energy taskforce

Work Package Four:

Accessible Data for Decision Making

Office for Low Emission Vehicles

CATAPULT Energy Systems

LowCVP Low Carbon Vehicle Partnership

Contents

1 Introduction

Introduction

The Electric Vehicle Energy Taskforce [1] was set up to address a range of questions related to meeting the demands of the wide scale adoption of Electric vehicles (EV) on the electrical networks. The Electric Vehicle Energy Taskforce established four Work Packages to consider the following issues;

- Work Package 1 – A common strategic understanding of the requirements of the energy system to support mass EV uptake.
- Work Package 2 – Engaging EV Users in Smart Charging and Energy Services
- Work Package 3 – Smart Charging Technical Requirements
- Work Package 4 – Accessible Data for Decision Making

Work Package 4 was asked to focus on the data requirements to allow the smart charging of EVs as part of a smart grid.

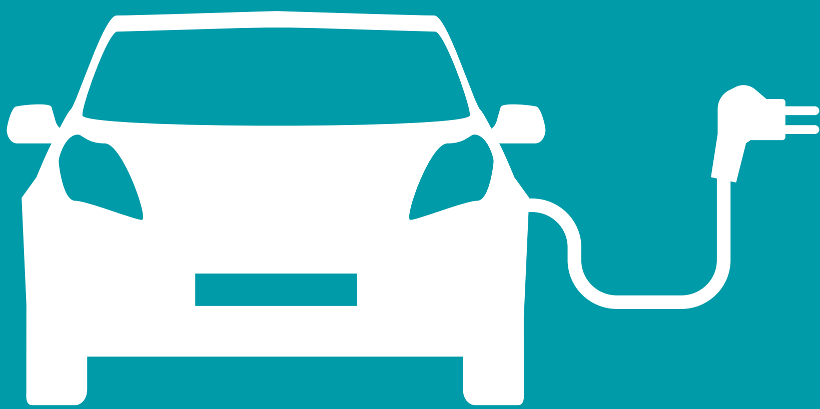
EVs offer both challenges and opportunities to the electricity system, combining the progress made in the decarbonisation of electricity supply and uptake of renewables with zero tailpipe emissions in transport. The challenge is largely focused on how to cope with the additional demand derived from the electrification of 324 billion vehicles miles driven in the UK every year, as well as the introduction of large-scale battery storage embedded into over 30 million vehicles. Addressing this challenge requires informed investment decision making, which is difficult to derive from an EV market that is still nascent. Innovation, new markets and operational solutions will also need to be embraced to deliver a reliable and fit for purpose system. There remain unanswered questions about where the most efficient locations for charging infrastructure are, especially given the potential changes to the nature of mobility as a result of advances in automated vehicles.

The large opportunities that EVs offer, aside from their obvious reduced carbon emissions and air quality benefits, are in the potential embedded flexibility of charging rate and time and storage capacity. This inherent flexibility could in part offset the additional demand placed on the overall system, as well as enabling the greater deployment of renewables. This flexibility could help to enable the creation of new energy markets and services, thereby enhancing consumer engagement and benefits.

Data and digital integration lie at the heart of these challenges and opportunities, and access to data is critical to achieve the maximum benefits from EVs. Data enables the understanding of where EVs are connecting, driving habits (energy usage), charging availability and how people use their electric cars, and this can greatly enhance savings and efficiency across the EV value chain. A key benefit of greater access to data is also to enable better planning and operation of electricity systems (from distribution level to transmission). Data can also help customers by facilitating better decision making around where to place charging points; enabling a better understanding of how they use their EV; and assigning ownership of data and hence options for how customers can commercialise this.

The work in this report builds on that of the Energy Data Task Force (EDTF). The EDTF made 5 key recommendations, which can be seen in table 1. The Electric Vehicle Energy Taskforce fully endorses these recommendations and believes that they will aid the EV registration process for customers, as well as better signpost the location and availability of chargepoint and electricity network infrastructure.

2 Context of Work Package 4



Context of Work Package 4

Aims and objectives

The purpose of Work Package 4 is to identify the various sources of data in the EV, infrastructure and energy value chain and address how EV-related data can be accessed and utilised, to ensure that the electricity system is able to facilitate the mass-deployment of EVs. Specifically, we sought to answer the following questions and address their associated issues:

1. What is the relevant data for decision making, who owns and benefits from it and where does it come from? What standards should this data feed?
2. How can data help remove barriers/ease access to getting a connection for EV charging infrastructure (and help inform EV infrastructure investment decisions)?
3. How can data help system operators improve system operation to help with EV demand?
4. How could sharing of data (e.g. around demand forecasting) help the energy sector better meet the energy impacts of EVs? How should we use data and how could sharing it be enabled and encouraged?
5. Do DNOs need better monitoring of the low voltage network or will real-time data from smart charging/smart meters largely avoid the need for this?
6. What data is needed to get the right types of chargepoints in locations that best meet the needs of EV users and the energy system?

Participants

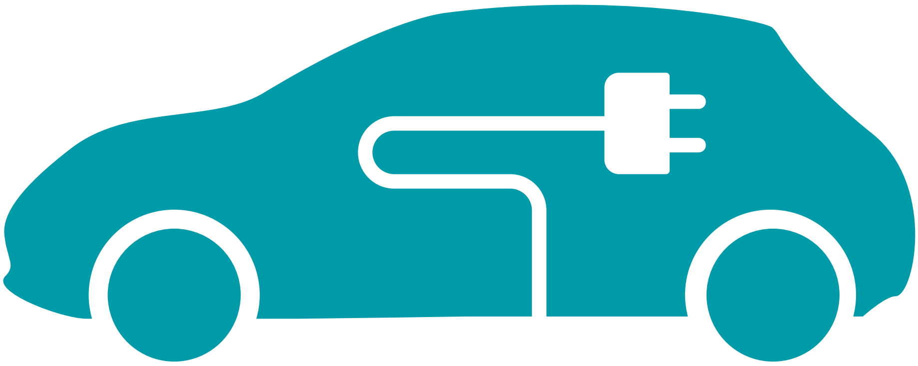
Work Package 4 was led by [Randolph Brazier] ENA and sponsored by [Matthew Evans,] Tech UK. Volunteers included members of organisations: BEAMA, Citizens Advice, EA Technology, Eversheds, Gemserv, Imperial College London, National Grid (SO), Octopus Energy, Pod-Point, Tesla and UK Power Networks.

Methodology

To answer each question, product teams were formed and in-depth analysis and best practice identification from around the world was undertaken. Each question generated its own document and included a number of use cases. These can be seen in the Appendices of this report.

The first stage in answering these questions was to understand exactly what data we were referring to. This involved identifying the different actors, systems and technologies with respect to EVs, and their associated data. This was the role of Q1, and a 'Digital Integration Overview' was produced to help identify the different players and data sets. This can be seen in the Q1 Appendix. The full list of data items, including itemised detail on parameters, potential use cases, location, access interface, ownership, etc, can also be seen in the Q1 document in the Appendix. This list of data items formed the basis for the rest of the Work Package 4 questions.

Once completed, a number of recommendations were identified for each question. These recommendations were then ranked based on the MoSCoW prioritisation system; "Must Have", "Should Have", "Could Have" and "Won't Have." These were ranked based on a short, medium and long-term timescale, as defined by the Electric Vehicle Energy Taskforce Steering Group. A full list of these recommendations for each question can be seen in Appendix A.



Once the recommendations were ranked, the “Must Have” recommendations were identified across each of the questions. These formed the basis of the “Summary Recommendations”, which were further consolidated and compared with recommendations from other Work Packages. A significant amount of synthesising was then undertaken to consolidate the recommendations of the Work Packages into a final set of proposals for the Electric Vehicle Energy Taskforce as a whole.

Work Package 4 landed on 5 key “Must Have” recommendations relating to energy data, as well as a number of other important recommendations across the questions identified in the purpose section above. In the final Electric Vehicle Energy Taskforce Main Report, the 5 key Work Package 4 recommendations were essential in helping form the overall Electric Vehicle Energy Taskforce proposals to government and industry. The overall proposals were formed by combining aspects of recommendations across multiple questions and Work Packages, but it is key that data is critical to the success of EV uptake.

3 Current position

Current position

Currently there is a lack of accessible data for monitoring, planning, and forecasting EVs (location, usage and charging patterns), and the behavioural change that innovative products and services may drive. Combined with the current lack of visibility of the low voltage networks in the UK, this poses significant challenges for electricity networks to be able to play an active supporting role in the deployment of EVs.

EV data from customers, manufacturers, aggregators, Government and others is often opaque, not easily accessible, poor quality and presumed closed due to real or perceived privacy and GDPR concerns; making planning for the uptake of EVs difficult for all involved parties. The lack of visibility of the low voltage networks is due to previously predictable loads at the residential level, and the slower than expected roll-out of smart meters as well as instrumentation of network assets and grid edge devices and data; visibility of the low voltage networks will not only enable more efficient operation of electricity systems, but also enable informed infrastructure investment decisions.

Electric vehicle usage and infrastructure data that can provide insight to enable more customer choice and efficient planning and operation of the electricity system will come from a range of sources. Monitoring of low voltage network data will need to increase over time and likely come from a range of sources including smart meters, grid edge devices, network monitoring and innovative data techniques. The EVs themselves and supporting cloud services are clearly a rich potential source of data, however it is not clear how readily available this data is given the global market that automotive manufacturers operate in. Information from charge points is another potential source and is critical to drive operational decisions, whole-system benefits and deliver policy outcomes. On domestic premises, smart meters are a further opportunity for system operators to increase their understanding of demand, although other sources of aggregated customer data may become available over time.

Currently, these challenges do not hinder the energy system in supporting the deployment of EVs, given the relatively low numbers deployed. However, this is quickly changing and in order to facilitate the expected mass uptake in demand of EVs through the 2020s and beyond, availability and access to quality data will need to increase dramatically.

4 Key Themes

Key Themes

A number of key themes have emerged from the research questions that were investigated by Work Package 4. These key themes centre around data: what, who, how, where, when. These can be broadly categorized as follows:

- **Ownership of data:** who owns the data, how do the various stakeholders share/delegate responsibility for accessing it and how should energy infrastructure data be made available. GDPR and privacy concerns relating to customer data are also critical issues and these are addressed within the Customer Experience Work Package 2.
- **Access to data:**
  - How should data be made available and in what format, including incentivising the provision of data
  - Where possible, incentivising data availability (e.g.: via market rules) is preferable to mandating
- **Data quality:** As far as possible, data should be digitised, standardised and consistent. This is paramount to achieving the maximum benefits of EV-related data. A local, national and global context needs to be considered when thinking about data quality.
- **Whole energy system benefits** and maximum benefits from data can only be achieved when a whole energy system approach is taken. This involves considering all aspects of electric vehicles and stakeholders, system operators, suppliers, aggregators, manufacturers, energy generation and consumption, networks, EV users, markets, charging and transportation infrastructure, etc.

Many of these themes align to the key proposals of the Energy Data Taskforce (EDTF). These can be seen below:

Table 1

	Energy Data Taskforce Recommendation Summary:
1	**Digitalisation of the Energy System** Government and Ofgem should direct the sector to adopt the principle of Digitisation of the Energy System in the consumers' interest, using their range of existing legislative and regulatory measures as appropriate, in line with the supporting principles of "New Data Needs" "Continuous Improvement" and "Digitalisation Strategies".
2	**Maximising the Value of Data** Government and Ofgem should direct the sector to adopt the principle that the Energy System Data should be Presumed Open, using their range of existing legislative and regulatory measures as appropriate, supported by requirements that data is "Discoverable, Searchable, Understandable", with common "Structure, Interfaces and Standards" and is "Secure and Resilient"
3	**Viability of Data** A Data Catalogue should be established to provide visibility through standardised metadata of Energy System Datasets across Government, the regulator and industry. Government and Ofgem should mandate industry participation through regulatory and policy frameworks.
4	**Coordination of Asset Registration** An Asset Registration Strategy should be established to coordinate registration of energy assets, simplifying the experience for consumers through user-friendly interface in order to increase registration compliance, improve the reliability of data and improve the efficiency of data collection.
5	**Visibility of Infrastructure and Assets** A unified Digital System Map of the Energy System should be established to increase visibility of the Energy System infrastructure and assets, enable optimisation of investment and inform the creation of new markets.

The Electric Vehicle Energy Taskforce endorses these recommenations from the EDTF and hence these also underpin the recommendations from this report. However, these recommendations by themselves are not enough. EVs will form a large part of the energy system and hence data needs to be considered from multiple sectors.

Data is a key enabler of EV uptake, and everyone can benefit from suitable data access. In fact, access to data is a 'win-win' and examples of beneficiaries include:

- Customers who have visibility of network and chargepoint infrastructure data will be able to connect faster, participate in new network services markets and plan how, when and where they charge (including generating power back into the grid). The data could be provided via the National Chargepoint Register or the Digital Systems Map (as per the EDTF), for example;
- System Operators & Energy networks that have access to sufficiently aggregated, anonymised or protected customer data will be able to better plan and operate the networks in a more efficient and sustainable way, with a targeted and informed investment strategy, while ensuring a reliable electricity supply;
- Upscaling of the EV market ensures that transport becomes decarbonised, not only significantly reducing its carbon emissions, but ensuring cleaner air for the public;
- Local Authorities can understand where the local economy is going and how it might be impacted by charging infrastructure constraints;
- SMEs and innovators will be able to create new technologies, markets, platforms and business models which deliver value for customers and create jobs for the UK, ensuring a prosperous low carbon economy; and
- EV manufacturers can provide more targeted data to potential customers, to inform them of benefits and address range anxiety.

5 Conclusions & Recommendations

Conclusion and Recommendations

Data is clearly a critical enabler for achieving whole energy system benefits from the large-scale roll-out of EVs. Transparency, visibility and access are key to making this data useful to the various actors in the energy, transport sectors and the wider market. Through the questions that were investigated as a part of this Work Package, a number of recommendations were made that should be considered by Government and the Industry.

The summary list of the Key Recommendations from Work Package 4 can be seen in Table 2 below, while the full set of MoSCoW prioritised recommendations can be seen in Appendix A.

These 5 recommendations formed a critical aspect of the overall Electric Vehicle Energy Taskforce report proposals; data was recognised by all work packages as essential to a successful EV roll-out, and this is reflected in many of the overall Electric Vehicle Energy Taskforce report proposals.

We have also mapped the most relevant EDTF recommendations against the recommendations from Work Package 4 in the second column. This further highlights how the two task forces are complimentary to each other.

Table 2

	Summary Recommendations	Relevant EDTF Recommendation
1	**System Resilience by Design** The digital integration of EVs needs to be delivered with system resilience by design to address and mitigate against system vulnerabilities (physical and cyber) with far reaching consequences. Efficient and effective safeguards to enforce clear accountabilities for: all market actors (eg: Electricity Networks, OEMs, Aggregators, etc), data access, privacy requirements and traceability of digital transactions and decision making to prevent system failures needs to be part of system resilience by design.	**1, 2**
2	**Access to Data** Enable the provision of suitably accurate Government, Infrastructure, Vehicle (including State of Charge) and Energy Market data at a regional and national level, to allow innovation, planning, investment and operational decisions around EV load and infrastructure by the appropriate parties, e.g.: for a DNO to better understand reinforcement and deployment of LV monitoring, or for installers to understand network capacity headroom and presence of smart charging schemes at a local level, or for an ESO to maintain system frequency and stability of the electricity grid. Data access and rules must develop in a way that encourages ongoing innovation and opens up the market to new solutions – the recommendations from the EDTF for data being assumed open, with a suitable triage process for access, should be implemented. Market participants should collect and share anonymised, statistical data on EV usage patterns, charging and energy consumption with relevant parties in order to allow the energy and transport systems to work effectively together and provide value to all market participants.	**3, 5**

	Summary Recommendations	Relevant EDTF Recommendation
3	**Chargepoint Registration** Public Chargepoint Operators, Owners and Market Actors must make data consistent and openly available on public chargepoint location, type, status, capacity, price and availability to enable EV drivers to find (and possibly reserve) an available, working public chargepoint that is suitable for their immediate charging needs. The data will need to be updated regularly, but the frequency will need to be further considered with an expectation that chargepoint availability would need to be updated more regularly than working status to be of most use. Access to data will need to be considered in line with the triage process proposed by the Energy Data Taskforce. This will maximise convenience for customers and encourage the development of innovative applications that help users identify how they can best meet their charging requirements. A single asset register must include all fixed chargepoints (i.e. private, public, workplace, etc) and should include all relevant data to ensure optimum planning and operation of the electricity networks. Provisions must be made to ensure appropriate access to this data – this is in line with the recommendations from the Energy Data Taskforce. Chargepoint operators should be incentivised to provide data through an appropriate mechanism such as the Renewables Transport Fuels Obligation.	4
4	**Deliver New Markets** that maximise the opportunities for customers to realise new revenue streams and offer demand flexibility services to support optimal network investment and whole electricity system efficiency. These new markets need to be co-ordinated with wider energy markets such as wholesale, system balancing and ancillary services. This would encourage new service offerings from both incumbent and Non-Traditional Businesses allowing EV users and customers generally to benefit by accessing flexibility markets (e.g. network constraint management) and offering system services (e.g. STOR, frequency response, etc.). Tariffs that better reflect true network costs (i.e. reflecting the Red, Amber and Green Band charges levied on Suppliers) and which more closely align retail price to wholesale market price variations (e.g. day-ahead dynamic tariffs) would further encourage demand flexibility. These propositions are to be engaging, and designed to bring about behavioural change, motivated in part by the carbon and environmental benefits, but also through offering price and/or revenue stream incentives. This objective would be further supported through a regulatory framework which encourages innovation in whole system and energy transition solutions. Networks, generators, suppliers and aggregators should ensure the market propositions that are developed are data driven.	1, 2, 5

	Summary Recommendations	Relevant EDTF Recommendation
5	**Investment in LV Monitoring** Investment in LV monitoring is critical over the next 10 years to enable accurate planning and operation of the LV networks, in turn reducing costs associated with reinforcement and operation for customers. It is unlikely to be required in all cases of EV uptake, but other trends such as electrification of heating and decentralisation of generation and storage mean that timely LV monitoring is essential to maximising benefits of LV investment. A sensible mix of LV monitoring solutions should be based upon a Cost Benefit Analysis (CBA). Time becomes the key driver, and as such the least regret volume programmes of network monitoring are to be launched ahead of need. The following data sets are essential for monitoring, and the specific mix of solutions in a certain area of the LV network will be dependent on a range of factors: a LV Substation Monitoring: three-phase power flow data in real-time, voltage and current waveforms, all power quality related information, real-time loss of supply information; b Smart Meters: voltage, real-time loss of supply, maximum demand and time by MPAN; c Smart chargers and connected EV: voltage, max current and time, connectivity/availability of EV battery (if V2G capable).	1, 3, 5

6 Appendices

Appendices

Additional recommendations

A full set of MoSCoW prioritised recommendations is shown below.

