



# ELECTRIC VEHICLES

Towards an Excellent  
User Experience

A consultation with companies and organisations that represent stakeholders in the large-scale adoption of electric passenger vehicles.

Excellent user experience as a catalyst for adoption – a thought leadership paper presented by the Future Cities, Transport Systems, High Value Manufacturing and Energy Systems Catapults on behalf of Innovate UK.



## THIS CONSULTATION

The objective of undertaking this stakeholder consultation was to assist IUK in gathering an updated point in time understanding of the issues that are concerning the multitude of groups involved in the transition to wide scale adoption of passenger electric vehicles.

The consultation, undertaken during the first quarter of 2018, is intended to raise awareness and understanding amongst the many stakeholders in this field, of the views, opinions and ideas of fellow stakeholders. While some additional information is included to contextualise and make readable the feedback received, it does not seek to judge the opinions and ideas gathered and it is not a statement of opinion on behalf of the Catapults or an endorsement of the views and opinions expressed by stakeholders.

It has been compiled by a Catapult working group drawn from Future Cities, Transport Systems, High Value Manufacturing and Energy Systems Catapults. The understanding gathered from this consultation will now be used to assist InnovateUK in identifying gaps and opportunities within existing programmes of innovation support in this field and better inform them and the Catapults for future planning.

The key findings and next steps can be found on pages 23 to 25.



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## INTRODUCTION

The electrification of transport is now a certainty. Battery technology is advancing rapidly and putting within reach the possibility for wide-scale adoption of passenger electric vehicles. The potential for zero tailpipe emissions to make a substantial contribution to both environmental objectives and the clean air challenges of congested cities has been seized on by governments around the world who are increasingly stating their intention to ban the sale of fossil fuelled vehicles. Norway intends to achieve this by 2025, with the Netherlands and India in 2030, and Scotland by 2032. Further announcements from other countries are expected with some cities declaring bans earlier than national targets.

These declarations come on top of significant new legislation that the industry is having to respond to such as the 2020/21 introduction of a lower new vehicle fleet average of 95gms of CO<sub>2</sub> per kilometre and the adoption of a new Worldwide Harmonised Light Vehicle Test Procedure (WLTP). The impact of these changes and the impending bans is driving major restructuring of the automotive sector, there is likely to be as much change in the industry over the next 10 years as there has been in the last 100.

The introduction of more Battery Electric Vehicles (BEV) and Plugin Hybrid Electric Vehicles (PHEV) that will be necessary to meet the new emissions targets will increase volumes and lower costs. Cost parity (ICE v/s BEV) will likely be achieved in the 2022/3 timeframe, according to latest projections, and some are forecasting 2025 as a key tipping point when many current cars will have been replaced with hybrid or full battery equipped vehicles.

Anticipating that PHEVs could well be at significant scale in the late 2020s (in both the UK and abroad), then it is essential that we are proactive in our planning and development of systems and solutions that will minimise the risks of transition and maximise the benefits. Society at large is the ultimate beneficiary from cleaner air, reduced noise pollution, reduced energy requirements and lower journey costs. However, many stakeholder interests must be accounted for if this revolution is to move forward successfully

and the UK is to capitalise on the market opportunities of the global shift.

This consultation has been commissioned by Innovate UK (IUK) and is intended to support IUK in identifying what innovation support might be needed to promote the development and mass adoption of electric vehicles in the UK and enable UK industry to compete for the global market opportunities that are emerging.

The electrification of transport is an area where diverse challenges and uncertainties exist.

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AND LOWER  
JOURNEY COSTS.**



There are many stakeholders in this fragmented landscape who must work together in new ways and no one-party has architectural control of the complex environment. The greatest uncertainties are associated with the vehicle users themselves: While their basic needs are understood, there is immense diversity in their transport requirements, preferences and attitudes. Vehicle users often have strong and quite protective views of how they would like to access, use or manage their vehicles. This is evidenced by the strong emotions that the subject of electric vehicles often generates, both by people who aren't yet EV drivers, and those who already are. It is therefore extremely difficult to predict what behavioural trends or issues may emerge, how users will react to new situations and new service offerings, or which dominant or disruptive solutions will prevail. Given that we are in transition to a society with many millions of electric vehicles, the market has enough diversity and scale to enable equally diverse and flexible solutions to thrive.

The transition to large scale passenger vehicle electrification fundamentally changes the requirements of transport systems, energy systems and the use of space. This creates an opportunity for new technology, system solutions, services and business models. If the UK does not move quickly to position itself, it will lose out on our ability to ensure the successful and rapid adoption of electrified transport and to take full advantage of a burgeoning global business opportunity.

Being proactive will allow the UK to build on the success of the established automotive industry, it being the third largest vehicle producer in Europe. In fact, 12.8% of UK's total exported goods, totalling £44bn, are automotive products. Around 3,000 UK companies are active, with 856,000 people (2017) employed in the sector and its supply chain producing 1,671,166 vehicles<sup>1</sup>.

This consultation captures and highlights a broad set of stakeholder views about the impact of and opportunities from EVs, from now through to a 2025 horizon, and presents these views through the eyes of the EV end-user.

## THE APPROACH

To prepare for stakeholder engagement, the authors mapped and identified relevant stakeholder groups. This resulted in an extensive list of sectors and organisations, some of which are directly involved in or affected by the shift to EVs, while others have less obvious stakes in the electrification of transport.

*The stakeholders broadly fall into the following categories:*

- Automotive sector+
- Community education
- EV users
- Geographic information system (GIS) operators and supply chain
- Private consultancies
- Regional transport bodies
- Think tanks
- Car share operators
- Energy sector\*
- Fleet operators
- Non-profit organisations
- Parking access supply chain
- Property developers
- Retail facilities
- Urban planners, local and transport authorities

<sup>1</sup> 2017 data from the Society of Motor Manufacturers and Traders (SMMT)



In total, the views of 57 stakeholders were explored either within two workshops organised by the Catapults, or through informal, hour-long interviews. The workshops and interviews aimed to capture a snapshot of stakeholders' views of their current position within the EV market, what future successful scenarios would look like and to discuss potential gaps and innovations, ultimately to improve the EV user experience. One of the workshops was specifically focussed on six existing EV users to gain a detailed understanding of their experiences of driving and owning an electric vehicle.

While some stakeholder comments were provided on condition of anonymity, all have been captured and correlated to support further work.

*+This sector's stakeholders include niche and high-volume manufacturers, academia and industry bodies.*

*\*This sector's stakeholders include suppliers, transport operators, systems operators, distribution network operators, regulators, consultants, settlement administrators, charge point operators, trade bodies, and supply, retail and equipment manufacturers.*

In addition to garnering stakeholder views and perspectives, our discussions also revealed stakeholder questions and uncertainties that may point to policy considerations, opportunities for innovation or lack of information. We have captured these questions in the Open Questions Appendix.

## THE USER EXPERIENCE

When such a significant change is about to happen, as that presented by the electrification of passenger vehicles, the ideal scenario would be that users choose willingly to make the changes required to transition to EVs. They make the change because of the advantages and benefits that EVs offer them when compared to continued use of ICE vehicles, not because of the risk of punitive measures. In simple terms, the user experience delivered by EVs acts as the motivation to change, with user advocacy then becoming a major stimulus of wider adoption.



The input from the stakeholders has been framed in the context of the User Experience. A contrast has been drawn between a simplified representation of users' current experience with their ICE vehicles and how that experience contrasts with today's experience of using an electric vehicle.

