elsewhere.

If the industry is to move towards a common roaming protocol, or to adopt the ISO15118 as a standard, independent organisations will be needed to coordinate market actors and objects in the charging ecosystem. This is an eminently do-able development.

The conversation about interoperability and about consumer experience is not just a conversation about charging companies and cars. It has wider-reaching implications – including for the choices landowners make about their investments and for how quickly and seamlessly fleets are able to become electric in the medium term. It also is a conversation about the wider energy sector and the ability not only to manage the future demands placed on our power system, but to make those new demands into market opportunities which in turn will spur innovation and growth.

With thanks to the following interviewees who participated in our structured interview process:

- Ben Fletcher, Head of Electric Vehicles, Renault UK
- James McKemey, Head of Insights Team, Pod Point
- Charles O'Donoghue, Chief Technology Officer, EVDriver
- Freerik Meeuwes, Head of Strategic, Projects & Interoperability, EVBox
- Jonathan Hampson, General Manager, ZipCar UK
- Lois Warner, Manager – Market Development in France, UK, Ireland, Spain, Portugal, Hsubject
- Marie Bonnefous, Communications Manager, Gireve
- Tanya Sinclair, Policy Director UK and Ireland, Chargepoint
- Tim Nicklin, Manager – Electric Vehicle Charging and Energy Management, Ford Motor Company
- Rutger Plantenga, Independent Consultant (formerly of New Motion)
- Tom Callow, Director of Communication and Strategy, BP Chargemaster

Additional conversations were had with REA members, a list of whom can be found here:

<https://www.r-e-a.net/membership/directory>

The REA would also like to thank **Francesca Putzu**, REA Policy Intern from King's College London, for her time and skill in conducting research for this report. With thanks as well to **Tom Baker**, REA Policy Intern from King's College London, for his contributions to this work.

Endnotes

- 1 “Reducing Emissions from Road Transport: Road to Zero Strategy.” GOV.UK. Accessed November 8, 2018. <https://www.gov.uk/government/publications/reducing-emissions-from-road-transport-road-to-zero-strategy>
- 2 “Industrial Strategy: Building a Britain Fit for the Future.” GOV.UK. Accessed November 8, 2018. <https://www.gov.uk/government/publications/industrial-strategy-building-a-britain-fit-for-the-future>
- 3 “PM’s speech at the Zero Emission Vehicle Summit: 11 September 2018” Gov.uk. Accessed 20 November 2019. <https://www.gov.uk/government/speeches/pms-speech-at-the-zero-emission-vehicle-summit-11-september-2018>
- 4 “Electric Cars.” Next Green Car. Accessed January 20th 2019. <https://www.nextgreencar.com/electric-cars/>
- 5 PricewaterhouseCoopers. “Charging Ahead! The Need to Upscale UK Electric Vehicle Charging Infrastructure.” PwC. Accessed November 8, 2018. <https://www.pwc.co.uk/industries/power-utilities/insights/electric-vehicle-infrastructure-report-april-2018.html>
- 6 Committee on Climate Change. “Plugging the gap: An assessment of future demand for Britain’s electric vehicle public charging network”. January 2018. <https://www.theccc.org.uk/publication/plugging-gap-assessment-future-demand-britains-electric-vehicle-public-charging-network/>
- 7 “National Chargepoint Registry (NCR) - Activity by Network.” National Chargepoint Registry 2018. Accessed November 8, 2018. <http://www.national-charge-point-registry.uk/network-activity/>
- 8 eMI3, Electro mobility – Interoperability Challenges paper, June 2015. <http://xwp4f3h137o27oft81jv1nyh.wpengine.netdna-cdn.com/wp-content/uploads/sites/5/2015/11/eMI3-Electro-Mobility-Interoperability-Challenges-v1.0.pdf>
- 9 “Regulations: Alternative Fuels Infrastructure. Article 5 (2)” GOV.UK. Accessed November 8, 2018. <https://www.gov.uk/guidance/regulations-alternative-fuels-infrastructure>
- 10 The Alternative Fuels Infrastructure Regulations 2017, 2017 No. 897 § Regulation 13(3): Amounts of Civil Penalty. Accessed November 15, 2018. <http://www.legislation.gov.uk/ukxi/2017/897/regulation/13/made>
- 11 EV Box. “EVBox and ChargePoint pave the way for fully electric future with ground-breaking global partnership” 9 October 2019. <http://news.evbox.com/en-WWW/168931-evbox-and-chargepoint-pave-the-way-for-fully-electric-future>
- 12 VW. “Volkswagen to become a power supplier”. 8 January 2019. <https://www.volkswagen.co.uk/about-us/news/2019/01/volkswagen-to-become-a-power-sup/14>
- 13 ElaadNL. EV Related Protocol Study. Accessed 1st February 2019 https://www.elaad.nl/uploads/files/EV_related_protocol_study_v1.1.pdf
- 14 Rives, Jean-Marc. eMIP Protocol. Accessed 1st February 2019 https://www.gireve.com/wp-content/uploads/2017/02/Gireve_Tech_eMIP-V0.7.4_ProtocolDescription_1.0.2_en.pdf