SUMMARY RECOMMENDATIONS				
	Recommendation	Short Term (by 2020)	Medium Term (2021-2025)	Long Term (2026-2030)
1	**System Resilience by Design** The digital integration of EVs needs to be delivered with system resilience by design to address and mitigate against system vulnerabilities (physical and cyber) with far reaching consequences. Efficient and effective safeguards to enforce clear accountabilities for: all market actors, data access, privacy requirements and traceability of digital transactions and decision making to prevent system failures needs to be part of system resilience by design.	M	M	M
2	**Access to Data** Enable the provision of suitably accurate Government, Infrastructure, Vehicle (including State of Charge) and Energy Market data at a regional and national level, to allow innovation, planning, investment and operational decisions around EV load and infrastructure by the appropriate parties, eg: for a DNO to better understand reinforcement and deployment of LV monitoring, or for installers to understand network capacity headroom and presence of smart charging schemes at a local level, or for an SO to maintain system frequency and stability of the electricity grid. Data access and rules must develop in a way that encourages ongoing innovation and opens up the market to new solutions - the recommendation from the EDTF for data being assumed open, with a suitable triage process for access should be observed. OEMs and other market participants should collect and share anonymised, statistical data on EV usage patterns, charging and energy consumption.	M	M	M

SUMMARY RECOMMENDATIONS				
	Recommendation	Short Term (by 2020)	Medium Term (2021-2025)	Long Term (2026-2030)
3	**Public Charge Point Data** Public Charge Point Operators, Owners and Market Actors must make data consistent and openly available on public charge point location, type, status, capacity, price and availability to enable EV drivers to find (and possibly reserve) an available, working public charge point that is suitable for their immediate charging needs. The data will need to be updated regularly, but the frequency will need to be further considered with an expectation that chargepoint availability would need to be updated more regularly than working status to be of most use. The National Chargepoint Register (or equivalent) must include all public charge points and include as much of this data as possible. The Register should also be expanded in scope to cover all fixed charge points (i.e. private, public, workplace, etc), but provisions must be made the ensure appropriate access to this data - this is in line with the recommendation from the Energy Data Taskforce on a single Asset Registration Portal. This will maximise convenience for customers and encourage the development of innovative applications that help users identify how they can best meet their charging requirements.	M	M	M
4	**Deliver New Markets** that maximise the opportunities for customers to realise new revenue streams and offer demand flexibility services to support optimised network investment and whole electricity system efficiency. These new markets need to be co-ordinated with wider energy markets such as wholesale, system balancing and ancillary services. This would encourage new service offerings from both incumbent and Non-Traditional Business Companies allowing EV users and customers generally to benefit by accessing flexibility markets (e.g. network constraint management) and offering system services (e.g. STOR, frequency response, etc.). Tariffs that better reflect true network costs (i.e. reflecting the Red amber and Green Band charges levied on Suppliers) and which more closely align retail price to wholesale market price variations (e.g. day-ahead dynamic tariffs) would further encourage demand flexibility. These propositions are to be engaging, and designed to bring about behavioural change, motivated in part by the carbon and environmental benefits, but also through offering price and/or revenue stream incentives. This objective would be further supported through a regulatory framework which encourages innovation in whole system and energy transition solutions. Networks, generators, suppliers and aggregators should ensure the market propositions that are developed are data driven..	M	M	M

SUMMARY RECOMMENDATIONS				
	Recommendation	Short Term (by 2020)	Medium Term (2021-2025)	Long Term (2026-2030)
5	**Investment in LV Monitoring** Investment in LV monitoring is critical over the next 10 years to enable accurate planning and operation of the LV networks, in turn reducing costs associated with reinforcement and operation for customers. It is unlikely to be required in all cases of EV uptake, but other trends such as electrification of heating and decentralisation of generation and storage mean that LV monitoring is essential to maximising benefits of LV investment. A sensible mix of LV monitoring solutions should be based upon a CBA. Time becomes the key driver, and as such the least regret volume programmes of network monitoring are to be launched ahead of need. The following data sets are essential for monitoring: a LV Substation Monitoring: three-phase power flow data in real-time, voltage and current waveforms, all power quality related information, real-time loss of supply information b Smart Meters: voltage, real time loss of supply, maximum demand and time by MPAN c Smart chargers and connected EV: voltage, max current and time, connectivity/availability of EV battery (if V2G capable)	M	M	M

Q1 RECOMMENDATIONS				
	Recommendation	Short Term (by 2020)	Medium Term (2021-2025)	Long Term (2026-2030)
Q1.1	The digital integration of EVs requires market governance to deliver large scale whole system benefits securely to all market participants while having sound and proven measures in place to mitigate system risks arising from data sharing and algorithmic automation.	M	M	M
Q1.2	Digital integration across borders requires suitable treaties and commitments across different jurisdictions. Market governance needs to ensure that data needed to unlock whole system value is available and secure to all market actors and standards are in place to enforce assurance and compliance by design for products and services affecting the energy system.	S	M	M
Q1.3	A digital reference architecture is needed for national and international standardisation, governance and legislation to be effective. The architecture will allow each data item to be assessed for its contribution to whole system value, risks and required governance. This has to be understood in the cross-sector industry context as the system components contributing to the whole system benefits do not reside within a single industry sector.	M	M	M
Q1.4	Digital infrastructure, data processing and oversight need to meet scalability requirements and support infrastructure choices.	S	M	M

Q2 RECOMMENDATIONS				
	Recommendation	Short Term (by 2020)	Medium Term (2021-2025)	Long Term (2026-2030)
Q2.1	Develop frameworks that enable access to customer and building energy data which can aid new services development and drive the rollout of new energy saving and energy management solutions.	W	S	M
Q2.2	Create an environment to facilitate the development and delivery of new data driven tools, services and processes to ensure customer experience and to allow charging infrastructure to be rolled out at the scale required.	W	M	M
Q2.3	Focus on interoperability for access and payment infrastructure, in order to avoid damaging the growth of the market.	C	M	M
Q2.4	Develop data rules and criteria in a way that encourages ongoing innovation and opens up the market to new solutions e.g. data that is publicly accessible (fully available on the web) vs. private (info submitted to DNO's in order to speed up the process for the purpose of the application).	S	S	M

Q3 RECOMMENDATIONS				
	Recommendation	Short Term (by 2020)	Medium Term (2021-2025)	Long Term (2026-2030)
Q3.1	Data items that facilitate accurate forecasting of electric vehicle demand in the immediate, short, medium and long term timescales; in both a national and regional basis.		M	M
Q3.2	Data items that allow a System Operator to assess the need for an electric vehicle to be charged unrestricted in occasions where there is a network constraint (Energy, Voltage or Thermal), or constrain its charging to protect network integrity.		M	M
Q3.3	Data items that improve the understanding of how electric vehicle assets operate (annual demand, contribution to peak and summer minimum etc.); both in national and regional basis in a series of timescales.	C	M	M
Q3.4	Data items that allows a forward, short term, view of when and where new electric vehicles will become active on the network (i.e. when and where it is registered). Equally data items that are longer term (i.e. when and where existing ICE contract ends).	C	C	C
Q3.5	State of Charge Data A key technical requirement for infrastructure operators is to understand the remaining capacity in EV batteries during charge events. As such, it is recommended that the ""state of charge"" should be shared by the EV with the charging infrastructure. Access to the SoC data should be subject to a triage process similar to that proposed in the EDTF. potentially through the imminent arrival of the ISO 15118 standard. Ideally, OEMs and charging infrastructure should be required to support this standard (in due course)."	C	S	M

Q4 RECOMMENDATIONS				
	Recommendation	Short Term (by 2020)	Medium Term (2021-2025)	Long Term (2026-2030)
Q4.1	The Government (or delegated body) track and openly publish monthly data on EV adoption (and associated infrastructure). This data is currently available from the SMMT (and others), but is not necessarily public.	M	M	M
Q4.2	DNOs must make localised network headroom data and forecasts available in an easily usable format – by installing additional instrumentation if necessary.	C	S	M
Q4.3	The National Travel Survey should collect and make available statistical, regional (or geospatial) vehicle journey data, in addition to the GB-wide data that is currently published. This could be extended to vehicle data as and when they are being serviced.	S	M	M
Q4.4	DNOs, generators, suppliers and aggregators should develop markets for EV charge management (within the under-development Open Networks framework) to enable customers to benefit from flexibility in charging (i.e. incentives to charge off-peak, demand turn-down services, etc).	C	S	S
Q4.5	OEMs should collect and share anonymised, statistical data on EV usage patterns, charging and energy consumption to enable accurate medium and long-term demand forecasting.	S	S	S

Q5 RECOMMENDATIONS				
	Recommendation	Short Term (by 2020)	Medium Term (2021-2025)	Long Term (2026-2030)
Q5.1	Grid edge data is valuable, and provision to trusted bodies should be considered.	S	M	M
Q5.2	Access to data (Must Have) for trusted bodies like Networks from Smart Meters should be mandated.	M	M	M

Q6 RECOMMENDATIONS				
	Recommendation	**Short Term (by 2020)**	**Medium Term (2021-2025)**	**Long Term (2026-2030)**
Q6.1	The prospective siting of many chargepoints will be determined directly by purchasers who intend to use them, e.g. home and some workplace charging units, and thus required little external influence. But it is recommended to mandate charging provision for new homes through planning. Public locations will require data indicating demand for charging, such as: 1 EV uptake and size of EV parc 2 Prevalent EV and charging technologies 3 Dwell times at prospective sites 4 Traffic volumes near to potential en route charging points Provision of such market data does not necesarily require external intervention. However, should the government seek to directly invest in charging infrastructure provision (e.g. supporting ultra-fast charging), suitable data should be obtained to inform likely utilisation rates.			
Q6.2	Data on available grid capacity, both in terms of local (DNO) network and transmission network for ultra-fast sites, helps determine the type and quantity of charging infrastructure that can be installed in a location. While it is possible to obtain information from DNOs etc for data on individual sites, consideration should be made to making a more holistic picture of network capacity available for those seeking to pro-actively install charging infrastructure (and other technologies, e.g. battery storage applications).			
Q6.3	How much charging infrastructure can be installed in a location is dependent on both capacity and flexibility of the charging infrastructure. Full data on the combination of available capacity and potential flexibility inherent within charging infrastructure that could be unlocked is not wholly visible. Such flexibility would take the form of demand reduction through deferment, or demand turn up (smart charging), and potentially bi-directional charging (V2G). Rather than try and focus on mandating specific data availability, it is recommended that, wherever possible, the government supports the development of a commercial market mechanism that will act as an enabler to realising this value and reducing unnecessary grid upgrade costs. By establishing a viable marketplace, the commercial incentive will seed innovation organically.			

Question 1 – What is the relevant data for decision making, who owns and benefits from it and where does it come from? What standards should this data feed?

Joachim Brandt (Gemserv), Marko Aunedi (Imperial College), Paul Barnfather (EA Technology), Michelle Davies (Eversheds)

Introduction

This paper describes the data aspects for the digital integration of Electric Vehicle Charging into the wider energy system specifically:

(Q1.1) What is the relevant data for decision making?
(Q1.2) Who owns and benefits from it?
(Q1.3) Where does it come from?
(Q1.4) What standards should this data feed?

The paper will also touch on:
(Q1.5) What data is needed to get the right types of charging infrastructure in locations that best meet the needs of EV users and the energy system?

Background and motivation

1. The government's ambition is to phase out fossil fuel vehicles over a relatively short time period to meet climate change targets and air quality compliance.
2. The electricity system is moving towards a more distributed architecture with large proportion of low carbon electricity generation from renewable sources such as solar and wind.
3. To unlock the potential of security of supply of low carbon electricity for transport purposes.
4. For illustrative purposes, if we assume a vehicle parc of 30 million vehicles in the UK with EV batteries in the order of 75 kWh capacity to provide a vehicle in the 300 miles range, then the embedded energy storage capacity connected to the electricity system would be in the order of 2.25 TWh. There is potential to derive large whole energy system benefits from it.
5. For illustrative purposes, if we assume that 1kWh delivers in the order of 4 vehicle miles, then the electrification of 324 billion vehicle miles driven in the UK every year would add in the order of 81 TWh generation demand per year (not considering any system losses).
6. There is significant energy flow embedded in the vehicle parc as vehicles travel from one location to another with the transport need consuming a relatively small proportion of the energy stored. EVs may also increasingly use onboard electricity generation e.g. solar PV, if we assume a 180W panel per vehicle the EV parc would have onboard generation capacity in the order of 5.4 GW geographically distributed.
7. The key enabler to create value with products and services as part of large-scale uptake of electric vehicles is digital integration and data.
8. An unpredictable, unmanaged charging infra-structure solution may increase risk and uncertainty for the electricity system and poses a barrier for high value products and services electric vehicles provide opportunities for.
9. The type and location of charging infrastructure and the choice of charging technologies for scalable deployment are likely to be contributing factors as the UK migrates to electric vehicles.
10. Products and services are delivered by a range of stakeholders with interdependencies between them such as sharing of data and interoperability within the wider system approach.

High level principles

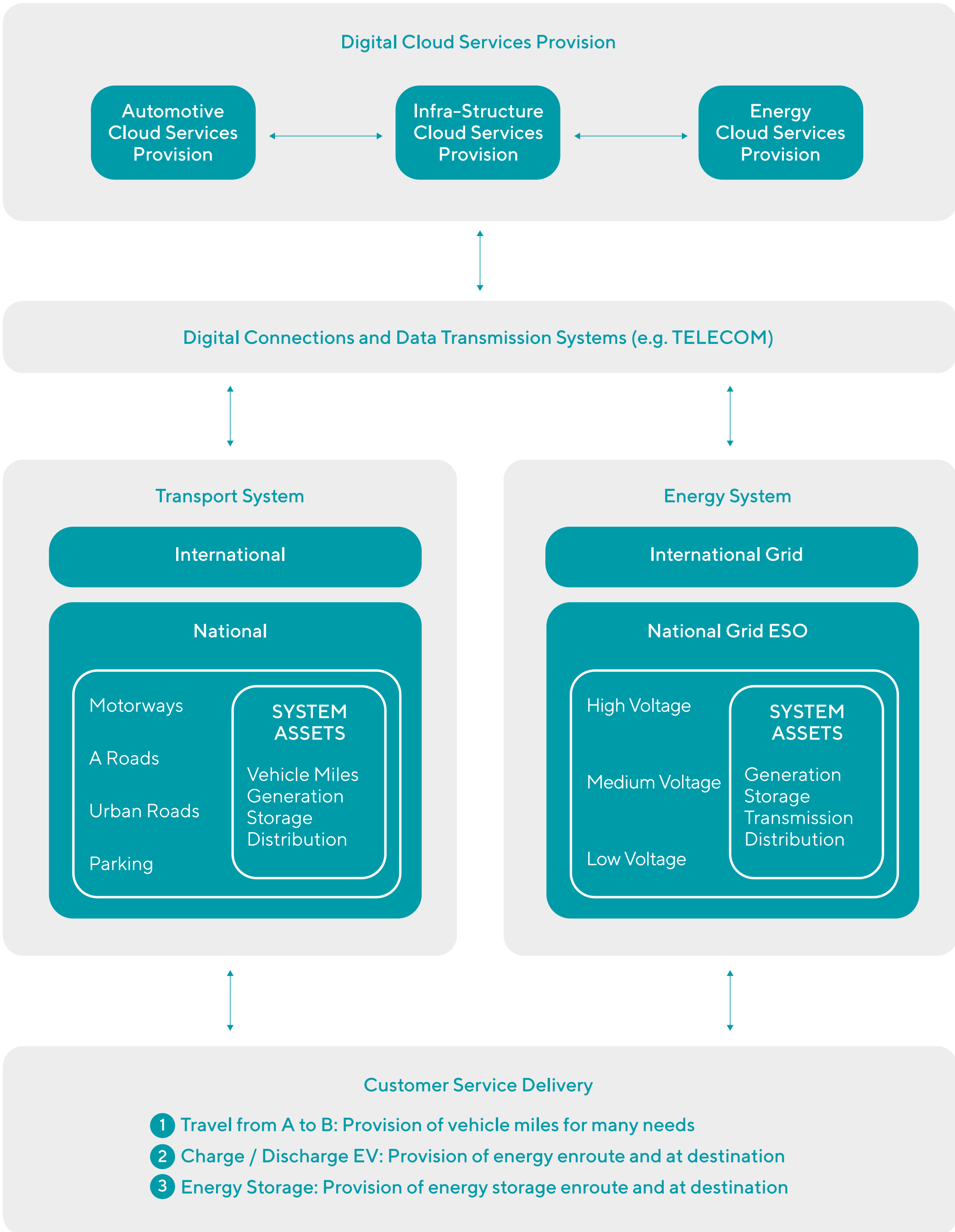
1. Digital Integration must be inclusive to all market participants to maximise the uptake of electric vehicles and unlock whole system value pools.
2. There needs to be clear guidance with regards to governance of data ownership, data sharing and management of data between market participants to create a level playing field. A cross market sector approach is required supported by a data and access privacy framework.
3. Digital integration is not bound by national boundaries and a global market view should be adopted for the UK to enter a global lead position.
4. Customer choice, customer assurance and customer value will determine the pace of innovation and time to market for novel digital products and services.
5. The digital integration of electric vehicles from a whole system perspective is a pre-cursor towards Connected Autonomous Vehicles (CAV) and as such wider aspects of cyber security, increasing levels of algorithmic automation and the rise of artificial intelligence should be taken under c consideration.