*ICE vehicle users are accustomed to the way their vehicles function and make allowances for this in how they use them. ICE users typically expect:*

- Reasonable access to a well-informed dealer network for purchase/lease and maintenance
- To be provided with generally reliable guidance as to the cost of ownership
- To make only minor adjustments in order to drive and obtain the same utility from a new model
- To fuel their vehicles by short refuelling stops when required
- To be able to do this at one of many fuelling stations selling the same fuel and do it with near identical equipment

- To find conveniently positioned refuelling stations at locations that harmonise with other aspects of their everyday life and to find them at a frequency that allows for journeys of any length to anywhere.
- To pay for their fuel when they purchase it, understanding this includes taxes

The transition to EVs at the current state of technology development impacts all these expectations.

*The current EV Users reality is characterised as:*

### **Journey planning**

- Now an essential element of preparation for non-regular trips
- Plotting the location of charging stations along the route and at the destination, determining what type of charging capability is present so that the battery range is not exceeded
- Determining how long the vehicle will need to charge for each leg of the journey

- Planning contingencies to allowing for non-working/non-availability of the chargers on arrival
- Finding alternative transport when the EV just isn't suitable

### Home Charging

- Almost exclusively for those with off-street parking
- Convenient but slow
- Simple metering means limited opportunity to optimise charging costs

### On-Street Charging

- Scarce, not convenient, frequently unavailable or incompatible

### Destination and Journey Charging

- Range and Charge anxiety
- Need to access different information sites to know where and what's available
- Scarce, not convenient, frequently unavailable or incompatible
- Can be free or subsidised

### Payment

- Liable to the cost to install new supply if capacity not available
- Variety of payment methods and types
- No fuel duty or road tax payable – but know it's coming
- Limited choice and lack of competition leading to higher cost to charge

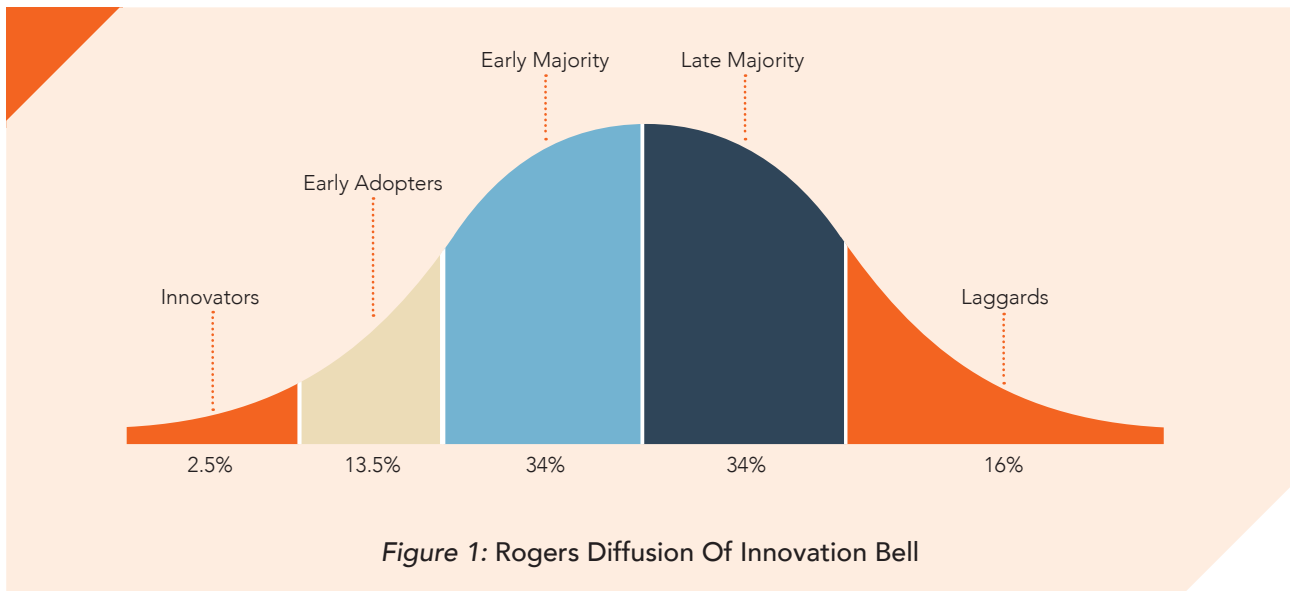
### Driving

- Takes a bit of adjustment
- Good experience and most wouldn't want to go back

### Vehicle Ownership

- Complicated and risky, worried about being sold the wrong vehicle
- Concerned about paying too much and poor residual value
- Expensive but subsidised, concerned about battery life
- Limited choice and supply, servicing not always convenient

There are many detailed studies and projects that explore the user acceptance of EVs, the changes that they introduce and how these can be positively influenced. Beyond these important findings we sought to understand stakeholder's views on how they could positively engage, or benefit from, the introduction of EVs to inform potential innovation opportunities that accelerate EV adoption.





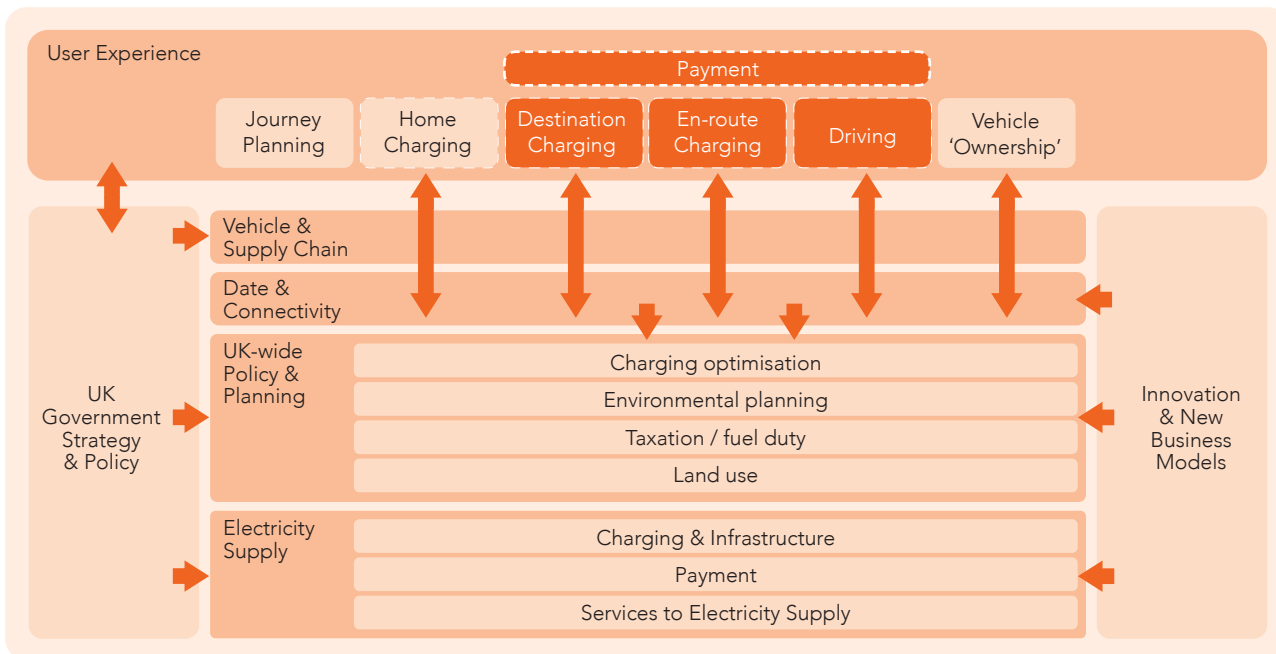
Like all new technology maturation cycles there are a variety of technical solutions coming forward, providing early adopters with similar services while at the same time competing to become the solution of choice that will enable their developers to achieve market leadership.