15 Marc Multin, Christian Gitte, Hartmut Schmeck. Smart Grid-Ready Communication Protocols And Services For A Customer-Friendly Electromobility Experience. Accessed 1st February.

<https://subs.emis.de/LNI/Proceedings/Proceedings220/1470.pdf>

16 Hubject. Open InterCharge Protocol for Emobility Service Provider. Accessed 1st February.

https://www.hubject.com/wp-content/uploads/2016/04/160428_OICP-2.1_Release-14.1_EMP_final.pdf

17 'Open Charge Point Interface OCPI, Projecten - Website'. Accessed 11 January 2019.

<https://www.nklnederland.com/projects/our-current-projects/open-charge-point-interface-ocpi/>

18 Ferwerda, Roland, Michel Bayings, Mart van der Kam, and Rudi Bekkers. 'Advancing E-Roaming in Europe: Towards a Single "Language" for the European Charging Infrastructure'. World Electric Vehicle Journal 9, no. 4 (7 December 2018): 50. <https://doi.org/10.3390/wevj9040050>

19 Open Charge Point Interface 2.1.1, document version: 2.1.1-RC1, January 2017.

https://www.nklnederland.com/uploads/files/OCPI_2.1.1-RC1.pdf

20 Ferwerda, Roland, Michel Bayings, Mart van der Kam, and Rudi Bekkers. 'Advancing E-Roaming in Europe: Towards a Single "Language" for the European Charging Infrastructure'. World Electric Vehicle Journal 9, no. 4 (7 December 2018): 50. <https://doi.org/10.3390/wevj9040050>. P.11

21 E-clearing.net. "Major step for EV drivers: e- clearing.net and eViolin connect", 21 November 2016.

<https://e-clearing.net/news/major-step-for-ev-drivers-e-clearingnet-and-eviolin-connect>

22 Gireve. "Our Partners' Networks," Accessed November 15, 2018.

<https://www.gireve.com/en/nos-partenaires>

23 "ChargePoint and EVBox Pave the Way for Fully Electric Future with Forward-Thinking Partnership." ChargePoint. Accessed January 15, 2019.

<https://www.chargepoint.com/about/news/chargepoint-and-evbox-pave-way-fully-electric-future-forward-thinking-partnership/>

24 "Charge Your Car Helps UK's Drivers Recharge in Europe - ChargeYourCar," December 15, 2014.

<https://www.chargeyourcar.org.uk/news/charge-your-car-helps-uks-drivers-recharge-in-europe/>

25 Gireve. "Gireve consolidates its position in the UK with Franklin Energy." 29 January 2019.

<https://www.gireve.com/en/archives/9915>

26 'ISO 15118-1:2013'. ISO. Accessed 10 January 2019.