Recommendations

1. Recommendations from the Energy Data Taskforce should be considered and tested in the context of the findings of the Electric Vehicle Energy Taskforce.
2. The digital integration of EVs requires market governance to deliver large scale whole system benefits securely to all market participants while having sound and proven measures in place to mitigate system risks arising from data sharing and algorithmic automation.
3. The digital integration of EVs needs to be delivered with system resilience by design and ready to accommodate connected autonomous vehicles as a global trend on the horizon. Consideration needs to be given to data access and privacy requirements.
4. Safeguards are required to ensure traceability of transactions and decision making for pre-emptive prevention of system failures, fault diagnostics, assured system/grid stability and evidence to support insurance of millions of connected EVs and system assets.
5. Digital integration across borders requires suitable treaties and commitments across different jurisdictions.
6. Market governance needs to ensure that data needed to unlock whole system value is available and secure to all market actors and standards are in place to enforce assurance and compliance by design for products and services affecting the energy system.
7. A digital reference architecture is needed for national and international standardisation, governance and legislation to be affective and provide the context against which each data item can be assessed for its contributing whole system value and risks and required governance.
8. Digital infrastructure, data processing and oversight need to meet scalability requirements and support infrastructure choices.

Digital integration overview

The schematic below illustrates the invasive nature of data with regards to the market actors involved in the customer services delivery across market sectors and geographical boundaries. This poses challenges in creating a level playing field for all market actors, the handling and owning of data for decision making and the need to resolve interdependencies between market actors to unlock economic market growth and delivery system readiness. No market actor can provide delivery system readiness in isolation for large scale uptake of EVs.



Vehicle parameters
Many of the data items relating to travel need, energy demand, energy storage capacity and energy flexibility are part of the vehicle and the aggregation thereof in the geospatial context of the national vehicle parc. The automotive sector is therefore an important market actor in terms of the sales of automotive products and services embedded in the electric vehicle with interdependencies within the energy sector.

Generic Vehicle Parameters

Decision Parameters:
- Location
- Manufacturer/model
- Battery capacity (kWh)
- Range when fully charged (km)
- Average consumption (kWh/km)
- Journey data (historical, satnav, average speed, route, parking location, etc)
- Owner/driver data (demographics)

Use Cases:
1 How much energy does the vehicle consume?
2 When and where is it likely to be charged?

Required For:
- Predicting charging requirements
- Matching charging requirements with available infrastructure and energy

Sourced From:
- Vehicle

Access Interface / Standards:
- CAN Bus (vehicle)
- CAN Bus (charging interface e.g. CHAdeMO)
- Charge Controller (EVSE e.g. CHAdeMO)
- Proprietary Apps (Automotive)

Owned by:
- Vehicle Owner

Interested Parties:
- Vehicle Driver
- Fleet Manager
- Vehicle Infotainment System: SatNav Provider
- Energy System: Energy Supplier, DNO, Transmission, Aggregators, Consumer/Prosumer
- Digital System: IoT e.g. automation and optimisation of power flows
- Third Party Service Providers

Battery: State of Charge

Decision Parameters:
- State of Charge (SoC)
- Vehicle Range (calculated value by the vehicle based on historic driving data)

Use Cases:
3 How far can the vehicle drive?
4 How much electricity is stored in the battery?
5 What's the value of the electricity stored in the battery?

Required For:
- Estimated vehicle range
- Estimated available electricity storage

Sourced From:
- Vehicle – Battery Management System (BMS)

Access Interface / Standards:
- CAN Bus (vehicle)
- CAN Bus (charging interface e.g. CHAdeMO)
- Charge Controller (EVSE e.g. CHAdeMO)
- Proprietary Apps (Automotive)

Owned by:
- Battery Owner

Interested Parties:
- Vehicle Driver
- Fleet Manager
- Vehicle Infotainment System: SatNav Provider
- Energy System: System Operator, Energy Supplier, DNO, Transmission, Aggregators, Consumer/Prosumer
- Digital System: IoT e.g. automation and optimisation of power flows
- Third Party Service Providers

Decision Parameters:
- Onboard Charging Power
- Max Power
- Min Power
- Configured Power
- Ramp Up / Down
- Uni/bi-directional

Use Cases:
6 What is the maximum load on the charging point?
7 What is the minimum load on the charging point?
8 What is the resolution of ramping up or down of power flow.

Required For:
- Dimensioning of electricity supply point
- Throttling or increasing of power flow of the connected vehicle

Sourced From:
- Vehicle – Charge Controller

Access Interface / Standards:
- CAN Bus (vehicle charge controller)
- CAN Bus (vehicle charging interface)
- Charge Controller (EVSE)
- Vehicle User Configuration Parameters

Owned by:
- Vehicle Owner

Interested Parties:
- Vehicle Driver
- Vehicle Infotainment System: SatNav Provider (mapping of EVSE)
- Energy System: System Operator, Energy Supplier, DNO, Transmission, Aggregators, Consumer/Prosumer
- Digital System: IoT e.g. automation and optimisation of power flows
- Third Party Service Providers

On-board Power Flow Management

Decision Parameter:
- State of Charge (SoC)
- Max Power
- Min Power
- Configured Power
- Ramp Up / Down
- Uni/bi-directional

Use Cases:

9 How long does it take to reach a certain SoC level?
  1 Forecast dispatchable electricity during a certain period.
  2 Forecast recoverable electricity during a certain period.

Required For:
- Supply constrain management
- Maximise self-consumption of onsite generation

Sourced From:
- Vehicle – Battery management system (BMS) & charge controller

Access Interface / Standards:
- CAN Bus (vehicle)
- Charge Controller (EVSE)

Owned by:
- Vehicle Owner

Interested Parties:
- Vehicle Driver
- Vehicle Infotainment System: SatNav Provider (mapping of EVSE)
- Energy System: System Operator, Energy Supplier, DNO, Transmission, Aggregators, Consumer/Prosumer
- Digital System: IoT e.g. automation and optimisation of power flows
- Third Party Service Providers

Onboard charging scheduler

Decision Parameter:
- State of Charge (SoC)
- Max Power
- Min Power
- Configured Power
- Ramp Up / Down
- Uni/bi-directional
- Time to start charging
- Time to complete charging

Use Cases:

10 Start – Complete charging using a pre-configured charging schedule
  1 Delay charging to a pre-set time.
  2 Start charging just in time to complete at a pre-set time.

Required For:
- Co-ordinate with ToU energy supply options
- Maximise self-consumption of onsite generation
- Minimise battery degradation
- Shift EV demand
- Co-ordinate charging with travel requirements

Sourced From:
- Vehicle – BMS / charge controller/ charge scheduler

Access Interface / Standards:
- CAN Bus (vehicle)
- Infotainment system (vehicle)
- Charge Controller (EVSE)

Owned by:
- Vehicle Owner

Interested Parties:
- Vehicle Driver
- Vehicle Infotainment System: SatNav Provider (mapping of EVSE)
- Energy System: System Operator, Energy Supplier, DNO, Transmission, Aggregators, Consumer/Prosumer
- Digital System: IoT e.g. automation and optimisation of power flows
- Third Party Service Providers

Onboard generators

There are various onboard generation capabilities on the market. For example, plug-in hybrids can be configured to use their fossil fuel engine to charge the battery for instance prior to entering a low emission zone or as ancillary generator in the V2X context. Solar PV embedded in the vehicle roof space is also available as onboard generation, which supplements the EV while driving or charges the battery if stationary in an open-air location. Whether or not onboard generation activates may be dependent on the SoC of the traction battery i.e. if the battery is fully charged onboard generation may not be able to be active.

Decision Parameter:
- State of Charge (SoC)
- Max Power
- Min Power
- Configured Power
- Ramp Up / Down
- Automatic / Manual Control
- Charging Scheduler settings

Use Cases:

11 Charge the EV battery from onboard generation

Required For:

- Co-ordinate with ToU energy supply options
- Reduce infra-structure dependencies
- Cost optimisation EV charging / discharging
- Maximise self-sufficient charging with travel requirements

Sourced From:

- Vehicle – BMS / onboard charge controller / charging scheduler

Access Interface / Standards:

- CAN Bus (vehicle)
- Infotainment system (vehicle)

Owned by:

- Vehicle Owner

Interested Parties:

- Vehicle Driver
- Fleet operator
- Vehicle Infotainment System: SatNav Provider (mapping of EVSE)
- Energy System: System Operator, Energy Supplier, DNO, Transmission, Aggregators, Consumer/Prosumer
- Digital System: IoT e.g. automation and optimisation of power flows
- Third Party Service Providers

EVSE parameters

Many of the data items relating to the energy supply point and energy flexibility are part of the EVSE and the aggregation thereof in the geospatial context of the national charging infra-structure. The manufacture and installation of EV charging points is therefore an important market actor in terms of the sales of EV charging products and services required for electric vehicles with interdependencies within the automotive and energy sector.

EVSE Charging Power

EVSE charging power is not to be confused with the onboard charging power. The EVSE charging power is more to be seen in the context of a supply constraint management, for example if the EVSE installation is limited to 16A, even if the car could charge at 32A the charge controller in the car will be negotiated down by the EVSE controller to charge at no more than 16A. In this context, smart charging implemented on the EVSE can influence the charging behaviour of the vehicle between "don't charge", "charge at minimum current 6A", charge at any negotiable rate between the EV and the EVSE to the permissible maximum of the EVSE which a supply constraint is imposed onto the car by the EVSE. However, in the context of DC charging solutions, the power electronics required for charging the EV are part of the EVSE with the EV only providing the functionality to close or open the battery contactors. In this context DC charging equipment adds considerable cost to the EVSE and duplicates the charging components within the vehicle.

Decision Parameters:

- Max Power
- Min Power
- Configured Power
- Ramp Up / Down
- Uni/bi-directional
- EVSE Location
- EVSE Availability
- EVSE Tariff
- EVSE Connections

Use Cases:

12 What is the maximum load on the charging point?
13 What is the minimum load on the charging point?
14 What is the resolution of ramping up or down of power flow

Required For:

- Dimensioning of electricity supply point
- Throttling or increasing of power flow of the connected vehicle

Sourced From:

- EVSE - Charge Controller (or indirectly from backend system if available)

Access Interface / Standards:

- Charge Controller (EVSE) / OCPP

Owned by:

- EVSE Owner

Interested Parties:

- Vehicle Driver
- Vehicle Infotainment System: SatNav Provider (mapping of EVSE)
- Energy System: System Operator, Energy Supplier, DNO, Transmission, Aggregators, Consumer/Prosumer
- Digital System: IoT e.g. automation and optimisation of power flows
- Third Party Service Providers

EVSE metering

Most EVSE have metering capability in particular those which have management or smart feature capabilities. If metering is required for billing purposes the meters used must be MID approved.

Decision Parameters:

- Import kWh
- Export kWh
- Time (settlement interval)

Use Cases:

15 How much electricity was supplied to the vehicle?
16 How much electricity was supplied from the vehicle?
17 What is the tariff for the electricity supplied?
18 Separation of electricity supply as transport fuel

Required For:

- Billing of imported electricity
- Billing of exported electricity
- Data analytics for energy forecasting based on behavioural patterns

Sourced From:

- EVSE – Metering (either directly from the EVSE or indirectly from a connected backend)

Access Interface / Standards:

- Charge Controller (EVSE) / OCPP

Owned by:

- EVSE Owner

Interested Parties:

- Vehicle Driver / Bill Payer / Recipient of Credits
- Energy System: System Operator, Energy Supplier, DNO, Transmission, Aggregators, Consumer/Prosumer
- Vehicle Diagnostics e.g. miles/kWh, battery cycling / degradation
- Digital System: IoT e.g. automation and optimisation of power flows
- Third Party Service Providers

Supply point

Supply point metering

Supply Points may be metered or unmetered. For example, street lighting has an unmetered supply. A domestic supply point has a metered supply with some of the supply point meter being smart meters. Metering may be used for billing purposes or smart controls.

Decision Parameters:

- Import kWh
- Export kWh

Use Cases:

19 How much electricity was supplied to the supply point?
20 How much electricity was supplied from the supply point?
21 What is the tariff for the electricity supplied?
22 What is the total electricity supplied to the charging points connected to the supply point?
23 What is the total electricity supplied to the supply point by the vehicle / vehicle parc?

Required For:

- Billing of imported electricity
- Billing of exported electricity
- Data analytics for energy forecasting based on supply point electricity supply history

Sourced From:

- Supply Point – Metering (either directly from the Supply Point or indirectly from a connected backend)

Access Interface / Standards:

- Either Manual or Data Interface for Supply Point Metering

Owned by:

- Supply Point Owner

Interested Parties:

- Vehicle Driver/ Fleet Operator / Bill Payer / Recipient of Credits
- Energy System: System Operator, Energy Supplier, DNO, DSO, Transmission, Aggregators, Consumer/Prosumer
- Vehicle Parc Diagnostics e.g. miles/kWh
- Digital System: IoT e.g. automation and optimisation of power flows
- Third Party Service Providers

Note: Metering may have a profound impact as to how the whole system operates. In this context mobile metering in the vehicle and autonomous tariff switching could give rise to the need of new business models.

Grid assets

Network monitoring

For the provision of smart energy services that may be provisioned as part of an EV offering, it will be required to ascertain the real time headroom condition that is to be mitigated and protected from overload and failure.

Decision Parameters:

- Asset headroom
- Phase Imbalance
- three-phase power flow data in real-time- direction
- Voltage and current waveforms
- All power quality related information is extracted from these waveforms
- Real-time loss of supply info
- Fault level
- Substation environmental conditions
- Smart Control of LV network devices

Use Cases:

24 Protect the electricity network assets from overloading
25 Proactively prepare flexibility products and tenders for intermediate cover
26 Investment planning decisions
27 Monitor service provision- verification functionality

Required For:

- Distribution Network assets remain operational at all times
- Targeted investment in distribution asset upgrades
- Data analytics for demand forecasting
- Cost reduction from unnecessary oversizing

Sourced From:

- Sub-station monitoring equipment
- Third party assets in a state estimation model
- SMETS2 Smart Metering Data

Access Interface / Standards:

- Currently most substations are not monitored
- Discuss- as this could be vast

Owned by:

- Distribution network owner
- Transmission network owner

Interested Parties:

- Distribution Network Company, Transmission Network Company
- System Operators
- Flexibility Services Aggregator / Provider
- Connecting customers
- City and infrastructure planners

Smart Charger /Meter Data

There is an argument to be made for understanding how all the data provided by smart chargers and smart meters can be used by networks as a bottom-up approach to having visibility of the changes in the network, as it may be cost prohibitive to have a total monitoring capability at the distribution substation locations.