The adopting of EVs might be expected to follow the familiar Rogers bell curve, *Figure 1* where personal principles, user interest, peer group advocacy, willingness to pay etc., are all at play as take up moves from early adopters to mass market. However, this technology evolution is also being driven by government policy at local and national levels.

These policy driven changes are directed towards the achievement of a societal benefit in the form of improved air quality through the reduction of Internal Combustion Engine (ICE) emissions. The policies allow for charges, penalties and the prohibition of ICE vehicles. This will see manufacturers producing more EVs and require users to assess and adjust their transport needs and/or make the transition from using ICE vehicles to EVs.

Some technology developments bring completely new products and services to customers while others evolve existing services with enhancements and new features. Typically, the relationship is between the technology provider or his reseller and the customer, with the user experience being determined by them.

The relationships involved in creating the user experience for those transiting to EVs, based on currently available technology is, however, much more complex. A user's experience is dependent not only on the technology provider, in this case the vehicle manufacturer and dealer network, but also on the delivery of policy and services from many other stakeholders. Government policy is acting in the area of planning, electricity supply, data regulations and industrial supply chains, with some of this being further interpreted at devolved administration and local levels. At the same time innovation and new business models are transforming technology options and introducing new service provision, all of which contribute to the final user experience. *Figure 2* below illustrates these complex relationships.



For many of these stakeholders, their contribution to the user experience necessitates significant change to existing facilities and service provision and or the implementation of completely new facilities and services. In both cases, because of the scale of provision being called for, substantial investment will be required.

Each change required, whether that be by the user or by other stakeholders, brings with it a risk and reward assessment. The harder it is to assess the risks and the greater the uncertainty of the reward, the longer the decision-making timeframe will be with the potential that decisions will be taken at the last possible moment or indeed for no decision to be made at all.

The following sections describe a high-level summary of the views expressed by the stakeholders covering a large part of this EV landscape.

## UK-WIDE POLICY AND PLANNING

### A. A NATIONAL PERSPECTIVE

Consensus from nearly all stakeholders identified the importance of central government's role in the electrification of transport, leading the way for EV uptake. Clear communications highlighting the impact of electrification, identification of various incentives and future regulations allows easier buying decisions for the public and fleets and greater opportunities for existing companies and emerging entrepreneurs to drive the initiatives forward.

However, many expressed that government should avoid mandating particular technology or charging specifications and focus on easing payment and solving interoperability issues. At the same time, the holistic, wide-ranging strategies that are needed will require the support of central government and other expert industry bodies.

It was suggested that the government take action towards achieving their own long-term air quality targets, for example by limiting support of OEM's production of internal combustion engines. One stakeholder suggested that it should be mandated that car sharing clubs have a certain amount of EVs, with a target of the end of 2020. Another asserted that the UK government should be clear about predicted timing for dates to cease new ICE car sales across the UK.

Stakeholders aware of the broader political picture argued that projections for market penetration should reflect what is realistic based on the capacities of vehicle supply from the relevant OEMs, rather than political aspiration. There are already long waiting lists for some popular vehicles, and one OEM has removed their best-selling EV from sale due to lack of availability for the UK market. Equally, the current EV manufacturing facilities for all OEMs are at maximum capacity and will not be able to produce the volumes of cars required to meet government targets. There is a fear that we will have an EV charging infrastructure that is rarely or never used in certain parts of the UK as a result.

It is clear from all the consultation that has been undertaken that a huge amount of uncertainty is present from almost all stakeholders, impacting on delivery and uptake of electrified transport. With so much uncertainty surrounding business models, required infrastructure and varying national and international emission targets, there are interdependencies that are hindering EV progress and investment. Despite regional approaches, consultation with stakeholders revealed there is inconsistency with targets and limits for tax, ownership and usage incentives (such as parking and bus lanes) across the UK. This could increase the cost of product offerings to the market and, ultimately, slow EV adoption. This situation is stalling decision making and investment and so slowing progress for fear of wasted effort or investing in the wrong solution.

There was a strongly articulated need for a single, long-term and cross-industry National Electrification of Transport Strategy, coupled with sufficient ongoing funding to deliver the strategy and drive a further accelerated step-change in technology and uptake.

The strategy should include clear and consistent long-term policies and positive incentives such as vehicle excise duty and fuel duty, and wider societal agendas; examples of these include charging point interoperability, air quality legislation and congestion charging, as well as mandating charging points for new build houses.

Delivery of the strategy should ideally be overseen by a single body that is independent of political change. This body would also ensure consistent messaging to users and industry while ensuring support for skills and employment within the manufacturing supply chain and aftermarket.

Two stakeholders suggested delivery on the Strategy should ideally be overseen by a single body independent of political change, who would ensure consistent messaging to Users and industry, and ensure support for skills and employment within the manufacturing supply chain and aftermarket.

There was a consistent view that ongoing clear messaging and offerings to consumers should win the hearts and minds of Users, rather than rely on taxation and strongarm tactics to force the agenda. The suggestion was that we should build on the good work of GoUltraLow and the Milton Keynes EV Experience Centre in order to continue to address consumer nervousness surrounding vehicle costs, battery range, charging locations, charging time, battery life and the second-hand market.

This is a rapidly moving market and many external factors were suggested as potentially disrupting the future direction of travel for EV. A few stakeholders voiced the need for government (and industry) to keep a watching brief internationally to learn from other countries. The Chinese market particularly was identified as rapidly growing and leading the world in EV uptake. Many stakeholders mentioned 'Dieselgate' as being involved in accelerating the interest in EV, whilst also impacting consumer trust in the automotive industry and in government policy surrounding emissions. One stakeholder was particularly concerned that consideration of EV Safety was not neglected, believing that a major EV related incident could destroy consumer trust.

### B. REGIONAL AND LOCAL GOVERNMENT

Car sharing operators who offer a flexible sharing service are reliant on permits from local authorities being granted to park their vehicles. There are multiple policies for London and more widely across the UK that are helping to stimulate a cleaner transport future. These include the Green Growth Strategy, the Clean Air Strategy, the Industrial Strategy, the draft London Transport Strategy and the Environment Strategy. These strategies and policies are supporting local authorities to develop their own strategic direction for sustainable modes of transport, including EVs. Two examples are as follows:

- The 'Milton Keynes Promise' is an initiative to guide the installation of public charge points within walking distance of residents' homes, to help those who do not have the capacity to install their own charging points.
- Improvements to local air quality is driving Hackney Council's programmes of work around EVs and active travel. Following the Transport Strategy, they aim to install a charger within 500 metres of residents.

A lack of information and clarity on the future governance for EVs is making it difficult for stakeholders to develop strategies to foster this change. Zipcar have focused their strategy to 2020 but beyond this the picture is unclear. Some stakeholders have suggested that despite the increase in charging infrastructure, there is no overall strategic vision guiding this.

Stakeholders noted that it would be beneficial for the National Infrastructure Planning regime and Development Consent Orders (DCO) process to appropriately aligned with the requirements and timescales needed to support EV growth rates and associated infrastructure investment.