<http://www.iso.org/cms/render/live/en/sites/isoorg/contents/data/standard/05/53/55365.html>

27 'Convenient Charging of Electric Vehicles without the Need for a Card or App: Hubject and Daimler Pilot a Solution for Plug&Charge That Is Ready for Production | Hubject'. Accessed 10 January 2019.

<https://www.hubject.com/en/convenient-charging-of-electric-vehicles-without-the-need-for-a-card-or-app-hubject-and-daimler-pilot-a-solution-for-plugcharge-that-is-ready-for-production/>

28 "Plugged-in Places." GOV.UK. Accessed November 8, 2018.

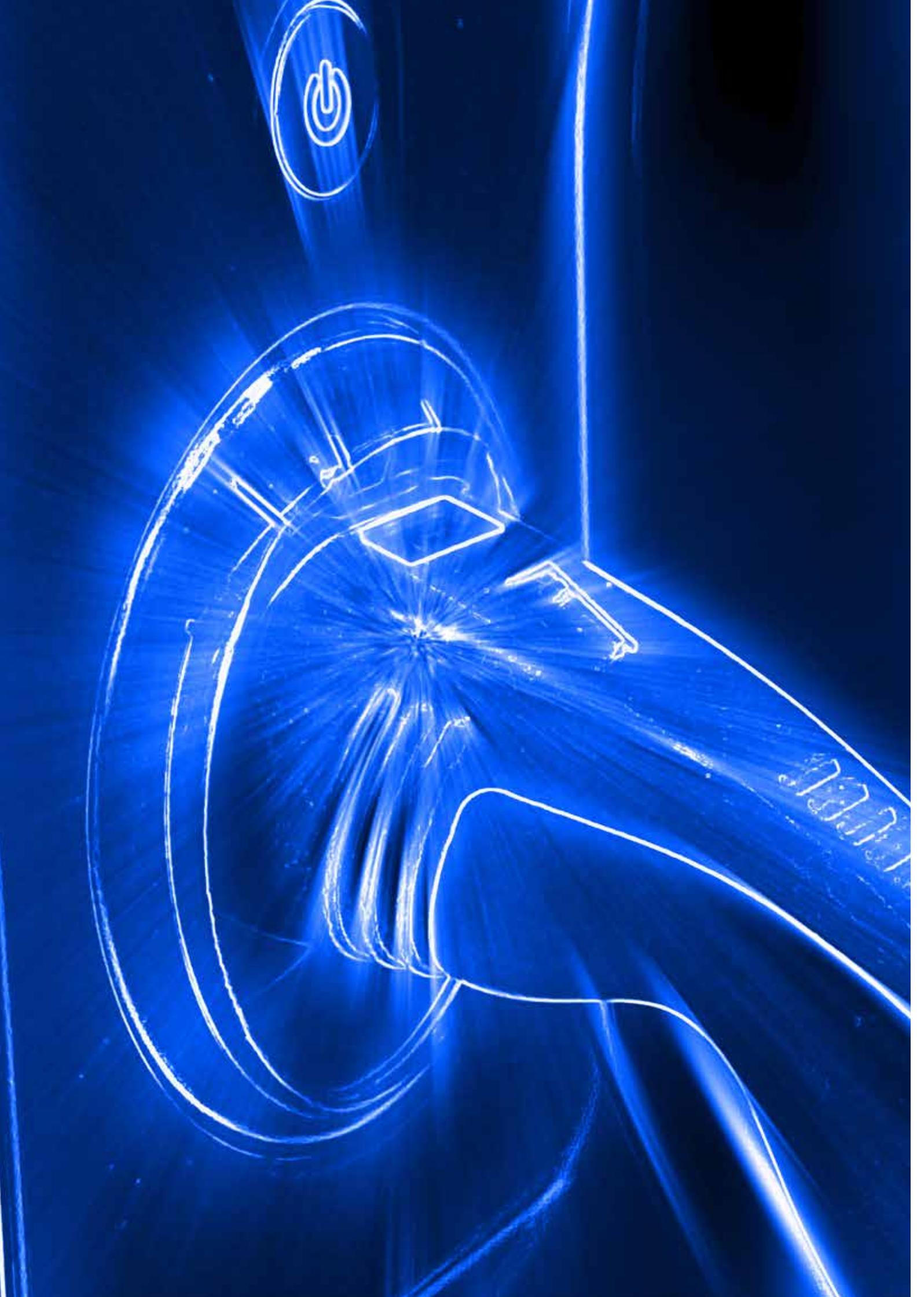
<https://www.gov.uk/government/publications/plugged-in-places/plugged-in-places>