Decision Parameters:
- Active Power Import/Export Data
- Reactive Power Import/Export Data
- Cumulative Energy Import/Export
- Maximum Demand Import/Export Registers
- Network (Voltage) Data
- Voltage Excursions

Use Cases:
28 Protect the electricity network assets from overloading and remain within parameters
29 Network monitoring deployment prioritising
30 Network performance CI/ CMLs
31 Customer Service

Required For:
- To give a more granular view of the network (bottom-up visibility)
- Provide a view of constraints manifesting below the secondary substation level
- Enable visibility to help with phase balancing
- Help detect the actual location of voltage excursions
- Allow networks to improve forecasts by having visibility of where EVs are located
- Inform location and availability of flexibility to help manage the network
- Unlocking ToU tariffs: suppliers could use half-hourly data from smart meters to ultimately reward customers for charging their cars at non-peak times and settle them according to their actual usage instead of a flat or assumed profile

Sourced From:
- Energy Suppliers, DCC, ...
- Charge Point Operator back end systems

Access Interface / Standards:
- Cloud-CIM etc

Owned by:
- Energy Suppliers, DCC,...
- Charge Point Operator back end systems

Interested Parties:
- Distribution Network Company, Transmission Network Company
- System Operators
- Flexibility Services Aggregator / Provider
- Chargepoint Operators

Flexibility markets

The uptake of EVs could result in the creation of clusters on the LV network. Such clusters could cause stress at this LV level. Therefore, there may be a need for local flexibility markets that can provide a response to local network constraints in the future. As such, a real time view of the network status at LV substation level will be required in order to identify the constraints forming and advise on the flexibility needed, verification of service provision and real time operation of a smart LV network.

Decision Parameters:
- Asset headroom
- Phase Imbalance
- Voltage
- Current
- Reactive Power

Use Cases:

32 Protect the electricity network assets from overloading
33 Identify Network flexibility cover required, delivered
34 Manage a flexibility market- enablement

Required For:
- Distribution Network assets remain operational at all times
- Reducing infrastructure investment in distribution asset
- Cost reduction from unnecessary oversizing

Sourced From:
- Sub-station monitoring equipment

Access Interface / Standards:
- Currently most substations are not monitored

Owned by:
- Distribution network owner
- Transmission network owner

Interested Parties:
- Distribution Network Company, Transmission Network Company
- System Operator
- Flexibility Services Aggregator / Provider

Digital platforms

Behind the Meter Energy Management Systems (HEMS / BEMS)

Energy flows behind the meter may be monitored by Home Energy Management Systems (HEMS) or Building Energy Management Systems (BEMS) as part of energy efficiency measures and cost optimisation.

Decision Parameters:
- Import kWh
- Export kWh
- Consumption on a per circuit basis
- Circuit utilisation patterns including connected devices
- Onsite Generation
- Etc….

Use Cases:

35 Maximise cost savings from ToU tariffs?
35 Maximise self-consumption from onsite generation and energy storage?
37 Forecast local energy demand / generation
38 Optimise the charging of the vehicle / vehicle parc

Required For:
- Billing of imported electricity
- Billing of exported electricity
- Data analytics for energy forecasting
- Investment returns on efficiency measurements

Sourced From:
- Connected Devices to the HEMS / BEMS

Access Interface / Standards:
- Industry standards for HEMS / BEMS e.g. Zigbee

Owned by:
- HEMS/BEMS Owner

Interested Parties:
- Vehicle Driver/ Fleet Operator / Energy Managers /Bill Payer / Recipient of Credits
- Energy System: System Operator, Energy Supplier, DNO, Transmission, Aggregators, Consumer/Prosumer
- Diagnostics e.g. miles/kWh
- Digital System: IoT e.g. automation and optimisation of power flows
- Third Party Service Providers

Telecom service providers

The provisioning and sizing of appropriate data services which are billable by the communications provider.

Decision Parameters:
- Number and density of connected devices
- Location
- Secured or unsecure connections
- Type of transmission system e.g. wired / wireless
- Data volume (message payload size/s, frequency)
- Performance criteria (latency, availability)

Use Cases:

39 Provide data transmission services between connected devices and cloud services
40 Provide cyber-security between the connected devices and the cloud services
41 Provide service level agreements with regards to reliability of connection and data transmission
42 Provision of virtual data networks

Required For:
- Remote control and management of the charging infra-structure nationally and globally

Sourced From:
- Telecom system

Access Interface / Standards:
- (open / international) Telecom Standards.
- Packet (IP) based/compatible.

Owned by:
- Telecom Operator

Interested Parties:
- Digital Services Providers
- Data Centres and Cloud Services Providers
- Bill Payer

Automotive cloud services

Vehicle connected services are primarily provided by the automotive cloud services. Considerations needs to be given as to other market actors for example from the energy sector to have access to the vehicles/ EVSE or whether relevant information is provided by the automotive cloud services. In some use cases real-time data access may need to be considered from a whole system architecture point of view.

All use cases with regards to data from the vehicle and EVSE are applicable as these may be sold as bundled automotive customer offerings.

Decision Parameters:
- Aggregated vehicle miles delivery
- Aggregated vehicle storage capacity by geographical clusters
- Aggregated vehicle travel data between geographical clusters
- Aggregated forecast of energy demand by geographical clusters
- Aggregated forecast of dispatchable energy by geographical clusters
- Etc....

Use Cases:
43 Map generation capacity onto aggregated vehicle parc demand
44 Map network flexibility requirements onto aggregated vehicle parc
45 Dynamic profiling of ToU tariffs in the context of the aggregated vehicle parc
46 Forecast of charging assets utilisation
47 Design of intelligent charging services

Required For:
- Geographical forecast of transport charging needs
- Geographical forecast of energy flexibility embedded in the vehicle parc
- Smart management of network assets in context of vehicle parc location
- Optimise value pools in the energy market
- Informed investment strategy leveraging energy services capabilities embedded in the vehicle parc

Sourced From:
- Aggregated vehicle data monitored and managed in the automotive digital cloud services

Access Interface / Standards:
- To be defined

Owned by:
- Automotive Cloud Services Providers

Interested Parties:
- Energy System Manager
- Automotive Service Providers
- Vehicle Owners
- Digital System: IoT e.g. automation and optimisation of power flows
- Third Party Service ProvidersPage Break

Infra-structure cloud services

Infra-structure connected services are primarily provided by the infra-structure cloud services. Considerations needs to be given as to other market actors for example from the automotive or energy sector to have access to the EVSE or whether relevant information is provided by the infra-structure cloud services. In some use cases real-time data access may need to be considered from a whole system architecture point of view.

All use cases with regards to data from the EVSE are applicable as these may be sold as bundled infra-structure customer offerings.

Decision Parameters:
- Aggregated vehicle charging data
- EVSE utilisation
- Pricing
- Aggregated Real Time Energy Demand
- Etc....

Use Cases:

48 Map infra-structure capacity onto aggregated vehicle parc demand
49 Map network flexibility requirements onto aggregated vehicle parc
50 Dynamic profiling of ToU tariffs in the context of the aggregated vehicle parc
51 Forecast of charging assets utilisation
52 Design of intelligent charging services

Required For:
- Geographical forecast of transport charging needs
- Smart management of infra-structure assets and customer experience

Sourced From:
- Aggregated infra-structure data monitored and managed in the infra-structure digital cloud services

Access Interface / Standards:
- Energy System Manager
- Cloud Services Interoperability

Owned by:
- Infra-structure Cloud Services Providers

Interested Parties:
- Energy System Manager, System Operator (forecasting purposes under "Forecast of charging assets utilisation", which by its very nature would then have significant impact on the energy balance forecasting. This will include the DSO.)
- Automotive Service Providers
- Vehicle Owners
- Infra-structure investment managers
- City Planners
- Digital System: IoT e.g. automation and optimisation of power flows
- Third Party Service Providers

Energy system cloud services

Energy System connected services are primarily provided by the energy system cloud services. Considerations needs to be given as to other market actors for example from the automotive or infra-structure sector to have access to the network assets or whether relevant information is provided by the energy system cloud services. In some use cases real-time data access may need to be considered from a whole system architecture point of view.

All use cases with regards to data from the energy system are applicable as these may be sold as bundled energy services customer offerings.

Decision Parameters:
- Aggregated Generation Data
- Energy market pricing data
- Generation Mix
- Aggregated Real Time Energy Demand
- Energy System Assets Monitoring: asset headroom
- etc....

Use Cases:

53 Map infra-structure capacity onto aggregated vehicle parc demand
54 Map network flexibility requirements onto aggregated vehicle parc
55 Create tariffs for different energy mix, for example certified renewable generation
56 Dynamic profiling of ToU tariffs in the context of the aggregated vehicle parc
57 Forecast of charging assets / grid assets utilisation
58 Intelligent charging services with whole system benefits

Required For:
- Geographical forecast of transport charging needs and energy system investments
- Smart management of infra-structure assets and customer experience

Sourced From:
- Aggregated digital cloud energy services

Access Interface / Standards:
- To be defined

Owned by:
- Energy Cloud Services Providers

Interested Parties:
- Energy System Manager, System Operator (ESO/DSO)
- Automotive Service Providers
- Vehicle Owners
- Infra-structure investment managers
- City Planners
- Digital System: IoT e.g. automation and optimisation of power flows
- Third Party Service Providers

Appendix use case summary

Use Case / Need	Category	Description
1. How much energy does the vehicle consume?	Generic Vehicle	Forecasting of charging requirements to manage supply demands and supply constraints.
2. When and where is the vehicle likely to be charged?	Generic Vehicle	Mapping traffic patterns onto available infrastructure and energy.
3. How far can the vehicle drive?	Battery BMS	To get from A to B with an EV it is critical that the vehicle can provide a reasonable estimate of its current range. This will directly impact on how a journey is being accomplished considering the refuelling options available in the geographical context.
4. How much electricity is stored in the battery?	Battery BMS	To quantify the amount of electricity stored in the battery is a pre-requisite to establish how much energy can be stored or how much energy can be discharged and the monetary value of the stored energy in relation to services it may provide.
5. What's the value of the electricity stored in the battery?	Battery BMS	Understanding the value of the electricity stored in the vehicle battery is a pre-requisite to derive any power flow optimisations that are profitable and viable.
6. What is the maximum load on the charging point?	Onboard Charging	To dimension the EVSE and deploy a safe charging installation there is need to specify the maximum load expected to be supported. This data will also be required for power flow optimisation and managed aggregation of loads and its potential to be monetised and used as a system benefit.
7. What is the minimum load on the charging point?	Onboard Charging	To understand the bottom line as to the ability to throttle power flow this is important to optimise energy system benefits. For example, as a rule the minimum charging current should be 6A or the charging transaction may be terminated.
8. What is the resolution of ramping up or down of power flow	Onboard Charging	To build a smart charging infrastructure that can leverage the flexibility of the EV battery optimising power flows, the capability of ramping up or ramping down is an important parameter to assess the contributions possible to managed and optimised power flows.

Use Case / Need	Category	Description
9. How long does it take to reach a certain SoC level? 1. Forecast dispatchable electricity during a certain period. 2. Forecast recoverable electricity during a certain period.	On-board power flow management	To utilise large amount of distributed energy storage embedded in the EV parc we need to be able to quantify the variability of the energy stored in the EV battery. This is required for offerings such as ToU tariffs, EV range considerations, etc.
10. Start – Complete charging using a pre-configured charging schedule 1. Delay charging to a pre-set time. 2. Start charging just in time to complete at a pre-set time.	On-board charging scheduler	In the context of achieving energy system benefits, it is essential that local controls in the vehicle such as charging schedules can be considered when delivering aggregated benefits embedded in the charging infra-structure.
11. Charge the EV battery from onboard generation	On-board generator	In the context of achieving energy system benefits, onboard generation is another aspect of the EV asset in addition to energy storage.
12. What is the maximum load on the charging point?	EVSE Charging Power	Upper bound, infrastructure control to manage charging constraints in a dynamic supply point context.
13. What is the minimum load on the charging point?	EVSE Charging Power	Lower bound, infrastructure control to manage charging constraints in a dynamic supply point context.
14. What is the resolution of ramping up or ramping down the power flow.	EVSE Charging Power	Irrespective of the vehicle constraints e.g. SOC this determines the granularity of the dynamic supply point context.
15. How much electricity was supplied to the vehicle?	EVSE Metering	The energy supplied to the electric vehicle must be quantifiable and billable.
16. How much electricity was supplied from the vehicle?	EVSE Metering	The energy supplied from the electric vehicle must be quantifiable and billable.
17. What is the tariff for the electricity supplied?	EVSE Metering	Billable electricity must be associated with a energy supply product i.e. Tariff
18. Separation of electricity supply as transport fuel	EVSE Metering	Electricity supplied as transport fuel may need to be accounted for separately as it may form part of revenue streams co-located in the transport sector.

Use Case / Need	Category	Description
19. How much electricity was supplied to the supply point?	Supply point metering	The energy supplied to the electricity supply point must be quantifiable and billable.
20. How much electricity was supplied from the supply point?	Supply point metering	The energy exported by the electricity supply point must be quantifiable and billable.
21. What is the tariff for the electricity supplied?	Supply point metering	Billable electricity at the supply point must be associated with an energy supply product i.e. Tariff
22. What is the total electricity s supplied to the charging points connected to the supply point?	Supply point metering	A supply point may provide electricity to one or more charging point. The aggregated supply must be quantifiable and billable and correspond to the sum of electricity supplied by the charging points.
23. What is the total electricity supplied to the supply point by the vehicle / vehicle parc?	Supply point metering	A supply point may export electricity from one or more charging point. The aggregated exported supply must be quantifiable and billable and correspond to the sum of electricity supplied from the charging points to the supply point.
24. Protect the electricity network assets from overloading	Grid asset monitoring	The summation of all charging transactions at any given time must not cause the network assets to overload or fail.
25. Proactively prepare flexibility products and tenders for intermediate cover.	Grid asset monitoring	Ensure that the grid remains predictable and manageable with large scale adoption of EVs.
26. Investment planning decisions	Grid asset monitoring	Ensure that the network companies are able to stay ahead of the curve and do not become a stumbling block for the electrification of over 324 billon vehicle miles in the UK.
27. Monitor service provision, verification functionality.	Grid asset monitoring	Ensure that grid flexibility is provisioned and verified in the context of demand side response and energy storage by the vehicle parc.
28. Protect the electricity network assets from overloading and remain within parameters.	Smart Charger / Meter Data	Assure grid stability

Use Case / Need	Category	Description
29. Network monitoring deployment prioritising	Smart Charger / Meter Data	Monitor grid stability
30. Network performance CI / CMLs	Smart Charger / Meter Data	Grid Performance: Customer interruptions, Customer minutes lost
31. Customer Service	Smart Charger / Meter Data	Customer incentives and service acceptance
32. Protect the electricity network assets from overloading	Flexibility Markets	Assure grid stability
33. Identify network flexibility cover required, delivered	Flexibility Markets	Assure grid stability
34. Manage a flexibility market – enablement.	Flexibility Markets	Assure grid stability
35. Maximise cost savings from ToU tariffs?	HEMS/BEMS	Time of Use tariffs either as fixed timing interval products or as part of dynamic tariffs must be available for algorithmic cost optimisation.
36. Maximise self-consumption from onsite generation and energy storage?	HEMS/BEMS	Electric vehicles can serve as mobile energy storage devices that can maximise self-consumption from onsite generation.
37. Forecast local energy demand / generation	HEMS/BEMS	The wholistic electricity system requires forecasting capabilities in terms of energy demand and energy generation with EV batteries providing flexibility benefits.
38. Optimise the charging of the vehicle / vehicle parc	HEMS/BEMS	Vehicle charging for one or more vehicle can be monetised in the smart charging context behind the meter.
39. Provide data transmission services between connected devices and cloud services	Telecom	Ensure adequate data infrastructure provision for the digital integration of EVs.
40. Provide cyber-security between the connected devices and the cloud services	Telecom	Ensure adequate data infrastructure provision for the digital integration of EVs.
41. Provide service level agreements with regards to reliability of connection and data transmission	Telecom	Ensure adequate data infrastructure provision for the digital integration of EVs.

Use Case / Need	Category	Description
42. Provision of virtual data networks	Telecom	Ensure adequate data infrastructure provision for the digital integration of EVs in the context of a layered data networks among market participants.
43. Map generation capacity onto aggregated vehicle parc demand	Automotive Cloud	Ensure Automotive Cloud Services share data for mapping aggregated vehicle demand with generation and network capacity.
44. Map network flexibility requirements onto aggregated vehicle parc	Automotive Cloud	Ensure Automotive Cloud Services are aligned with network flexibility requirements.
45. Dynamic profiling of ToU tariffs in the context of the aggregated vehicle parc	Automotive Cloud	Automotive Cloud Services are aligned with the dynamics of the energy system described in ToU tariffs pricing signals.
46. Forecast of charging assets utilisation	Automotive Cloud	Automotive Cloud Services are aligned with charging infrastructure utilisation and availability.
47. Design of intelligent charging services	Automotive Cloud	Automotive Cloud Services are able to support intelligent charging services that are aligned with whole energy system benefits.
48. Map infra-structure capacity onto aggregated vehicle parc demand	Infrastructure Cloud	Infra-structure cloud services are able to process aggregated vehicle parc demand.
49. Map network flexibility requirements onto aggregated vehicle parc	Infrastructure Cloud	Infra-structure cloud services are able to process network flexibility embedded in the aggregated vehicle parc.
50. Dynamic profiling of ToU tariffs in the context of the aggregated vehicle parc	Infrastructure Cloud	Infra-structure cloud services are able to deliver dynamic whole system benefits embedded in ToU tariffs.
51. Forecast of charging assets utilisation	Infrastructure Cloud	Infra-structure cloud services are able to take into account charging assets utilisation.
52. Design of intelligent charging services	Infrastructure Cloud	Infra-structure cloud services are inherent intelligent and dynamic services.
53. Map infra-structure capacity onto aggregated vehicle parc demand	Energy System Cloud	Energy system cloud services are able to process aggregated vehicle parc demand.
54. Map network flexibility requirements onto aggregated vehicle parc	Energy System Cloud	Energy system cloud services are able to process flexibility requirements embedded in the aggregated vehicle parc.