The complexity of the market is huge, and every local authority is approaching EV usage differently. In general, local authorities are not forward thinking in terms of developing infrastructure, which stalls progress. There is a belief that the private sector has taken the lead on getting the charging infrastructure ready, and thus the government does not have to get involved.

Some of the current incentives, like tax reductions for plug in hybrids, were felt to be necessary in the short term, but should be phased out as and when hybrids have served their purpose to increase acceptance and familiarity with electric vehicles. One stakeholder was concerned that some hybrid users are predominantly using their vehicles as petrol cars, as many of the hybrid owners who obtain cars through work never install home chargers. In effect, this behaviour could cancel out the intended long-term benefits of plug-in hybrid incentives. Another stakeholder felt the benefits for hybrid users must be better managed, as they are currently interfering with EV uptake, for example by occupying charging spaces.

One stakeholder suggested that the public sector should take some responsibility to provide access to charging, for example by requiring new developments to provide charging or incentivising car parks. A challenge faced by local authorities is how to support charging infrastructure in areas where on-street parking is already at a premium. There is a risk that if councils install charging points in areas that are already under pressure, those EV-only spaces will inevitably increase the pressure further. To date, few councils have used On Street Residential Grant Scheme to address the problem of insufficient charging.

EVs are creating disruptive innovation of the mobility space. As such, it is not surprising that there are several regulatory and policy barriers restricting their deployment. Various stakeholders, particularly local authorities, car share operators and electricity networks, have identified several regulations and planning laws that are restricting the development of infrastructure.

A recent case with Zipcar highlights this challenge. Westminster Council completed site surveys for Zipcar's parking/charging bays in the borough. Following the assessment, a high proportion of the bays were deemed not suitable for electrification, for reasons including narrow pavements, basements beneath charging infrastructure, and conservation areas. These strict planning laws make it difficult to deploy the infrastructure necessary to support the transition to EVs.

DriveNow also highlighted that the current environment often sees regulation getting in the way of various initiatives and actions that are trying to help the transition to EVs. To deploy their sharing vehicles across London, they need to approach each of the 33 local authorities separately and then obtain the relevant agreements and permission from various individuals with the authority.

### C. ENVIRONMENTAL STRATEGIES

There was a consistent opinion that policies regarding air quality zones and congestion charges will play a significant part in driving consumer uptake and influence vehicle design and manufacture. Balancing congestion with carefully designed logistics patterns, delivery design, depots and last mile delivery could prove vital. One stakeholder suggested that cities will eventually compete to attract business and citizens based on their clean-air and anti-congestion strategies. However, many automotive stakeholders also voiced concerns that differences in local policy driven by income generation or individual political agendas could be detrimental to user uptake and to the vehicle manufacturing industry. One stakeholder suggested it is essential that there is a coordinated nationwide approach to air quality and congestion charging across all Local Authorities in line with a National Electrification Strategy; differences and vagaries in rules between cities risks having a negative knock-on effect to vehicle design and hence cost and time-to-market.

Some scene setting for future cities, was voiced by several stakeholders. They anticipate that zero emissions zones in cities will be driven by air quality and congestion rather than CO<sub>2</sub> targets, with all new smaller city cars being almost entirely EV powered. Wider urban vehicles, extra-urban and inter-city vehicles could use low emission pollution ICEs. They are likely to use geofencing technology, auto switching between ICE and EV where needed.

## ELECTRICITY SUPPLY

Stakeholders commenting on electricity supply raised topics that largely orientate around six areas: 'time of use' and energy services; market arrangements; monitoring, forecasting and planning; charge point optimisation; and regulation.

### A. TIME OF USE AND ENERGY SERVICES TO THE ELECTRICITY SUPPLY CHAIN

In most cases, suppliers or distribution network operators (DNO) cannot currently influence or control charging of residential or public EV charging to manage network congestion or take advantage of lower energy costs.

The majority of residential charging points have no time of use price signal or incentives to reduce charging over electricity network peaks or increase charging when energy costs are low. However, there are a limited number of legacy 'economy 7' tariffs that reward delayed charging to more favourable times. This is set to change with the roll out of smart meters to circa 30 million properties throughout the UK and some EV specific time of use tariffs are beginning to emerge.

There are many trials that have and are examining the charging behaviour of EV drivers in a variety of scenarios to understand how charging patterns change with a range of interventions. However, these have yet to draw clear conclusions on the best way to manage residential charging as EV ownership and use migrates from early adopters to the average motorist.



DNOs are not yet clear on the ways they will be able to influence charging behaviour to manage network congestion or capacity sharing and the role that they, suppliers and aggregators will have in delivering a safe, efficient and convenient service for EV drivers. Stakeholders generally believe that smart meter rollout will enable 'time of use' pricing to be deployed, however it is uncertain how the market and EV users will respond and whether other mediums, for example internet-based arrangements, might also be deployed.

Many parties cited proposals in the Automated and Electric Vehicles bill which would require smart charging capability to be installed in public charge points. However, this would require broader energy sector changes to utilise effectively. It was also noted that the same requirements were not proposed for residential charging units.

In response to the existing electricity supply arrangements, many stakeholders suggested that EV charging facilities should have the necessary infrastructure, communications and commercial frameworks to minimise the cost of charging vehicles and provide energy services to the electricity supply chain. Some stakeholders thought that 'Time of Use' and smart charging capability should be mandated for EVs but participation in smart charging should be voluntary.

Most electricity supply chain stakeholders thought it is important for EV user charging behaviour to be responsive to 'time of use' pricing and ideally there should be a willingness to offer services to the energy system. Whatever the actual response is however, those parties needing to invest considered it important that charging behaviour and willingness to be influenced is understood and sufficiently reliable to base decisions.



Suppliers and network owners wanted the ability to design tariffs or provide price signals that stimulated and rewarded efficient charging behaviour. Some networks owners thought that they would need some level of control to address network congestion, should they arise.

Many stakeholders, including EV drivers, saw advantages in seamless charging and payment arrangements across home charging, public charging and places of work. Suppliers, aggregators and charge point operators wanted the design of these tariffs to be underpinned by reliable and forecastable revenues for services (for example, balancing services) that were reflective of market energy prices and costs.

Complementary to tariff and service considerations, stakeholders interested in providing applications in the home envisaged that home energy consumption, production (for example, solar), EV charging and storage should be co-ordinated in response to energy prices, network congestion and amenity required by home owners. For example, EV charging is paused during household peak demand.

Some suppliers thought there could be opportunities from integrating charging facilities and other amenities such as supermarkets, retail parks and entertainment. Integrated offerings could be attractive to customers and commercial enterprises e.g. to generate extra footfall.

## B. ELECTRICITY MARKET ARRANGEMENTS

Technology isn't seen as a major barrier for electricity supply by stakeholders, however, the circular dependency of EV charging behaviour, how it might be influenced or controlled and the business models, communications and the role that parties should play is creating uncertainty.

Ofgem note that market mechanisms needed for efficient integration of EV charging into the energy market are closely aligned with the arrangements required for demand side response and flexibility and cite complimentary developments in half hourly settlement, network charging arrangements and access to flexibility markets. They also note that they are considering future supply arrangements more generally, given the changing sources of generation, flexibility and use of electricity.



Ofgem and Elexon have created opportunities to trial new frameworks and settlement arrangements for electricity more generally (Regulatory Sandbox, Innovation Link and Settlement arrangements) to help inform stakeholders. Elexon note they have developed a viable solution to process roaming meters which could allow the charging capability developed for street lights to be progressed. They have recently published a white paper on how customers can buy power from multiple providers which may facilitate charging at multiple charge points with a single supplier, or several suppliers providing charging facilities at a single meter point.