29 "Lessons Learnt from the Plugged-in Places Projects." GOV.UK. Accessed November 8, 2018.

<https://www.gov.uk/government/publications/lessons-learnt-from-the-plugged-in-places-projects>

- 30 Office for Low Emission Vehicles . “Making the Connection: The Plug-In Vehicle Infrastructure Strategy.” Office for Low Emission Vehicles , June 2011.
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/3986/plug-in-vehicle-infrastructure-strategy.pdf
- 31 “Charging Infrastructure Investment Fund.” GOV.UK. Accessed November 8, 2018.
<https://www.gov.uk/government/publications/charging-infrastructure-investment-fund>
- 32 “National Infrastructure Assessment 2018.” National Infrastructure Commission. Accessed November 8, 2018. <https://www.nic.org.uk/publications/national-infrastructure-assessment-2018/>
- 33 “Going electric: rolling out an EV charging network.” National Infrastructure Commission blog. Accessed January 22, 2019. <https://www.nic.org.uk/going-electric-rolling-out-an-ev-charging-network/>
- 34 “National Infrastructure Assessment 2018.” National Infrastructure Commission. Accessed November 8, 2018. <https://www.nic.org.uk/publications/national-infrastructure-assessment-2018/>
- 35 “Government’s Interim Response to the National Infrastructure Assessment.” GOV.UK. Accessed November 8, 2018.
<https://www.gov.uk/government/publications/governments-interim-response-to-the-national-infrastructure-assessment>
- 36 “Electric Vehicles (Standardised Recharging) Bill 2017-19 — UK Parliament.” Accessed January 15, 2019. <https://services.parliament.uk/bills/2017-19/electricvehiclesstandardisedrecharging.html>
- 37 “Electric Vehicles (Standardised Recharging) - Hansard.” Accessed January 15, 2019.
[https://hansard.parliament.uk/commons/2018-11-20/debates/2B6AC9B4-7D6A-4A72-8F86-F14942C52F4F/ElectricVehicles\(StandardisedRecharging\)](https://hansard.parliament.uk/commons/2018-11-20/debates/2B6AC9B4-7D6A-4A72-8F86-F14942C52F4F/ElectricVehicles(StandardisedRecharging))
- 38 “Electric Vehicles (Standardised Recharging) Bill 2017-19 — UK Parliament.” Accessed January 15, 2019. <https://services.parliament.uk/bills/2017-19/electricvehiclesstandardisedrecharging.html>
- 39 [https://hansard.parliament.uk/commons/2018-11-20/debates/2B6AC9B4-7D6A-4A72-8F86-F14942C52F4F/ElectricVehicles\(StandardisedRecharging\)](https://hansard.parliament.uk/commons/2018-11-20/debates/2B6AC9B4-7D6A-4A72-8F86-F14942C52F4F/ElectricVehicles(StandardisedRecharging))
- 40 ZapMap. “Zap-Map survey reveals top EV charging networks.” 3 October 2018.
<https://www.zap-map.com/zap-map-survey-reveals-top-ev-charging-networks/>
- 41 “California SB454 | 2013-2014 | Regular Session.” LegiScan. Accessed November 8, 2018.
<https://legiscan.com/CA/comments/SB454/2013>
- 42 Argonne National Laboratory. “EV-Smart Grid Interoperability Center.” Accessed February 2019.
<https://www.anl.gov/es/evsmart-grid-interoperability-center>
- 43 Décret n° 2017-26 du 12 janvier 2017 relatif aux infrastructures de recharge pour véhicules électriques et portant diverses mesures de transposition de la directive 2014/94/UE du Parlement européen et du Conseil du 22 octobre 2014 sur le déploiement d’une infrastructure pour carburants alternatifs, 2017-26 § (n.d.). Accessed November 8, 2018.
- 44 “Les offres éligibles – ADVENIR.” Accessed November 8, 2018.
<http://advenir.mobi/labellisation/les-offres-eligibles/>
- 45 “Bilsalget i september.” Opplysningsrådet for Veitrafikken AS. (English: The Norwegian Road Traffic Advisory Board). Accessed November 8, 2018. <http://www.ofvas.no/bilsalget-i-september/category782.html>