Use Case / Need	Category	Description
55. Create tariffs for different energy mix, for example certified renewable generation	Energy System Cloud	Energy system cloud services support tariffs able to monetize certified renewable generation.
56. Dynamic profiling of ToU tariffs in the context of the aggregated vehicle parc	Energy System Cloud	Energy system cloud services can process dynamic profiling of ToU tariffs.
57. Forecast of charging assets / grid assets utilisation	Energy System Cloud	Energy system cloud services can access charging assets forecasts and optimise grid asset utilisation.
58. Intelligent charging services with whole system benefits	Energy System Cloud	Energy system cloud services can optimise whole system benefits through intelligent charging services.

Question 2 – How can data help remove barriers/ease access to getting a connection for EV charging infrastructure (and help inform EV infrastructure investment decisions)?

Owner: Anthony Bivens (BEAMA)
Supporters: Paige Mullan (Nuvve) and Charles Crawley (Tesla)
Feedback Incorporated to date: BEAMA, Nuvve, Tesla, UK Power Networks and National Grid

Introduction

This paper consider how data can facilitate the removal of barriers in EV connections, ease access to connections and inform investment decisions. Whilst we do not consider all of the proposals and options outlined are a present day need and accept some of this is already available on some networks and for some products, we suggest that this type of data and services offerings will be key in facilitating the ongoing connections of electric vehicles and other loads.

An important consideration in terms of data accessibility is public (fully available on the web) vs. private (info submitted to DNO's in order to speed up the process for the purpose of the application) data. An assessment and justification as well as a distinction between who can access what information would be a useful exercise in the developing the understanding and associated implications here, as well as understanding the next level of detail as this work progresses. It is also important to note distinctions between 'connect and notify' charging equipment for example at a local domestic level and for 'apply to connect' charging infrastructure for example service stations and the nuances between the barriers posed to these types of connections. It is not realistic to identify every possible barrier, nor is it possible to overview each possible solution, as such these suggestions serve to provide an indication, with context rather than definitive and fully evaluated solutions.

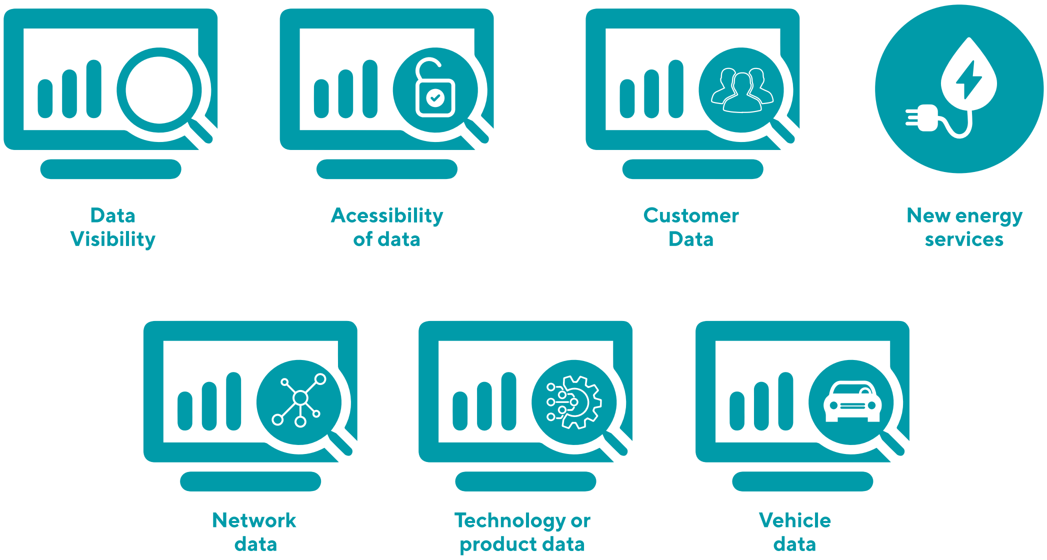
We suggest the following three principles underpin EV charging infrastructure solutions; Technology agnostic, market led and customer driven solutions.

Question context

This question is about the delivery of energy and enabling all actors in the direct energy supply (i.e. generators, suppliers, DNOs) to deliver that energy to customers at the most competitive price and with the least environmental impact. Third parties (e.g. aggregators) may well play a crucial role. We think the second part of the question also implies "What barriers need to be removed to make this happen?".

Q	Detail	Context/Narrative	Owner	Supporter
2	How can data help remove barriers/ease access to getting a connection for EV charging infrastructure (and help inform EV infrastructure investment decisions)?	Network owner side – what do networks need to know to provide a connection? Network constraints? Connectee side – what do customers need to know to connect? Investment strategy	Anthony Bivens – BEAMA	Paige Mullen – Nuvve / Charles Crawley – Tesla

Enabling data



Facilitating EV connections

In order to facilitate connections of EVs at domestic and commercial level, data will need to be understood and services and processes developed to ensure that data can be a key enabler of EV infrastructure rollout and improve the customer experience. From there tools and services can be developed that enable customers or private infrastructure providers to asses, understand and connect new infrastructure in a straightforward, timely and cost-effective way (where costs are present).

Data Visibility

Having visibility of data is key for market participants and for users to make informed decisions. This links closely to data accessibility and how data is visibly presented to those who need it, be that to inform decisions and provide a better of EV infrastructure connections for those seeking to connect.

A number of examples are included below:

Near to real time visibility of charging infrastructure activity, demand at feeder, substation, property will be required to inform smart/ managed charging interactions.

Historical or average demand (Hourly demand) at a feeder, substation to indicate potential cost to connect or indicate ability for a flexible connection agreement.

For public infrastructure we are also looking for what data/info would be helpful to identify potential expensive areas to connect or areas that have excess capacity and could be cheaper. What do companies looking to build infrastructure need to know?

Accessibility of Data

The accessibility of customer or building energy data for new services that could help implement new solutions as required is a key consideration where market development, rule and access criteria will need to be established. This will help to inform investment decisions and remove barriers by providing data to the organisations that need it in order to make informed decisions. There is a layer of value and interpretation that can added to data accessibility to develop heat maps or provide conectees access to services which can help inform decisions or better understand connection requirements and processes.

New Energy Services

We expect that as the market develops, new energy services will begin to proliferate and innovation and market development over time here will add further value to these services. For example, smart tariffs, ToU, price signals which could service to minimise connection costs or requirements for new infrastructure entirely in some cases. Such services would serve to manage demand at peak times, mitigate against network pinch points and encourage flattening in demand without the need for reinforcement.

Network Data
Monitoring of the LV/MV networks and substations to understand demand, pinch-points at a localised level and to enable any actions by DSO i.e. reinforcement or smart interventions. This level of monitoring, which is currently not deployed at scale will help network operators to better understand localised demands and potential supply interruptions in areas where 'tipping point' levels of EVs and infrastructure exist.

Customer Data
Data that the customer could provide (opt-in) or otherwise, from smart meter, home energy managers, chargepoint infrastructure, energy service providers and elsewhere.

Vehicle Data
Data that the vehicle could provide to required parties i.e. DNOs or data that is available at the discretion of the customer or vehicle owner.

Technology or Product Data
Data derived from technology in the building i.e. charging infrastructure, smart meters, connected homes technology, energy management etc. on a customer opt in basis or via a service provider. This links closely to 'customer data.'

Sourcing of data
The table below presents the types of data that market participants may have access to for the purposes of providing and managing an EV charging infrastructure connection, above those are the market participants who may seek to access these data types. This assessment has been undertaken on a needs basis as oppose to making all data to available to all participants. Suggest this is for group to work through and agree.

	DNO	TO	SO	Energy Supplier	Chargepoint Provider	Comms (DCC etc)	Vehicle Manufacturer	Aggregator or service providers	Technology Providers	Customers	Central Services (Elexon etc)
Customer load profile											
Smart meter data (HH)											
Other metered data											
Chargepoint data											
Product data (Home energy managers etc.)											
Export data											
Generation data											
Vehicle charge data (historic, charge, demand patterns etc)											
Network data LV											
Network data MV											
Network data HV											
Price signal data											
Etc.											

Key

Description	Shortened
Must have	MH
Should have	SH
Could have	CH
Won't have (this time)	WH

Network operators and customers: EV connections

Network operators have an obligation to provide a safe and timely connection to customers within guaranteed standards. In some cases, a new connection point may be cost prohibitive for the customer if a connection request results in the need for network upgrades for example a new transformer or service cable.

In order to provide a customer with an EV charging point connection or in some cases provide a offer for a connection, network operators will require access to data including:

- Rating of chargepoint infrastructure and maximum demand
- Local constraints on LV network
- Locations where fuse rating, services and cut out sizes may need to be assessed prior to connecting significant numbers of EV charging infrastructure
- Local LV network monitoring data as available/ installed
- Understanding of customer cut out fuse rating
- Understanding of demand on customer premise e.g. domestic property with electric heating, multiple appliances and calculation of After Diversity Maximum Demand (ADMD)
- DVLA post code data to understand localised proliferation of EVs
- EV chargepoint data via OLEV to understand where infrastructure is installed – Note a chargepoint does not in all cases signify that an EV is present. Cross analysis of DVLA and OLEV data could be valuable here
- Customer or installer submitted data as apart of chargepoint install notifications or applications

In terms of accessibility and straight forwardness of connections, new tools, services and processes will need to be developed in order to ensure customer experience and allow charging infrastructure to be rolled out at the scale required - Some examples of these are included in the paragraphs below.

Connection Heat maps – An online tool, much similar to generation connection heat maps would highlight opportune areas, where capacity exists and where connections may be more straightforward and less costly than saturated areas. It is noted that in lots of cases customers wont always be flexible on chargepoint location, particularly for domestic properties or workplace charging schemes for example.

Standardised connection offerings and processes – As much as possible all network operators should offer standardised, clear and online EV connections. Customers and installers would visit the network operator website and submit a notification that chargepoint has been connected (currently via OLEV grant scheme) or to submit an application for a connection assessment.

EV charging guides and customer education – Customer and installer facing guidance and engagement that is designed to educate customers and installers on requirements for EV charging infrastructure, process and compliance.

Data - Provision of market data to those who need it to make investment and operational decisions around EV load and infrastructure i.e. a DNO to understand reinforcement, deployment of monitoring or an installer to understand presence of a smart charging scheme at a local level.

Customer journey efficiency - Consumers and market participants will need to access data in a way that does not cause undue delay or that deters them from using recognised channels, web services and fast track connection requests and tools can help provide data a local, national and regional level

New market propositions and incentivising alternate consumer behaviour – Creation of propositions at a market level that are engaging and designed to bring about behavioural change either as a result of active participation (carbon and environmental benefits) or offering a payment or cost reductions.

EV charging connections – removing barriers and informing investment

Barrier	Solutions	Investment Decisions
Lack of visibility on LV networks and impacts at medium and high voltages (MV - EHV) that will sufficiently enable connections and understanding constraints at a local level.	Enabling and installing monitoring, accessing smart meter data and deploying other solutions at local level as well as any other solutions required at higher voltages that can enable customer charging in a smart way. Make necessary data available at a local, regional and national level. Making available heat maps, capacity signals, information and other tools to the customer, chargepoint providers/ operators and other market participants and that can better inform decisions and processes involved. Standardised processes and approaches from DNO > DSOs that add clarity for consumers and market participants in terms of getting a connection. Removes uncertainty from investment decisions by companies investing in the charging infrastructure	Informs near real time decision, actions from asset owners/ operators e.g. smart charging schemes and DNOs. Could minimise demand at peak times, spread charging demand across a number of profiles at LV level (e.g. stop everyone shifting from 5pm to 11pm – 3am and creating the same problem). Enables decision making and provides oversight for DNOs and other market participants. Current and predicted local, regional and national EV demand data and behaviour is needed by this group, e.g. where there are competing potential EV charging sites and connections. E.g. home vs rapid local (petrol station model) and Distribution vs. Transmission connection. Inform areas that are either congested or have excess capacity to indicate areas (post codes, feeders, substations, etc) that would be easier to get a connection or would require more work or flexible connection agreement.
Inaccessible data or data provided in poor or inconsistent formats Poor visibility of data required to inform investment decisions Speed of access Access the right kind of data efficiently – Real time vs historic and the options in-between	Provision of market data to those who need it to make investment and operational decisions around EV load and infrastructure i.e. a DNO to understand reinforcement, deployment of monitoring or an installer to understand presence of a smart charging scheme at a local level etc. Balance between 'blanket' availability and 'data to those who need it'. Consumers and market participants will need to access data in a way that does not cause undue delay or that deters them from using recognised channels, web services and fast track connection requests and tools can help provide data a local, national and regional level Enable access to data at an appropriate level so that market participants can make informed investment/ operational decisions. DVLA and post code data to analyse and interpret EV proliferation at local and regional level Visual data: GIS maps, input post code and select layers of data you want to see. Download data: download certain CSV files of congested area. Allow analytics on potential sites to help decide which seem to be the most lucrative initially. Where to spend your time.	Allows new entrants and existing market incumbents to develop new offerings, services and solutions that add value for customer, defer investment and better understand required actions. This should not be blanket availability. Key to understand who should have access to data and how this is managed. Allow anyone looking to install a charging stations (similar to generation generation) look at the grid constraints and target investment to key sites.

Barrier	Solutions	Investment Decisions
Not enabling new service offerings in a timely manner or in a way that erodes potential long-term value of flexibility services. Charge for a connection that a customer may never fully need. More expensive than necessary i.e. larger upgrade or services that could be delivered via market i.e. smart charging	Provide a balance between smart and flexible interventions vs reinforcement and a case by case basis or in line with agreed 'trigger' points. Allows those seeking EV connections to provide some additional information to allow the DNO to properly evaluate the service they need.	In practice would encourage customer, energy services providers, smart technologies to change energy demand to times where there is an energy surplus or move away from times when demand is high. In order to promote investment from service providers there would need to be a good aggregate level of participants who are willing/ able to participate or from a DSO perspective this would need to have the response level required to defer reinforcement or offer a cost saving on other options.
Lack of visibility on LV and potential impacts on consumer supply Understanding the implications at higher voltages	Deployment of monitoring equipment to gather data and better understand impacts at local, regional and national level, or access of other available data that may be available i.e. technology, charger or vehicle data.	Allows DNO/DSO to better understand localised energy demand and inform any interim or enduring action required i.e. reinforcement / upgrades.
Making energy engagement sufficiently attractive/ valuable to the consumer. Understanding how market participants will access and use customer data either via permission or as part of terms and conditions/ commercial contracts or service participation at point of purchase.	Create propositions at a market level that are engaging and will bring about behavioural change either as a result of active participation (carbon and environmental benefits) or offering a payment or cost reductions.	Visibility of customer energy use and access of that data to third parties, energy demand management, charging on calendar-based applications or on customers behalf. Could minimise demand at peak times, spread charging demand across a number of profiles at LV level (e.g. stop everyone shifting from 5pm to 11pm – 3am and creating the same problem)
Focus on interoperability for access and payment, in order to avoid damaging the growth of the market.	Once this is solved, it could provide the necessary platform to build further services upon in terms of any vehicle to grid integration requirements etc.	Rate of charge of vehicle, likely time to recharge, range left, next journey (some EVs have calendar links), typical charging patterns. Some of these can potentially come from EV chargepoint or customer as well. Could help to understand predicted charging requirements across LV network etc.
Interoperability of systems, services and devices and data requirements therein to enable required solutions/ applications i.e. smart charging. Customer privacy, cost for such granular data and ability to access such data with or without permission (i.e. data that is accessible when purchasing a vehicle or product)	Product aggregated data, network aggregated data, post code aggregated data by smart meter. Ability for products and associated services to play into an open secure market	mportant to outline that data is available more widely than just a chargepoint or at LV feeder level. Depending on type of data, this could inform on potential cost to connect to the network. EX: understanding that this area is congested at certain hours.

Case study: Marshfield Village

Use case mapping

EV usage	
Home	✓
En-route	
Destination	✓
Fleet	

Connection stage	
Getting connected	✓
When connected	
Moving house	

Actors
DNO
DSO
Charge Point Operators
Central Service Providers (eg: Elexon)
Communications Operators
EV Owner
Public Employers/Councils
Developers (eg: commercial housing)
EV Driver (Consumers)
EV Driver (Prosumer)
Fuel-poor users
Investors
Community Stakeholders
E-mobility Service Provider

The potential use of shared data in evaluating options for infrastructure is illustrated in this following real-world example.

Marshfield is a village of around 850 households in South Gloucestershire. The residents have formed Marshfield Energy Group to explore options to make Marshfield village more sustainable, and to build a robust model of energy use in the village. There are already a number of electric vehicles in the village and uptake of them is expected to grow. However, the village streets are narrow, the houses are terraced and there is limited charging infrastructure. This is likely to inhibit the uptake of electric vehicles.