Many stakeholders wanted a clear understanding of roles and responsibilities in influencing, managing and controlling EV charging behaviour between DNOs, suppliers, aggregators and other parties to deliver secure and efficient EV charging arrangements. It is generally recognised that the coordination and information exchange between supply chain actors must be secure and sufficient for each party to undertake their activities effectively e.g. efficient charging infrastructure planning, investment and operation.

All electricity supply stakeholders consulted acknowledged the role that half hourly settlement and smart meters is likely to have in stimulating efficient charging of vehicles, however, some stakeholders thought that the electricity commercial framework should be more encompassing and include flexibility frameworks that facilitate the simultaneous participation in network, system and supply flexibility markets.

## C. ELECTRICITY NETWORK REGULATION

As noted in the previous section, Ofgem is leading complimentary developments which impact on both market arrangements and electricity network regulation. Part of this work is considering how domestic consumer network access should be managed, how network capacity should be shared and how potential increases in capacity should be paid for.

National Grid TO observed that the current regulatory and commercial framework for electricity networks does not support strategic investment ahead of need and may not unlock the necessary network investments required to stimulate EV growth. They cited the creation of rapid charging facilities as an example which was both a strategic investment ahead of need and to address perceived range anxiety concerns of prospective EV drivers.

National Grid also noted that the current regulatory regime for electricity looked solely at the energy domain and did not incorporate wider benefits to the UK economy.

Some stakeholders within the automotive supply sector thought that charging infrastructure should be available ahead of need to support EV uptake.

More generally across electricity supply stakeholders, questions were raised over how charging infrastructure in the home and elsewhere should be funded and concern that costs may fall on consumers who didn't yet own EVs.

Coalescing these stakeholder views, it suggests that consideration should be given to a suitable regulatory framework that supports justified national infrastructure and strategic investments ahead of need. The funding of this would need to be through a fair distribution of costs across electricity customers and central funding so that wider benefits to the UK economy are enabled, whilst broadly following the principle of costs falling where they are incurred.

## D. MONITORING, FORECASTING AND PLANNING

All parties in the electricity supply chain would like a better understanding of the uptake rate and location of EVs, their charging behaviour and how that could be influenced in order to plan how they will be respond.

DNOs and partnering stakeholders have and are undertaking a broad range of innovation projects through a variety of funding mechanisms under DNO regulatory price controls – the Network Innovation Allowances (NIA) and Network Innovation Competition (NIC) route – and innovation calls from Innovate UK and BEIS. These cover EV user behaviour, vehicle to grid (V2G), network modelling, forecasting and monitoring EV impacts and 'last mile' solutions. Stakeholders thought these projects will go some way to addressing gaps in understanding and enhancement of the DNO toolkit.

Notwithstanding existing work, DNOs state they do not currently have detailed data sources for their low voltage infrastructure. This can make it difficult and time consuming to assess the impact of EV charging, charge point applications and then ongoing network management of network congestion. They have developed a staged approach to addressing the impact of EVs including forecasting, monitoring, mitigation including smart based solutions, and investment in infrastructure.

In general, DNOs believe they have a good understanding of the technology and infrastructure available to manage the network and the projects underway will enhance this knowledge. However, the market mechanisms and understanding of EV charging behaviour and ability to influence and control them are less clear.

The DNOs broad approach recognises there is a balance between investment in infrastructure and smart solutions, where charging can be varied and influenced to manage network congestion and energy market conditions. Smart charging can also help provide a buffer while necessary infrastructure investment in planning and consents is obtained and delivered.

There is a requirement to notify DNOs once a charge point is connected to their network in a similar fashion to residential roof top solar installations, however, in practice notifications are incomplete. DNOs supplement this data with other sources that are publicly available, though they have incomplete and patchy data on charging points in residential and commercial premises. As a result, DNOs have limited visibility of charge point installations clustering to inform what action needs to be taken.

Distribution network operators (DNOs) wanted visibility of residential and commercial EV charging infrastructure and a means of identifying emerging clusters of EV charging points. They would like a sufficiently detailed understanding of their low voltage networks, monitoring and control to efficiently manage investment and congestion. As part of this, they are exploring how to develop appropriately granular models and analysis capability of real lower voltage networks. They are aiming to fully develop a toolkit of options following conclusions to their innovation projects and learning from other electricity system jurisdictions.

Smart charging is seen as important but DNOs point out that additional infrastructure will be required as EV uptake becomes mainstream. DNOs thought it was important to understand the EV infrastructure distribution network costs for a range of geographies (for example, urban, rural and various charging behaviours), to inform strategic and investment decisions. Similarly, the transmission and system operator thought it was important to have visibility of EV requirements from the electricity system in planning, scheduling and operational timescales, for example the location of vehicles, expected charging, charging behaviour and services available to the electricity system.

A DNO noted that they do not have clarity over residential consumers' desire for enhanced electricity supply to enable more rapid charging. They also noted that this could be achieved in several ways, for example, home storage to buffer rapid charge, increased connection size, or a mixture of the two.

### E. CHARGE POINT OPTIMISATION

Charging and parking is considered further in the [Policy and Planning] section of this consultation however the location, type and number of charge points installed, and how they are used, are important variables to allow the electricity supply chain to efficiently meet EV users' needs.

Charging points are currently most likely to be connected to the DNO network at lower voltages (i.e. 11kV/415V). This is where most electricity network concern lies regarding EV take up and where there is relatively poor understanding of network capacity, data and modelling. This often makes it difficult for DNOs to assess the specific impacts of EVs in a region and what action needs to be taken. Many DNOs have adopted a 'monitor, mitigate (for example, by developing smart solutions) and invest where appropriate' strategy, with each element requiring innovation to some degree.

A DNO observed that there is little collective understanding across local authorities, charge point operators and DNOs of how to optimise charging connection point location. The process and information to support efficient electricity network connection and driver convenient charging point installations is currently not well co-ordinated across stakeholders, and not geared to the number of installations that are being proposed.

Residential off-street charging is currently the dominant approach, however, the optimum portfolio of options will depend on the desire to overcome range anxiety, charge anxiety and convenience; which are themselves dependent on the size of battery within the vehicle, speed of charge and the location amenity. There are a variety of charge point options that are installed today including residential, on street, public, work place, retail outlets, transport hubs and rapid charging on major roads. Stakeholders held various views on what was required however, there is no consensus over the number and type of charge points that should be deployed on a nationwide basis to support mass EV uptake.

One DNO observed that if a roll out of on street charging is required (for example, to encourage residents without off-street parking to adopt EVs), a viable large-scale solution doesn't currently exist.

Charge Point operators noted that there is a lack of 24-hour fleet operator (e.g. taxis and delivery vehicles) rapid charging facilities which may require more specific infrastructure to be installed.



## DATA, CONNECTIVITY AND NEW BUSINESS MODELS

Many parties expressed the importance of data, connectivity, business models and the relationships between parties in delivering an excellent user experience.

### A. DATA AND CONNECTIVITY

Appropriate access to data, the connectivity between devices exchanging data and interoperability of charging infrastructure are considered by many as essential components for an excellent EV user experience. However, data is either unavailable, incomplete or held solely by the parties collecting it. Data ownership, standards, cyber security and governance over which parties should have access to data are regarded as key enablers.