- 46 Samferdselsdepartementet. "Meld. St. 33 (2016–2017)." Stortingsmelding. Regjeringen.no, April 5, 2017.
<https://www.regjeringen.no/no/dokumenter/meld.-st.-33-20162017/id2546287/>
- 47 Payment for public charging will be introduced in 2019 in Oslo municipality
- 48 BMVI. The starting signal for the federal charging infrastructure program. Accessed 8th February 2019
<https://www.bmvi.de/SharedDocs/DE/Pressemitteilungen/2017/019-dobrindt-e-ladesaeulenooffensive.html>
- 49 BMVI. FAQ for the federal program charging infrastructure. Accessed 8th February 2019.
https://www.bmvi.de/SharedDocs/DE/Anlage/Presse/bundesprogramm-ladeinfrastruktur-faq.pdf?__blob=publicationFile
- 50 BMVI. Federal Ministry for traffic and digital infrastructure. Accessed 8th February 2019.
https://www.bmvi.de/SharedDocs/DE/Anlage/G/foerderrichtlinie-ladeinfrastruktur-fuer-fahrzeuge-in-deutschland.pdf?__blob=publicationFile Paragraph 6.1
- 51 About us, eViolin.nl, <http://www.eviolin.nl/index.php/over-ons/>
- 52 eMI3, Electro mobility – Interoperability Challenges paper, June 2015.
<http://xwp4f3h137o27oft81jv1nyh.wpengine.netdna-cdn.com/wp-content/uploads/sites/5/2015/11/eMI3-Electro-Mobility-Interoperability-Challenges-v1.0.pdf>
- 53 "Emerging Best Practices for Electric Vehicle Charging Infrastructure | International Council on Clean Transportation." Accessed November 8, 2018.
<https://www.theicct.org/publications/emerging-best-practices-electric-vehicle-charging-infrastructure>
- Other references: Weber, Kai. "Electro Mobility - Interoperability Challenges ." eMobility ICT Interoperability Innovation Group, June 23, 2015.
<http://xwp4f3h137o27oft81jv1nyh.wpengine.netdna-cdn.com/wp-content/uploads/sites/5/2015/11/eMI3-Electro-Mobility-Interoperability-Challenges-v1.0.pdf>
-



For further information on this report, please contact;

Daniel Brown
Policy Manager & EV Lead
dbrown@r-e-a.net
+44 (0)20 7981 0857

To discuss REA membership, please contact;

Lindsay Barnett
Head of Membership, Marketing & Events
lbarnett@r-e-a.net
+44 (0)20 7925 3570



GROWING THE RENEWABLE ENERGY & CLEAN TECHNOLOGY ECONOMY



Renewable Energy Association, 80 Strand, London WC2R 0DT

Tel: 020 7925 3570 Fax: 020 7925 2715 Web: www.r-e-a.net

Email: info@r-e-a.net