Figure 1 View of Marshfield High Street (looking East) [Source: Google Maps]

Through the Marshfield Energy Group's participation in the OpenLV project, the residents have asked "How can we provide public charging infrastructure?"

Using the Network Assessment Tool (developed under the Electric Nation project), it was possible to quickly ascertain the local electricity network capacity and potential uptake of electric vehicles:

Figure 2 Network Assessment Tool study of Hay St substation [Source: WPD]

From this, we can see that that there is plenty of capacity at the nearest substation to support a modest take-up of electric vehicles, but the local network suffers from voltage drop issues. So, it is likely that new feeders would be necessary (with additional cost and resulting in disruption to the village from their installation).

However, the adjacent St Martin's Lane, just off the High Street is potentially a much easier location to install EV charging infrastructure.

Figure 3 View of St Martin's Lane (looking North, towards the High Street) [Source: Google Maps]

There is a substation on St Martin's Lane, but unfortunately it does not appear to have much capacity available.

Figure 4 Network Assessment Tool study of St Martin's Lane substation [Source: WPD]

However, returning to Google Earth, we can see that the substation occupies a generous plot and there is plenty of room to increase the transformer capacity.

Figure 5 Close-up view of St Martin's Lane substation [Source: Google Maps]

So, what to do? Is there enough upstream capacity to support a bigger substation? Are there technological alternatives to a bigger substation that would provide a better solution (e.g. energy storage, managed charging, etc)? Only WPD would know this (despite the provisions of LC25). Is it feasible to place EV charging infrastructure on St Martin's Lane? We'd need to find out who owns the adjacent land and whether it would be available for parking. Perhaps the local council will know? How much infrastructure is needed? We'd need more details on the typical journeys performed by the residents (how far, how often?) Who can provide this data? Will the proposed infrastructure be "future proof"? To do that, we'd need an accurate local forecast of EV uptake. Is this available anywhere?

We can see from the above that there is some useful data available that could help to inform the residents of Marshfield. However, such data is probably difficult for them to access and requires access to multiple systems to give an informed view.

Question 2 recommendations

1 Develop frameworks that enable access to customer and building energy data which can aid new services development and drive the rollout of new energy saving and energy management solutions.
2 Create an environment to facilitate the development and delivery of new data driven tools, services and processes to ensure customer experience and to allow charging infrastructure to be rolled out at the scale required.
3 Enable the provision of market data to those who need it to make investment and operational decisions around EV load and infrastructure i.e. a DNO to understand reinforcement, deployment of monitoring or an installer to understand presence of a smart charging scheme at a local level.
4 Encourage new data driven market propositions and incentivise active consumer behaviour – Creation of propositions at a market level that are engaging and designed to bring about behavioural change either as a result of active participation (carbon and environmental benefits) or offering a payment or cost reductions.
5 Focus on interoperability for access and payment infrastructure, in order to avoid damaging the growth of the market.
6 Develop data rules and criteria in a way that encourages ongoing innovation and opens up the market to new solutions e.g. data that is publicly accessible (fully available on the web) vs. private (info submitted to DNO's in order to speed up the process for the purpose of the application).

Question 3 – How can data help system operators improve system operation to help with EV demand?

The context of the question

A System Operator can be either National Grid ESO, any of the future Distribution System Operators or any party that manages a power network to ensure reliable delivery of electricity to consumers, businesses and industry. Data, discussed in question 1, is utilised by a System Operator to fulfill its primary duties to maintain and operate an electricity network in an economic and efficient manner.

System operator obligations

System Operator entities will have obligations that cover the following areas:

- Frequency and Voltage balancing:
  - Ensuring that the kWh's of demand are met with an equal amount of kWh's of supply and residual balancing of supply and demand where they are not met
  - Management of constraints on physical networks (Capacity, Voltage or thermal constraints)
  - Ensure that active power demand and active power supply are matched to maintain system frequency within a defined range
  - Ensure that reactive power is matched, in a similar way to active power, to maintain system voltage levels.
- Forecast demand, at different future times series (hours, days, years etc.) to allow planning for assets, system operator(s) control actions to protect customers & allow customers to plan how to meet energy demand etc.
- Facilitate connection of assets to networks
  - Plan & design the direct connection of demand or supply assets to the network
  - Understand the impact on the wider network, plan and recommend changes to the wider network based upon expected connections of assets.
  - Plan reinforcement of the network where/if it is required

Analysis and subsequent publications by System Operators support the efficient and optimal use of the network and therefore deliver benefits to consumers. As an example, accurate forecasting of the electricity demand by National Grid System Operator ensures that the right level of generation is procured in the Capacity Market thereby reducing the cost to the consumer of buying more generation than needed or conversely a lower level of security of supply if enough hasn't been procured. A 1 GW (or 2%) over procurement could result in £100m additional cost to consumers[1].

System operator data requirements

The data a System Operator receives would be used to support this work and ensure that they can continue to optimise the reinforcement and use of the network. Relevant results will also support the gas network. For example, by modelling how the electricity generation mix may be used in the future due to changes in electricity demand from electric vehicles, we are able to garner valuable information about how gas demand for electricity generation may change.

Each of data item utilised by a System Operator may have different timescales of usage associated to them. For example, demand forecasting for a network happens under multiple timescales from within day up to multiple years into the future. Therefore, the data they collect for these processes may be immediately utilised to better operate the network within the same day as well as utilised in longer term demand forecasting processes such as those that feed the Capacity Market and ensure future security of supply. This therefore touches on the issues of timeliness, quality of data as well as the data items mentioned within question 1.

[1] A 1 GW error on the high side this could increase the auction clearing price by say £2 which when procuring in the T-4 auction would cost end customers an extra 50 GW x £2/kW = £100m.

When we categorise the requirements of system operators

Must have:

- Data items described in Battery State of charge, Onboard charging power, On-board power flow management, On-board charging scheduler, on-board generators, EVSE charging power, EVSE metering, smart charger/meter data & Infra-structure Cloud Services from question 1 that facilitate accurate forecasting of electric vehicle demand in the immediate, short, medium and long term timescales; in both a national and regional basis.
- Data items described in Battery State of charge, Onboard charging power, On-board power flow management, On-board charging scheduler, on-board generators, EVSE charging power, EVSE metering, smart charger/meter data, Infra-structure Cloud Services & Network Monitoring that allow a System Operator to assess the need for an electric vehicle to be charged unrestricted in occasions where there is a network constraint (Energy, Voltage or Thermal), or constrain its charging to protect network integrity.

Should have:

- Data items, in addition to those noted in the must have, those that are described in Generic Vehicle parameters, Flexibility Markets, Energy System Cloud services, Supply point metering, Digital Platforms & Behind the Meter Energy Management Systems (HEMS / BEMS) from question 1, that Improve the understanding of how electric vehicle assets operate (annual demand, contribution to peak and summer minimum etc.); both in national and regional basis in a series of timescales.

Could have:

- Data items in addition to those noted above in must & should haves, those that are described in Generic vehicle parameters that allows a forward, short term, view of when and where new electric vehicles will become active on the network (i.e. when and where it is registered).

Would like to have:

- Data items, in addition to those noted above in must, should and could haves, those that are described in Generic vehicle parameters & Automotive cloud services that allows a forward, longer term, view of when and where new electric vehicles will become active on the network (i.e. when and where existing ICE contract ends).

Question 4 – How could sharing of data (e.g. around demand forecasting) help the energy sector better meet the energy impacts of EVs? How should we use data and how could sharing it be enabled and encouraged?

Recommendations

1. The Government must set clear annual targets (or scenarios) for EV adoption (and associated infrastructure), in accordance with transport policy
2. The Government (or delegated body) must track and openly publish monthly data on EV adoption (and associated infrastructure)
3. The National Chargepoint Register (or equivalent) must be expanded in scope to cover all fixed charge points (i.e. private, public, workplace, etc) and must make data openly available on public charge point location, type, capacity, price and availability to enable EV drivers to find (and possibly reserve) an available, working public charge point that is suitable for their immediate charging needs
4. DNOs must make localised network headroom data and forecasts available in an easily usable format
5. All new charge points (whether public or private) must record consumption, charge rate and time of use, have a means of remotely reading this data and (for chargers above a certain capacity) a means of remotely setting the charge rate

Our understanding of this question:

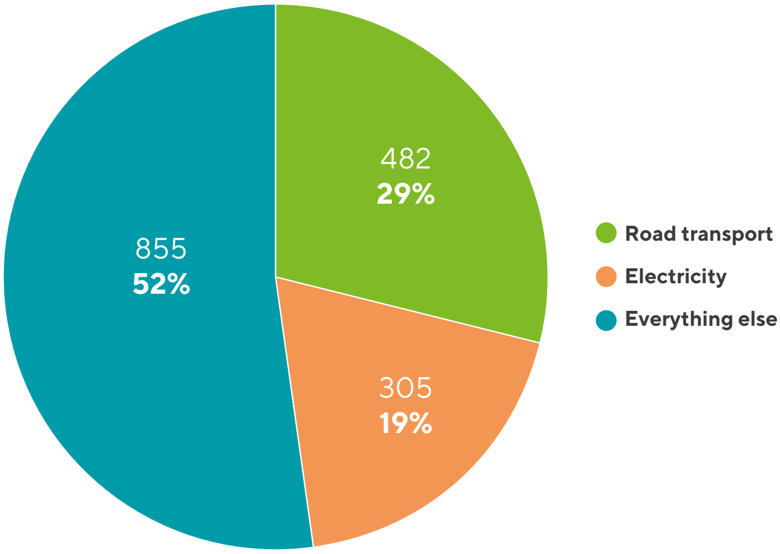
This question is about the delivery of energy and enabling all actors in the direct energy supply (i.e. generators, suppliers, DNOs) to deliver that energy to customers at the most competitive price and with the least environmental impact. Third parties (e.g. aggregators) may well play a crucial role.
We think the second part of the question also implies "What barriers need to be removed to make this happen?".

Out of scope for this question: system investment (Q1), getting a connection (Q2), system operation (Q3), smart meters vs. network monitoring (Q5), charge point location (Q6)

EV energy consumption in context

The total energy consumption in the UK in 2017 was 1,642 TWh[2]. Transport is the largest consumer of energy (657 TWh), representing 40 per cent of energy consumption. Road transport alone (482 TWh) represented 29% of the total. By comparison, only 18.5% (305 TWh) of energy consumption was in the form of electricity. A negligible 0.2 TWh (0.1%) was in the form of electricity for road transport.

UK Energy Consumption 2017 (TWh)



The National Grid FES 2018[3] estimates that the existing 0.2 TWh for electric transport will increase to approximately 60 TWh by 2040 (resulting from 34 million electric cars). FES 2018 assumes no significant electrification of heavy goods transport; full electrification of all forms of road transport (including heavy goods) may add approximately 60 TWh [2] - assuming no significant change in current transport behaviour.

This would represent an increase in energy to be delivered by the UK electricity system over current levels of between 20-40% by 2040.

On the face of it, this appears significant (but manageable), given the generally available headroom on the GB system). However, the rate delivery of electrical energy varies considerably in any 24-hour period: from 16-37GW (in Summer)[4] to 20-50GW (in Winter)[5]. Given that the electricity system has very limited headroom at certain locations at times of peak demand, the key question is at what time of day and where will this additional energy will be delivered? Answering this question (and ensuring that EV charging occurs at times of lower demand) will be crucial to meeting the energy impacts of EVs. There is growing evidence that a significant component of EV charging load is flexible and can be managed or incentivised accordingly[6] to shift EV demand to off-peak hours and smooth out demand curve.

OLEV's requirement that government-funded charge points must be "smart" by July 2019 [7] will drive the rollout of the necessary infrastructure to ensure that the benefits from flexible charging can be fully realised.

[2] EV energy consumption is ~25% that of conventionally fuelled vehicle consumption, due to approximately 4x better energy efficiency. This assumption should be tested to ensure that it is still valid for commercial transport.

Which actors and use cases would be involved in meeting the energy impacts of EVs?

Given the significance of EV charging behaviour on the electricity system (as opposed to simple EV volumes), a large number of actors and use cases are relevant to meeting the energy impacts of EVs. Relevant actors include Networks, Operators, Connectees, 3rd Party Intermediaries, Users, Manufacturers and others. The Government is expected to play an essential role in the provision of en-route charging infrastructure, as this is likely to require strategic (as opposed to purely-market-led) deployment.

How could sharing of data (e.g. around demand forecasting) help the energy sector better meet the energy impacts of EVs?

The following "menu" of data items is taken from Work Package 4 Q1. For full details on the parameters, use cases, purpose, source, access standards, ownership and interested parties, reference should be made to that document:

- Vehicle parameters
  - Battery state of charge
  - On-board charging power
  - On-board power flow management
  - On-board charging scheduler
  - On-board generator
- EVSE charging power
- EVSE metering
- Supply point metering
- Substation monitoring
- Behind the Meter Energy Management Systems (HEMS / BEMS)
- Telecom Service Providers
- Automotive Cloud Services
- Infra-structure Cloud Services
- Energy System Cloud Services

It is recognised that there may be difficulties in collecting and sharing some of this data. It is therefore important that there is an appropriate level of market governance to encourage or enable this sharing. In each of the following sections, the specified actors (and associated use cases) must be clearly defined and agreed upon via consultation - and in all cases comply with GDPR.

The following data MUST be available to specific actors to meet the energy impact of EVs:

- EVSE charging power
  - Location, type, capacity, price – to enable EV users to charge
- EVSE metering
  - Both public & private identity, kWh, kW, time – for energy settlement and billing and mapping of trends in demand
- Vehicle parameters
  - On-board charger type & capacity, battery capacity by segment, typical energy consumption – for national modelling and estimation, as well as overall EV numbers (total fleet by segment, monthly sales by segment – preferably actual, but targets would do, geographic region) – for national/regional modelling and estimation of uptake rate

In addition to the above, the following data SHOULD be available to specific actors to meet the energy impact of EVs:

- EVSE charging power
  - Live availability, type i.e. public, private, workplace, fleet, etc – to enable EV users to find the right charge point, both en-route and at destinations
- Energy System Cloud Services
  - Live energy mix (gCO2/kWh, time) – to encourage low-carbon charging and new use cases
  - Available network headroom (location, capacity, time) – to enable local planning
- Vehicle parameters
  - Location, demographics – to enable local planning
- On-board power flow management
  - Statistical EV usage data (specific consumption, charge rate, charge time, charge duration, usage, journey distance)
- Substation monitoring
  - Network usage forecasts (kW, location, time) – to enable local planning
  - Energy use forecasting (kWh, location, time) – to enable local planning

The following data COULD be made available to specific actors to meet the energy impact of EVs:

- Vehicle parameters
  - Historic journey data (frequency, purpose, demographics, route) – to enable new use cases
  - Historic vehicle energy consumption data (specific consumption, charge rate, charge time, charge duration, usage) – to enable new use cases
  - Historic vehicle location data (location, time, dwell time) – to identify clusters of EV use and ownership
  - Live vehicle data (location, state of charge) – to enable new use cases and active network management
- Substation monitoring + Energy System Cloud Services
  - Live network data (location, capacity) – to enable new use cases
- Battery state of charge + On-board charging scheduler + Vehicle parameters
  - Forecast journey data (frequency, purpose, demographics) – to enable business planning and investment and active network management
  - Forecast vehicle energy consumption data (specific consumption, charge rate, charge time, charge duration, usage) – to enable business planning and investment

How would the above help to meet the energy impacts of EVs?

A number of benefits have been identified for the following actors:

The Government would:

- Have clearer visibility of EV adoption and use
- Have clearer visibility of the demand for EV charging infrastructure
- Have data to support policies that encourage/mandate charging rates or times to minimise cost and/or CO2 (if required)
- Be able to identify market failures in charging provision and intervene accordingly (e.g. charging provision for disadvantaged communities, remote communities, emerging monopolies, socialising of costs, measuring how many vehicle miles have been electrified, etc)
- Be able to support local/community initiatives to encourage EV adoption

EV users would:

- Be better able to understand and engage with their EV charging options
- Have more EV charge points available in the right places and at times of peak charging requirement (e.g. holiday destinations during Bank Holidays, sporting events, festivals, etc) that reflects customer behaviour & preference
- Have more headroom for EV charging in accordance with customer behaviour & preference (i.e. fewer time-of-day-restrictions and/or lower energy costs), achieved by moving flexible charging towards times of low demand, thereby freeing up headroom for those with less flexible charging requirements
- Have increased visibility of the effect of managed charging, so that any obligatory restriction or price penalty (e.g. DNO constraint management or time-of-day DUoS charges) is transparent
- Have lower connection costs for charge points by aligning installation with available connection capacity of existing assets – recognising that there is (typically) no connection cost associated with individual home installations (this cost is socialised under current regulations).
- Be able to make an informed choice on how they want to charge/discharge their EV and understand how this impacts energy demand/supply and the environment, giving consumers the data they need to become “prosumers” (if they wish).