### B. STANDARDS

Standards were seen by stakeholders as key to facilitate operability and information exchange. However, they observed that there was no unified smart charging protocol or standard and consequently there were multiple proprietary systems for smart charging which were inhibiting the exchange of information and operability to provide an efficient and responsive charging experience for EV users, the electricity system and other stakeholders.

*From an electricity network perspective, the following are regarded as desirable:*

- Standardised architecture and functionality set for Smart Charging to facilitate participation in the energy markets
- An incentivisation mechanism that accelerates adoption of the standardised method, either through grants, regulations or connection requirements
- Standards to allow for interoperability for charging equipment and communications
- EV charging points have appropriate standards to promote interoperability and integration with the energy system.

### C. CYBER SECURITY AND GOVERNANCE

All stakeholders recognised that the coordination and information exchange between supply chain actors must be secure but sufficient for each party to undertake their activities effectively e.g. efficient charging infrastructure planning, investment and operation.

Stakeholders within the electricity system domain considered the need for cyber security as essential to ensure no malicious or unintended disruption in EV charging behaviour which could jeopardise the integrity and safe operation of the electricity system in real time. Therefore, in addition to robust and secure communication arrangements between parties and systems, appropriate controls over authorised access to real time market and operational data is required.

## D. USE OF DATA

Notwithstanding cyber security and data access considerations, many stakeholders wanted access to data and the ability to interface with EVs and other assets to deliver better EV user experiences, support efficient operation and pursue commercial opportunities.

*For example, the following opportunities were highlighted:*

- Providing seamless charging and payment over many locations
- Parties interested in providing applications in the home envisaged that home energy consumption, production (such as, solar), EV charging and storage could be co-ordinated in response to energy prices, network congestion and amenity required by home owners. For example, e.g. charging is paused during household peak demand
- Many vehicle drivers have destinations that they need to travel to however there is no means of easily establishing the logistics of what charging is required and when. By combining EV state of charge, available charging resources and real-time data (e.g. current traffic conditions), optimal charging approaches can be deployed, which could go some way to alleviating range anxiety and minimising unnecessary charge point and network constraints
- Combining data from EVs with other data to build attractive offerings; for example, integrating with retail, entertainment or leisure opportunities
- Locating and gaining access to charging points is frequently seen as challenging; this is compounded by a common perception or anxiety that public charging points are out of order or unavailable. Sharing this information more widely could help both EV drivers and other charge point operators in highlighting alternative arrangements
- Some stakeholders noted the hypothesis that there is value to be gained from data analytics associated with charging, travel and other behaviours but it was currently uncertain how this might be exploited and remained largely untapped.

Local authorities, electricity networks, charge point providers and other stakeholders identified value in capturing and having access to EV data, such as charging behaviour, to inform and justify investment decisions. Clarity was sought on how this data and subsequent investment decisions could be co-ordinated and shared to ensure buildings, parking and charging infrastructure investments and operation could be optimised.



## E. NEW BUSINESS MODELS

The impact of the electrification of vehicles is far reaching: Transport and energy sectors will be more closely linked and EV growth is likely to affect retail and vehicle dealership models, electricity supply models and vehicle ownership models. It is as yet unclear how new business models will develop and who is best placed to make them work. For electricity supply, many roles, responsibilities and market arrangements will be captured within regulatory frameworks however other areas will be less formal. Within the electricity domain, some parties observed that it was unclear how 'behind the meter' activities, where regulation did not apply, could be efficiently integrated into arrangements where regulatory arrangements did apply. Some parties within the EV supply industry thought that EV business models were fragmented, and in some cases broken which led to poor user experiences.

Elxon, the electricity Balancing and Settlement Code (BSC) administrator, observed that determining the criteria for a good business model is not straightforward and there doesn't seem to be a forum that allows many dimensions to be considered e.g. defining the business model and defining what needs to happen in various domains. There is an established change process for BSC, however, this may be somewhat detached from the parties developing the business models. Ofgem, have introduced a regulatory sand box and innovation link to facilitate exploration of new frameworks and business models.

Some parties suggested that organisations from the automotive industry may become more active in Electricity Supply and provision of electricity services such as storage, and conversely Electricity Suppliers entering the car leasing arena. Other business models might also emerge to support the needs of fleet users, long distance users and commercial enterprises.

Stakeholders noted that Car clubs, shared ownership, 'all-inclusive' energy and 'Mobility as a Service' options could play important roles in determining the landscape if travellers consider 'non-ownership' models at scale. In addition, future EV charging markets arrangements roles and responsibilities are uncertain and likely to evolve and consequently many

potential actors who are able to play a role are reticent about the action they will take. One party commented that, although charge point operators ran separate networks today, would they be integrated at some point in the future, citing automatic teller machine (ATM) arrangements as an example of how models can change.

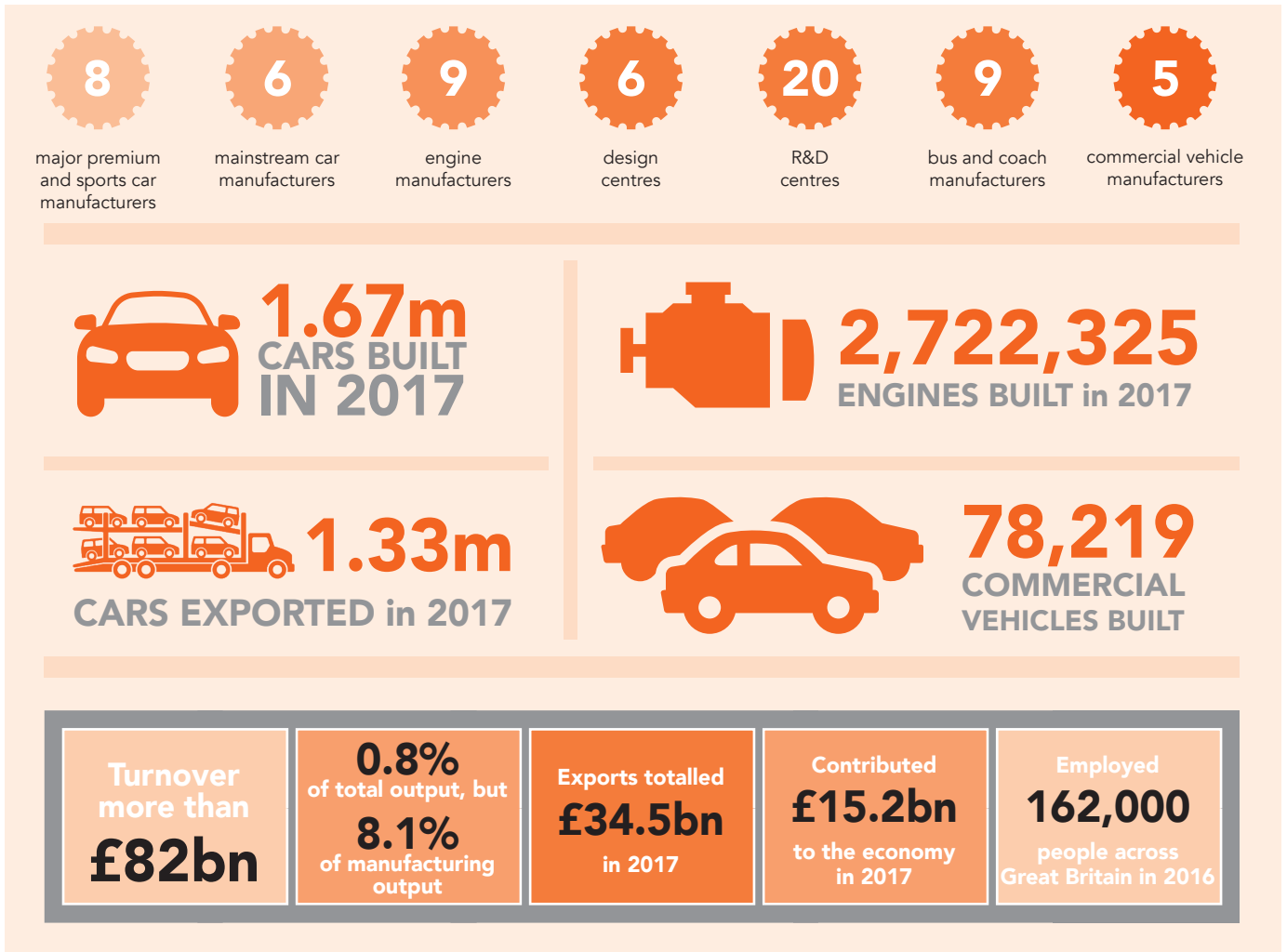
Overall, the potential for different business models and opportunities to offer combinations of service was seen as positive, but this was tempered by uncertainty over which business models would succeed, where responsibilities might lie, and which opportunities individual parties should pursue.