Electricity consumers would:
- Have lower electricity bills by ensuring that the energy for EV charging does not lead to electricity price spikes at peak times (by shifting EV charging load to periods of lower demand)
- Have lower electricity bills by ensuring DUoS charges are as low as possible (by ensuring EV charging remains on-grid as much as possible)
- Experience reduced disruption due to network upgrades by reducing the amount of network upgrades (or delaying the necessary upgrades for a long as possible). Here is an illustrative example of disruption caused by a distribution cable repair:
- Prosumers" would be able to participate in local load balancing with EVs

Fuel-poor users[3] would:
- Be able to charge their car near to where they live i.e. on a convenient, nearby on-street location, rather than having to drive to more distant a charging hub.
- Benefit from targeted interventions to support EV uptake in areas of high fuel poverty
- Be able to charge their car at the lowest possible cost if they use an EV (by opting for low-cost, or even free flexible charging - rather than more expensive, on-demand rapid charging)

Connectees, Community Stakeholders, Planning Authorities and Investors would:
- Be able to create business opportunities through installation of destination chargers
- Have a clear understanding of whether the business model or funding for a charge point installation is sustainable, helping to ensure that the resulting charge point is always maintained in good working order
- Benefit from the release of pockets of "natural capital", where patches of currently unused land are made available for EV charging. For example, land that is not currently viable for parking (alone) could become viable given the additional potential income from charging provision (and associated ancillary services such as refreshments and entertainment).

3rd Party Intermediaries would:
- Have potentially lower costs for charge point installation
- Be able to evaluate the risk/reward and uncertainty for charge point investment

Generators and Energy Suppliers would:
- Be able to better optimise energy delivery to match available generation
- Be able to participate more in flexibility markets for generation and ancillary services (e.g. turn-town/turn-up services for EV charging demand)

Networks and Operators would:
- Benefit from potentially lower infrastructure costs
- Be able to evaluate the risk/reward and uncertainty for network investments associated with EV charging
- Have better visibility of EV connections so could plan infrastructure upgrades in time and avoid network issues
- Have better visibility of EV load so could procure flexibility from 3-parties managing EV load

[3] Fuel poverty in England is measured using the Low Income High Costs (LIHC) indicator. Under the LIHC indicator, a household is considered to be fuel poor if they have required fuel costs that are above average (the national median level) and, were they to spend that amount, they would be left with a residual income below the official poverty line.

What barriers need to be removed to make this happen?

Despite all of the above benefits from sharing of data, there are a number of apparent barriers to realising these benefits. Some of these are:

1. Energy datasets may be subject to access restrictions that prevent the relevant actors from accessing the data to ensure consumer privacy.
2. DNO data is currently shared through the publication of a Long Term Development Statement (LTDS) which provides visibility of investment plans and network capacity as it exists today, and how it changes with approved major reinforcement projects over the coming years. DNOs do not, at this point, know how the mass electrification of transport will affect the electricity networks, particularly for non-residential demand and the impact of vehicle-to-grid technology. So, while the overall figures for EV load-growth can be determined, the detail of "where" and "when" is largely unknown, giving rise to highly uncertain outputs.

   The breadth of data potentially required for forecasting is substantial and will require collecting consumer permissions to develop effective local and national solutions. For example, in the Marshfield case study below, the data that can be collected will need a range of user permissions.
3. Transport datasets (e.g. National Transport Survey but also perhaps Ordnance surveys) and energy datasets are fragmented and not in a format that enables them to be easily collated. Cross-mode consumer journeys and energy requirements are not being looked at in a joined-up way to evidence how infrastructure can be modified in a joined-up way.
4. The sheer complexity and volume of these datasets means that some sort of automatic processing is necessary to enable them to be understood in a meaningful way.

How should we use data and how could sharing it be enabled?

To encourage the necessary sharing, we recommend the following:

1. The Government must set clear annual targets (or scenarios) for EV adoption, in accordance with transport policy.
2. The Government (or delegated body) track and openly publish monthly data on EV adoption (and associated infrastructure). This data is currently available from the SMMT (and others), but is not necessarily public.
3. The National Chargepoint Register (or equivalent) must be expanded in scope to cover all fixed charge points (i.e. private, public, workplace, etc) and must make data openly available on public charge point location, type, capacity, price and availability to enable EV drivers to find (and possibly reserve) an available, working public charge point that is suitable for their immediate charging needs.
4. DNOs must make localised network headroom data and forecasts available in an easily usable format – by installing additional instrumentation if necessary.
5. All new charge points (whether public or private) must record consumption, charge rate and time of use, have a means of remotely reading this data and (for chargers above a certain capacity) a means of remotely setting the charge rate (as already required for OLEV-funded chargers from July 2019)
6. The National Travel Survey [8] should collect and make available statistical, regional (or geospatial) vehicle journey data, in addition to the GB-wide data that is currently published.
7. DNOs, generators, suppliers and aggregators should develop markets for EV charge management (within the under-development Open Networks [9] framework) to enable customers to benefit from flexibility in charging (i.e. incentives to charge off-peak, demand turn-down services, etc).
8. The live energy mix should continue to be publicly available from the System Operator.
9. OEMs should collect and share anonymised, statistical data on EV usage patterns, charging and energy consumption to enable accurate medium and long-term demand forecasting. This will ensure that charge point infrastructure (and the upstream energy system) is effectively planned and efficiently deployed - with reduced risk of under- or over- investment (thereby avoiding short-term constraints or stranded assets).

Question 5 – Do networks need better monitoring of the low voltage network, or will real-time data from smart charging / smart metering largely avoid the need for this? Ultimately, what is the value of smart charging data for the Networks?

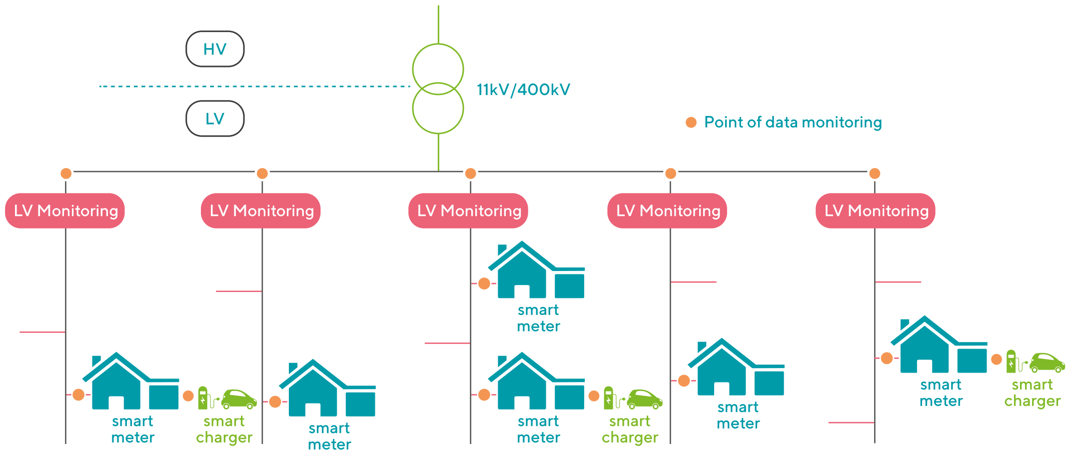


Figure 1 Different locations for monitoring the low voltage (LV) network

Context – What is low voltage (LV) monitoring?

Network LV monitoring:

Traditionally, load growth was always more predictable and therefore LV monitoring was not required. Network operators generally monitor power flows across their networks down to the 11kV voltage, in real time, via their control room.

As an example, UK Power Networks' secondary substation Remote Telecommunication Units (RTUs) have been installed in approximately 11% of the 88,000 LV ground mounted sites, giving the control room limited visibility of the HV/LV network interfaces. Most of the current monitoring are located in the more complex urban networks like London.

As a result, currently, distribution planning engineers become aware of increases in peak demand on LV feeders beyond their capacity through:

- collection of Maximum Demand Indicator (MDI) readings following site visits and inspections;
- repeated fuse operations due to high load current; and
- customer-initiated voltage violation investigations.

As customers install low carbon technologies (LCTs) to the LV network, including electric vehicles (EVs), storage, PV and heat pumps, the traditional load profiles are starting to change. Additionally, networks will start to see impacts on the LV network such as voltage rise across LV feeders, harmonics and voltage sags and swells, making LV monitoring increasingly more relevant.

Local flexibility markets & LV monitoring

The uptake of EVs could result in the creation of clusters on the LV network. Such clusters could cause stress at this LV level. Therefore, there may be a need for local flexibility markets that can provide a response to local network constraints in the future. As such, a real time view of the network status at LV substation level will be required in order to identify the constraints forming and advise on the flexibility needed, verification of service provision and real time operation of a smart LV network.
Some of the benefits of RTU substation data include:

- Capturing actual peak as opposed to estimated peak, which will enable to avoid unnecessarily early reinforcement
- Power quality (PQ) data will enable DNOs to determine potential issues, however, not having granular data from where the load is located doesn't enable finding the actual location of the problem
- Monitoring the substation will point out real opportunities for flexibility
- Real time dynamic operation of the network, medium term data for flexibility and long-term data for investment decisions

Ultimately, LV monitoring should allow networks' planning and control engineers to design a more efficient network and manage the network proactively and in real-time, thus releasing capacity and deferring network reinforcement at constrained LV substations.

One of the key challenges of LV monitoring at this level of data provision is cost, time and resources to deploy across all networks. Therefore, benefiting from existing LV data on the system is of interest to networks and of benefit to network customers. Also, LV monitoring data do not provide a very granular view of the LV network.

The value of smart charging and smart meter data for networks

There is an argument to be made for understanding how all the data provided by smart chargers and smart meters can be used by networks as a bottom-up approach to having visibility of the changes in the network.

Both smart meters and smart chargers provide several benefits to networks:

- Give a more granular view of the network (bottom-up visibility)
- Provide a view of constraints manifesting below the secondary substation level
- Enable visibility to help with phase balancing
- Help detect the actual location of voltage excursions
- Allow networks to improve forecasts by having visibility of where EVs are located
- Inform location and availability of flexibility to help manage the network

Benefits to energy suppliers:

- Unlocking TOU tariffs: suppliers could use half-hourly data from smart meters to ultimately reward customers for charging their cars at non-peak times and settle them according to their actual usage instead of a flat or assumed profile.

Some of the challenges to be considered for networks accessing smart charger and smart meter data are:

- Regulatory changes could be required to allow networks access to (aggregated) data from smart meters and smart chargers
- Managing large volumes of data
- Data protection: data should be aggregated
- Network IT systems required to be built/enhanced to allow for reception and processing of smart meters and smart charger data
- Minimum volume of smart chargers/smart meters required at a specific part of a network to provide \ accurate visibility
- Data alignment: there are possible conflicts between LV monitoring, smart chargers and smart meters when providing data for same part of the network – data from different sources need to be treated appropriately and in a coordinated manner in order to ensure better network visibility is achieved

Somewhere in the middle

The need for LV data becomes increasingly evident; however, understanding how networks can use data from LCTs, including EV charge points will help avoid excessive LV monitoring deployment and could provide the visibility network operators need to unlock flexibility from and for customers.

In summary, Yes networks do need better monitoring at the LV, however the optimum coverage will come from multiple sources of monitoring- smart charging and smart meter data can create a granular bottom-up view of the LV network. This can provide networks with sufficient information to estimate load profiles at secondary substation level and visibility of the network down to service connection levels.

In terms of timescales, while there is limited volume of LV monitoring installed already, there are programmes across many networks looking at strategically deploying more LV monitoring. At the same time, the smart meter installation program is gaining momentum. The mandate for all residential chargers to be smart from July 2019 onwards increases the likelihood of having a critical mass of smart chargers in place in the next few years, providing a very granular network monitoring ability. As a result, a combination of the above data sources will help reach a high % of LV network visibility in the coming decade.

The uptake of other LCTs, such as heat pumps, will make the role of smart meters even more important, as they will can ensure all loads located behind the meter (not only EVs) are monitored.

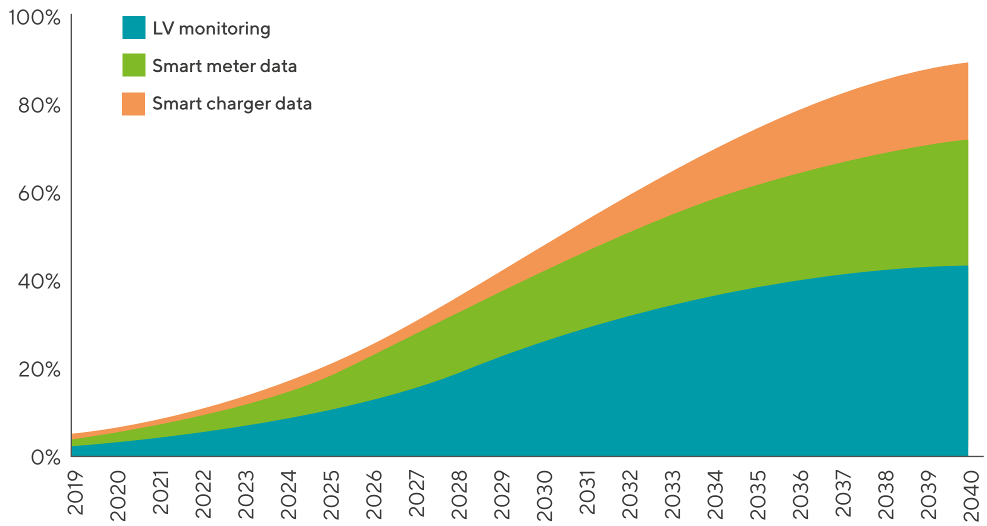


Figure 2 LV visibility uptake projection

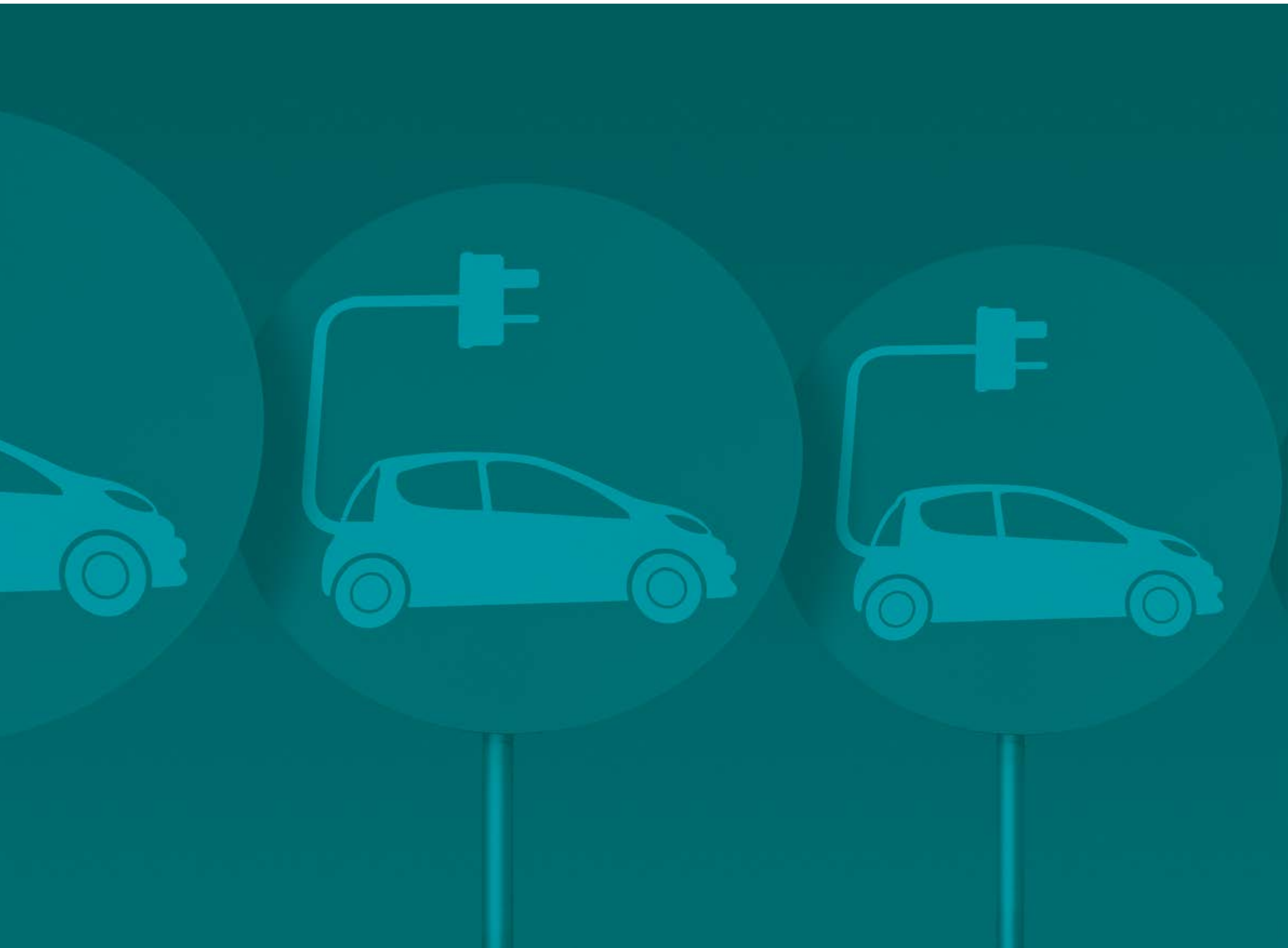
Data comparison

LV substation monitoring	MoSCoW Analysis
• three-phase power flow data in real-time	M
• Voltage and current waveforms	
– All power quality related information are extracted from these waveforms	M
• Real-time loss of supply info	M
• Phase balance info	S
LV substation monitoring	
• Active Power Import/Export Data	S
• Reactive Power Import/Export Data	C
• Cumulative Energy Import/Export	S
• Maximum Demand Import/Export Registers	M
• Network (Voltage) Data	C
• Voltage Excursions	C
LV substation monitoring	
Data to be monitored as a minimum requirement (MVP) by a smart charger	
• Current	C
• Voltage	C
• Frequency	C
Data to be monitored by a smart charger to allow provision of flexibility services	
• Active Power export (to EV)	C
• Availability of EV (plugged-in/charging/standby)	S
Connectivity / availability of EV battery (if V2G capable)	M

*Smart meters provide other signals including power outage and restore events and read device configuration and supply status.

Question 5 recommendations

1. Investment into LV monitoring is key over the next 10 years to ensure energy infrastructure is ready
2. LV network monitoring is unlikely to be required in all cases of EVs, and mix should be based upon a CBA
3. As a minimum requirement the following is a must have data level for monitoring:
   a. LV substation monitoring- three-phase power flow data in real-time, Voltage and current waveforms, all power quality related information are extracted from these waveforms, Real-time loss of supply info
   b. Smart Meters- Voltage- Real time loss of supply- Maximum Demand and time- by MPAN
   c. Smart chargers- Voltage- Max Current and time of such- Connectivity / availability of EV battery (if V2G capable)
4. Grid edge data is valuable, and provision to trusted bodies should be considered
5. Access to data (Must Have) for trusted bodies like Networks from Smart Meters should be mandated.
6. For data to be of value ahead of the uptake, time becomes the key driver, as such we recommend the least regret volume programmes of network monitoring are launched ahead of need



Question 6 – What data is needed to get the right types of chargepoints in locations that best meet the needs of EV users and the energy system?

Assumptions:

A There are 2 effective types of chargepoints:
  a 1) Top-up (e.g. 7kW) where drivers will plug in for longer periods whilst otherwise occupied.
  b 2) En-route chargers (50kW+) where drivers will visit the charger to quickly charge whilst en route elsewhere.(50kW will likely become an intermediate speed chargepoint in time, as power increases to 150kW-350kW for cars and even higher for larger vehicles, but keeping to two categories for simplicity).

B This document considers primarily conventionally used vehicles. Planning for shared AEVs could broaden the scope too much at this time, particularly as it is unclear what approach will prove popular (I.e. will it be more of a fleet and hub model, or dispersed privately held assets charging at homes etc overnight, offered to AEV fleet operators like Ubers are today (just without a driver).

Useful data for siting top-up chargepoints:

1 Driver dwell time – Is this a location where cars spend sufficient time parked to warrant plugging in to a top up charger?
2 Available capacity at site – Is there capacity in the site's distribution board?
3 Available capacity in local distribution network – Can the local distribution network support the optimal number of chargepoints at this site without the need to trigger network reinforcement?
4 Relative costs for storage to alleviate grid constraints – Can batteries make the site viable in a cost effective way? Most likely to apply to multiple chargepoint installations.
5 Current EV market penetration – are there sufficient EVs on the road in this region to merit the installation?
6 Forecast EV market penetration – will there (soon) be sufficient EVs on the road in this region to merit the installation?
7 Upcoming advances in EV tech – will conduction continue to be the norm? Will the connector types change?

NB: Many top up chargepoints will be bought/obtained by drivers who intend to use them themselves (particularly home chargepoints), so some of the siting will organically self-select according to need.

Useful data for siting en route chargepoints:

1 Driver dwell time – It is important not to over invest in high powered chargers if a top up charger would work better (e.g. hotels, some fleet applications).
2 Proximity to high volume traffic flows – To ensure healthy utilisation the chargepoints must be in highly trafficked areas (e.g. arterial roads, or at base for high utilisation fleets).
3 Available capacity – While some sites can make 50kW available, it can be assumed that no sites will have existing spare capacity for installation of multiple 150kW chargers, and reinforcement will be required. Therefore capacity on the distribution network and even the transmission network capacity data is critical.
4 Relative costs for storage to alleviate grid constraints – Can batteries make the site viable in a cost effective way?
5 State of the art in EV rapid charging – Most EVs today can take 50kW max, it seems likely this will increase to 150kW-350kW for cars and potentially to the MW level of larger vehicles. Will the connector types standardise (CCS)/change? Will battery swap find some traction?
6 Suitable site layout – Can the site physically accommodate suitable bays? Does it have suitable amenities.
7 Current EV market penetration – are there sufficient EVs on the road in this region to merit the installation?

Forecast EV market penetration

- will there (soon) be sufficient EVs on the road in this region to merit the installation?

Notes:

- Given the uncertainty of pace of uptake, and the associated near-term capacity required for these chargepoints, rather than pre-emptively investing in network reinforcement, smart charging will be preferred to mitigate load in line with existing network capacity available. However, as utilisation increases, capacity may be saturated, triggering upstream reinforcement for some parts of networks.
- Due to high capital costs, en route chargepoints will typically be funded by companies/bodies on a strategic basis, making the assessment of available data all the more important.

Getting charging infrastructure deployment right

Considering charging technologies

There are a range of charging solutions available today that can satisfy use cases in transport and energy and will deliver the sum of all charging transactions within the marketplace. These charging solutions will be competing against each other within the market and take a share of the available business. There are several scenarios which provide a need to be satisfied by a range of charging solutions. For example:

1. Managed or unmanaged
2. Destination or en route
3. Low power or high power
4. Uni-directional or bi-directional (V2X)
5. Plug-in, pantograph, battery swap, static wireless and/or dynamic wireless
6. With or without energy storage

There is the choice of managed or unmanaged charging solutions to consider. It should not be assumed that all charging transactions are managed form a holistic system's view. Charging solutions are either destinations based in the context of vehicle dwell time or en route opportunity charging as part of a journey.

Unmanaged Charging

1. Any plug-in electric vehicle can be charged from a domestic 3-pin socket using a mode 2 charging solution. Charging power is usually 10A or less. Considering the average commute of no more than 25 miles per day, this very basic charging solution can deliver a significant proportion of the annual charging transactions at very low or no installation cost. This is based on the premise that vehicles are most of their time stationary and hence there is plenty of time available to replenish the vehicle range using low power charging. All managed charging features are either embedded within the vehicle (charging scheduler, power settings) or in the EVSE (configurable power setting i.e. 10A or less). This is the bottom line in terms of EV charging with its sole purpose to satisfy the EV travel needs.
2. Unmanaged mode 3 charging solutions are installations that meet the electrical requirements of the supply point (supply fuse) to increase the available charging power typically to 16A or 32A and thus reduce the charging time considerable if the vehicle is equipped with higher power onboard chargers. This type of installation is more expensive in terms of the mode 3 charging equipment and the installation to satisfy increased supply capability. This type of EVSE installation may be of limited benefit as it demands capacity allocation in line with the EVSE rating and thus this capacity would be ringfenced for EV charging whether it is being used or not. All charging control features such as power settings would typically reside in the vehicle with the EVSE simply providing a higher capacity supply. Clustering of these type of charging solutions for example in a residential area could result in increased demand on distribution network assets such as street transformers and substations as compliance to the supply fuse rating not necessarily prevents overloading of network assets. This may be of concern where large uptake of EVs would require upgrading of network assets.

3 Smart unmanaged mode 3 charging solutions. This may be counter intuitive, but smart charging can be unmanaged and standalone. A typical example would be a smart charge controller in the EVSE that takes into account local decisions parameters to optimise charging power. Such a use case would be EV charging with onsite generation such as Solar PV maximising self-consumption of local generation. The EVSE would regulate the charging power in the context of a mode 3 charging solution by keeping the import/export current at the grid supply point as close to zero as possible. If the supply point would start to export solar generation, the EVSE would increase the charging power, if the supply point would start to import electricity it would reduce the charging power. It is easy to see that this type of solution combines the benefits of onsite generation and the energy storage provided by EV batteries delivering a net reduction of the grid connection. Similarly, this type of solution could take into account a Time of Use (ToU) tariff minimising the overall cost of EV charging.

4 Smart unmanaged V2X charging solutions, currently based on CHAdeMO. Similar to point 3, in addition to charging the vehicle to meet travel requirements the power flow between the supply point and the vehicle is in both directions with the aim to minimise the import/export current from the grid to zero as close as possible. As the power flow is bi-directional this charging solution delivers travel and local energy services.

5 Smart unmanaged fleet charging solutions. Similar to point (3) and (4) a local controller optimises the charging power across a cluster of connected fleet vehicles in order to achieve a net reduction in the supply point. This is likely to be used in the context of commercial buildings e.g. work charging solutions or organisations that use fleet vehicles.

6 High power mode 4 charging solutions. Although probably niche, even high-power charging solutions could be unmanaged e.g. 50kW or higher. A typical use case would be a work side that is confined to operational needs with appropriate supply connection and/or onsite generation. Such a use case could be airport operations, depot-based fleets in the context of freight logistics or public transport.

Unmanaged charging solutions have limited capabilities to deliver whole system benefits, but nevertheless can be quite applicable in an increasingly distributed and localised energy system.

Managed Charging

Managed charging solutions add the paradigm of remote aggregated control in comparison to the unmanaged stand-alone solutions with digital integrated services delivering whole system benefits. This applies to mode 3, mode 4, V2X or in fact to any type of charging solution at destination or en route. There are significant value pools in terms of energy system flexibility that an electric vehicle parc could unlock for all stakeholders, whether this is a consumer, prosumer, commercial enterprise, the energy sector, investment finance sector or the UK government to mention a few. This represents a significant economic value that will be only available in a managed whole system context. A few examples for illustrative purposes would be:

- Increased investment returns on renewable generation.
- Certainty for key strategic investment needs.
- Large amount of geographical distributed energy storage embedded in the connected vehicle parc.
- Aggregated flexibility services and constraint management in dense urban areas
- Increased asset utilisation within charging infra-structure.
- The need for accountability and billing e.g. public charging infra-structure which could include residential, commercial, national and international service provisioning.

Destination Charging

Due to the widespread availability of electricity in buildings, destination charging can play a major role in the provision of a large amount of the charging/discharging transactions for electric vehicles. The type of charging solutions is primarily determined by the vehicle and supply point e.g. the expected dwell time of the vehicle, the charging/discharging demand for transport and energy needs and the vehicle specifications defining the power flow constraints or choice of technology.

En-route Charging

The primary constraint with en route charging is the much-reduced dwell time of the vehicle in the context of completing its journey. In this context, battery technologies and EVSE pose constraints in terms of thermal management of the chemical process and energy supply as well as the energy system assets involved such as cables, street transformers and sub-stations.

This can potentially be mitigated by battery swap solutions.

In comparison to a "pit stop solution", dynamic wireless charging would allow charging while driving. This technology is available for up to motorway speeds as well as high power transfers. Similarly, for some vehicles, overhead charging solutions with pantographs could supplement battery vehicle operations while driving.

Low Power vs High Power Charging

As most vehicles have considerable dwell time during the day, many of the travel needs can be satisfied with low power charging solutions. On the other hand, if the vehicle battery is to create business as part of energy services, high power solutions would provide more flexibility and business opportunities. Hence, clarity about the service offering the customer will engage with and the vehicle spec would influence the choice of charging infra-structure.

Uni-directional or bi-directional (V2X)

To satisfy the travel need only uni-directional charging solutions are required. From a bundled service offering perspective, where the vehicle may also provide energy services, bi-directional power flow would considerably increase the value proposition.

Charging Interface

There are electrical charging interfaces which will cater for the power flow to charge or discharge the vehicle. These can be conductive, wireless static, wireless dynamic, uni-directional and bi-directional. There are digital charging interfaces which will cater for the control of the charging process located in the vehicle as well as the EVSE.

Charging reinforced with energy storage

In the context of rural infra-structure which may have significant grid supply constraints or in the urban context which may also have significant grid supply constraints, energy storage can serve as a buffer between the constraint grid supply or off-grid solution and the charging demand from electric vehicles. However, this will increase the supply losses within the electricity system due to the energy storage conversation losses.

Infrastructure deployment considerations

Energy System Perspective

Although electricity supply is widely available, there is significant variability of supply capacity. To make the best choice in terms of costs and investment needs the following data is required:

1. The geographic location of network assets
2. The available capacity of network assets
3. The additional capacity that can be achieved with targeted investment
4. The demand for flexibility services within the locality

Vehicle Parc Perspective

1. The travel demand and patterns with the vehicle parc
2. The charging technologies and standards likely to be present in the vehicle parc
3. The batteries and standards likely to be present in the vehicle parc.
4. The dwell time patterns by location

Charging Infra-Structure Technology Perspective

1. Managed or unmanaged/stand-alone solution
2. With or without smart features
3. With or without energy services solution
4. With or without payment solution
5. With or without roaming solution
6. High power or low power
7. Distributed or central solution (Hub, Battery Swap)
8. Destination or en route
9. With or without energy storage reinforcement
10. Charge while drive

City Perspective

1. Public or private
2. Technology Choice e.g. conductive / wireless
3. Number of charging bays in relation to vehicle parc
4. Impact assessment city landscape / required street furniture
5. Charging demand e.g. vehicle miles / energy services
6. Charging Infra-structure utilisation
7. Charging infra-structure protection and maintenance
8. Availability of Electricity Supply

Road Network Perspective

1. Travel patterns – vehicle miles delivered en route
2. Availability of Electricity Supply
3. Scalability of Charging Hub
4. Charging Hub Utilisation

The Customer Perspective

1. Availability of Charging Points as part of day to day travel and Destination Dwelling Time
2. Customer Experience and confidence in products and services
3. Level of Customer Service
4. Value for Money – e.g. charging at work or home instead of public charging
5. Convenience
6. Etc. Ref WP2

Business Perspective

1. Return on Investment
2. Charging Services Utilisation
3. Profit

System Operator Perspective

To make the best choice in terms of system operation, design and investment proposals to the networks, the following data is required:

1. The demand for flexibility services
2. The charging demand and patterns of the vehicle parc
3. Utilisation of the charging infrastructure & what type of infrastructure that is
    a. Destination or en route
    b. With or without energy storage reinforcement
    c. Distributed or central solution (Hub, Battery Swap)
    d. Technology Choice e.g. conductive / wireless
    e. Etc.

Acronyms

AC	Alternating Current
BEMS	Building Energy Management System
BMS	Battery Management System
CAN	Controller Area Network (context vehicle bus standard)
CAV	Connected Autonomous Vehicles
CHAdeMO	A DC quick charging standard
CI	Customer Interruptions (context electricity network performance)
CML	Customer Minutes Lost (context electricity network performance)
DC	Direct Current
DCC	Data Communications Company (context smart meter rollout in the UK)
DNO	Distribution Network Operator
DSO	Distribution System Operator
ESO	Electricity System Operator (e.g. National Grid)
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
HEMS	Home Energy Management System
IoT	Internet of Things
LV	Low Voltage (context electricity network)
MID	Measuring Instruments Directive
MoSCoW	"Must have/Should have/Could have/Won't have" prioritisation technique
OCPP	Open Charge Point Protocol
PV	Photovoltaic
SoC	State of Charge
ToU	Time of Use (context electricity tariff)
SMETS	Smart Metering Equipment Technical Specifications
V2X	Vehicle to X (context electric vehicle bi-directional charging)
Zigbee	Wireless ad hoc network IEEE 802.15.4

References

1 Energy Data Taskforce Report 2019. [Online]. Available: http://www.evenergytaskforce.com/.
2 BEIS Energy Statistics 2019. [Online]. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/729317/Energy_Consumption_in_the_UK_ECUK_2018.pdf
3 National Grid ESO, "Future Energy Scenarios" 2019. [Online]. Available:http://fes.nationalgrid.com/media/1363/fes-interactive-version-final.pdf
4 National Grid, "Summer Outlook Report" 2018. [Online]. Available: https://www.nationalgrid.com/sites/default/files/documents/14782_NG_Summer%20Outlook_2018.pdf
5 National Grid ESO, "Winter Review and Consultation" 2019. [Online]. Available: https://www.nationalgrideso.com/sites/eso/files/documents/2018%20Winter%20Review%20and%20Consultation%20FINAL%20v2.pdf
6 Electric Nation "What we've learned so far" Oct 2018. [Online]. Available: http://www.electricnation.org.uk/wp-content/uploads/2018/10/Electric-Nation-What-weve-learnt-so-far-Oct18.pdf
7 GOV.UK "Government funded electric car chargepoints to be smart by July 2019". [Online]. Available: https://www.gov.uk/government/news/government-funded-electric-car-chargepoints-to-be-smart-by-july-2019
8 National Travel Survey: 2017. [Online]. Available: https://www.gov.uk/government/statistics/national-travel-survey-2017
9 ENA, "Open Networks Project" [Online]. Available: http://www.energynetworks.org/electricity/futures/open-networks-project/open-networks-project-overview/

energy
taskforce

Low Carbon Vehicle Partnership
3 Birdcage Walk,
Westminster,
London SW1H 9JJ