**TRANSPORT AND ENERGY SECTORS WILL BE MORE CLOSELY LINKED AND EV GROWTH IS LIKELY TO AFFECT RETAIL AND VEHICLE DEALERSHIP MODELS, ELECTRICITY SUPPLY MODELS AND VEHICLE OWNERSHIP MODELS.**

# THE VEHICLE

## A. THE EVOLVING AUTOMOTIVE INDUSTRY

UK Automotive industry is a key part of the economy with a turnover of more than £82 billion.



Electrification, with its significant changes to the vehicle architecture and components, presents risks but also an opportunity to increase UK content and reduce the trade deficit.

There was a consistent view among those consulted, that continued and potentially additional, Government support is needed at multiple levels. The support is primarily required to continue R&D and innovation programmes, ensuring that both product and manufacturing technologies are developed and anchored in the UK. It was also noted that the critical skills required to deliver those programmes need to be developed, not only in those joining the workforce, but also for those currently in employment whose roles are likely to be disrupted.



It was suggested that broader Government support may come in a variety of forms, perhaps rapid planning consent for new manufacturing facilities, or mapping and developing the UK supply base for high-value components to cater for both global high-volume and niche vehicle manufacturers. One stakeholder believes that manufacturers are responding to the global signals and demand, but clear directives and support from UK Government and organisations such as the Automotive Council, SMMT and APC is also needed.

An area of significant concern for the respondents was the impact that the growing shift towards electric vehicles will have on the prosperity of the sector in the UK. The UK automotive sector, while highly productive and successful, currently produces 2.7m Internal Combustion Engines in 2017 (SMMT) (with 1.5m exported). While the disruptive shift towards electrification represents an opportunity for the UK to address the trade deficit by growing a battery and electrified powertrain supply base for domestic supply and export, the transition away from ICEs and related powertrain components that are manufactured and assembled locally needs to be managed carefully.

Concerns were also raised about the longer-term impact on dealerships, aftermarket suppliers and independent organisations engaged in the maintenance, repair and servicing of vehicles. Electric vehicles typically have fewer parts and require less frequent servicing than ICEs but increasing levels of connectivity and autonomy meant that the equipment and skills sets needed to maintain and repair the vehicles is likely to be considerably different to today.

When combined with the growing trend towards new business models such as servitisation (which is leading to fewer people owning vehicles) this shift is likely to have an even greater impact.

## B. BATTERIES AND THEIR INFLUENCE ON VEHICLE COST AND RANGE

From a technology perspective, batteries were highlighted as the main issue for EV users, mainly due to their cost. While the cost of components for an EV powertrain is roughly half the cost of that of an ICE vehicle, when the fuel tank (or battery pack in the case of an EV) is included, an EV powertrain is currently significantly more expensive than a comparable ICE one. User nervousness remains in both mass-production and niche vehicle types, particularly with 'miles per charge', speed of charging, battery ageing and its effect on second-hand values. There were a few different views of the future suggested. One vision saw a future of smaller, cheaper batteries in every vehicle, rapidly charged very regularly, using widely available charging infrastructure. Other visions saw larger batteries in vehicles in order to travel reasonably long distances between refills, then using super-fast charging at speeds comparable with refilling your tank today. Most stakeholders believed that Government investment in research via the likes of the Faraday Challenge should be continued to further the technical advances in battery technology, although one stakeholder felt that battery technology is fundamentally ready.

There was a desire to establish reliable battery manufacturing capabilities at scale in the UK, but it was acknowledged that there will be challenges associated with this. Several stakeholders stated that the security of battery chemistry raw materials was a particular threat to battery manufacture and, in turn, to future EV supply. Accelerated research into solid-state batteries and other technologies were suggested as solutions to this problem. Generally, it was acknowledged that there is a place in the future for Hybrid, Low emissions Diesel engines with an EV element, and Hydrogen Fuels cells too.

## C. DRIVING EXPERIENCE

Respondents who were also EV owners were overwhelmingly positive about driving an Electric Vehicle and usually reluctant to go back to an ICE vehicle, despite any challenges that they may experience with charging, parking and payment. EV users acknowledged the importance of understanding their particular requirements (duty cycle), especially regarding range and charging infrastructure in order to select the appropriate model. This was seen as something that is very important for a positive EV user experience but has historically been much less of a consideration for ICE vehicles, where the choice is typically been between petrol and diesel (and the associated trade-offs against purchase price, running cost, performance and vehicle tax rates).

Respondents felt that there will be a continued increase in EV sales as new EV ranges and models come to market that will support most user needs. However, there is a continuing need for manufacturers to better understand the consumer experience lifecycle, including how user perceptions of EV changes as the market matures



## SUMMARY AND NEXT STEPS

Despite the compromises with the user experience on offer today, early adopters frequently report that they would not want to go back to driving an ICE vehicle.

It is suggested in the User Experience section that positive user advocacy has the potential to exert a strong influence on the rate of adoption and that the collective effort of stakeholders, interested organisations and innovators engaged in the transition from ICE to electric vehicles should have delivery of an excellent user experience as a key goal.

Building from the feedback received during the consultation, the table that follows takes key aspects of the user experience and associates the current experience with suggestions received about what an excellent user experience might be.

The table is not intended to be a statement of requirements or to constrain ambition. It is intended to point at opportunity and need, to stimulate discussion and ideas and highlight areas where further policy, standards and innovation could benefit the UK.

The understanding gathered from this consultation will now be used to assist Innovate UK in identifying gaps and opportunities within existing programmes of innovation support in this field and better inform them and the Catapults for future planning.

The next phase of this work has already begun, the outputs of which will be publicised in the Spring of 2019 for the benefit of innovators, broader stakeholders and government.

Creating excellent, engaging, and rewarding end user experiences is principally an intellectual challenge and not a technical one, and the UK, with the support of the uniquely rich and diverse innovator community can be a world leader in delivering them.



EV User Experience	Today	To be Excellent – might be
Journey Planning	<ul style="list-style-type: none"> <li>Confidence in battery range is lacking and recharging times are substantial when compared with ICE vehicles</li> <li>Users cannot rely on the ready availability of charging provision or the nature of the charging provision at charging locations which gives rise to 'Range and Charge Anxiety'</li> <li>EV users must plan their journeys more akin to that of a commuter using public transport</li> <li>EVs unsuitable or impractical for some journeys</li> </ul>	<ul style="list-style-type: none"> <li>No additional preparation required when compared with using ICE vehicles</li> <li>Range and Charge Anxiety no longer present</li> <li>Reliable and accurate range information</li> <li>Clear visibility of Air Quality and congestion charging zones (HEV)</li> </ul>
Home Charging	<ul style="list-style-type: none"> <li>Only really available to those with off street parking</li> <li>Coupling up to the domestic electricity supply via specifically designed chargers is the primary method of charging EVs in private ownership. <i>Ref: GoUltra low – Chargemaster analysis of EV refuelling behaviour shows that more than 90% of all electric vehicle charging takes place at home</i></li> <li>The majority of residential charging points have no time of use price signal nor means of influencing their charging behaviour. Limited opportunity for EV users to optimise their charging costs</li> <li>The installation cost of such chargers currently benefits from government subsidies</li> </ul>	<ul style="list-style-type: none"> <li>Solutions delivered that mean those with on street parking can charge 'at home'</li> <li>Legislations requires charging points to be installed at all new build property with off-street parking and planning processes deliver similar provision where parking is on street</li> <li>Inductive charging is the norm with no need to plug in it that delivers a rate of charge that allows full charge to be achieved in a 'reasonable' period</li> <li>Vehicle managed charging requiring no user intervention with built-in cyber security</li> <li>User benefits for accepting managed charging that supports the energy system, including vehicle-to-grid</li> </ul>
On-street Charging	<ul style="list-style-type: none"> <li>No viable large-scale solution available</li> <li>Users rely on local authority or, if available, commercial provision with the type of charging available determined by those who provide the service</li> <li>There is no requirement (is this true?) on any party to make such services available in sufficient quantity or within reasonable distance of users' homes</li> <li>Users frequently find charging points not working or unavailable due to being occupied by ICE vehicles</li> </ul>	<ul style="list-style-type: none"> <li>A large-scale solution for EV users of on street charging is in place.</li> <li>On street charging facilities are well maintained with very low downtime ensures high availability</li> <li>Charging can be booked in advance to guarantee availability</li> <li>Charging bay occupations by non EV users has been resolved.</li> </ul>
Destination and Journey Charging	<p>As per on street charging plus:</p> <ul style="list-style-type: none"> <li>Although many users' normal journeys fit within the manufacturers' quoted range for their vehicles, range anxiety remains a real issue. <i>(Go Ultra Low research shows that 98% of drivers travel less than 100 miles daily)</i>,</li> <li>Where travel is a journey to work then some limited charging facilities may be available. <i>(Government supported via the Workplace Charging Scheme)</i></li> <li>Marketing initiatives are seeing a growing offer of charging facilities at other amenities, such as supermarkets, tourist venues, service station etc, however, the numbers remain limited and there may be charges for access</li> <li>Information on availability and serviceability of provision can be limited</li> <li>Confusion exists around connectors and charger types</li> </ul>	<ul style="list-style-type: none"> <li>Charging points offer universal interoperability and standards and are available to all user groups</li> <li>Sufficient rapid and public charging facilities are in place to give users the confidence they will be able to make their journeys and associated charging in the timeframes they want to</li> <li>Intelligent connected vehicle systems optimise charging requirements according to the user's journey plan with the user able to receive promotional offers for preferential rate charging in close proximity to their journey route</li> </ul>
Payment	<ul style="list-style-type: none"> <li>For home charging, payment for the electricity consumed is via the domestic electricity tariff, however, the majority of residential charging points have no time of use price signal or incentives to reduce charging over electricity network peaks or increase charging when energy costs are low</li> <li>Fuel duty tax nor road tax are currently levied</li> <li>On-street charging payment is at the discretion of the service provider with both payment methods and rates being set by them. This also applies to destination and journey charging</li> <li>EV specific supply contracts are emerging</li> <li>Users can face excessive cost for an electricity supply provision if current facilities are at maximum capacity</li> </ul>	<ul style="list-style-type: none"> <li>The ability to distinguish domestic supply and EV charging use and allows charging of and payment by the EV owner whether normally present at the property or visiting</li> <li>Payment for charging is seamless and simple with contract/PAYG options and an ability to pay using standard payment mechanisms</li> <li>Provision of a charging supply to property where not already available is a flat rate charge</li> <li>Fuel duty tax and road tax automatically collected as part of the charge</li> <li>Access to charging provision at a flat</li> </ul>
Driving	<ul style="list-style-type: none"> <li>Driving an EV requires user adjustment but does not require any formal testing or licensing by the DVLA</li> <li>Driving experience is good and once users have experienced an Electric Vehicle they are reluctant to go back to petrol or diesel despite any issues they may experience with charging and parking</li> </ul>	<ul style="list-style-type: none"> <li>Automatic availability identification, routing and reservation of charging points directly from the vehicle, based on information on battery condition and range available</li> <li>Geofencing technology provides for auto switching between ICE and EV where needed</li> <li>Vehicle upgrades and performance optimisation in real time 'over the air' dependent on the desires and needs of the User</li> </ul>
Vehicle Ownership	<ul style="list-style-type: none"> <li>Choosing an EV is perceived to be more complicated and risky than choosing an ICE. Users are concerned about the accuracy and quality of the advice they are being given</li> <li>People don't want to be out of pocket or invest in the wrong technology. Range anxiety, battery degradation, charging challenge and second hand value all present additional barriers</li> <li>Drawn towards leasing agreements to limit risk but may be overpaying</li> <li>EVs represent a small part of most automotive manufacturers' product ranges (reference or evidence required) with a limited number of manufacturers exclusively offering EVs</li> <li>Some manufacturers have chosen to concentrate their EV sales through a select number of dealers in a desire to ensure customers are served by knowledgeable staff for sales, service and repair but which is less convenient for users</li> <li>Purchase price subsidies important</li> <li>Anticipated battery life and replacement costs are a prime driver of the residual value. (Ref or Evidence?)</li> <li>Plans to restrict or ban ICE vehicles from cities and countries is providing a stimulus to demand for EVs which manufacturers may not be able to respond to</li> <li>The cost and availability of vehicles is a barrier to adoption</li> <li>EVs benefit from government subsidies that operate to reduce the initial purchase price and finance and leasing options are available for the purchase of EVs. Company car drivers enjoy preferential benefit-in-kind tax rates</li> </ul>	<ul style="list-style-type: none"> <li>Users buying with confidence based on a quality sales and service process supported by accurate and reliable information</li> <li>Clear and consistent long-term policies and positive incentives via the likes of Vehicle Excise Duty and Fuel Duty have supported the growth in EV adoption</li> <li>Non-subsidised ownership costs better than comparable ICE vehicles</li> <li>Hybrids and range extenders as standard in new vehicles by 2025</li> </ul>

## APPENDIX A – Stakeholder Open Questions

In addition to garnering stakeholder views and perspectives, our discussions also revealed stakeholder questions and uncertainties which seemed to inhibit stakeholder investment and progress. We have captured below those questions that may point to policy considerations, opportunities for innovation or lack of information.

### SOCIETAL FACTORS

Potential EV user perceptions were seen by many stakeholders as significant challenges to overcome. Some open questions included:

- How do we help potential EV users gain confidence in their buying decision?
- How do we access the general public to convince them of the benefits of driving an EV?
- How do we ensure that EVs do not negatively impact social equality?
- What alternative models can be explored for multi-car households? E.g. Use of a shared-model?
- Who owns our car and charging data and how can open access to this data be provided to those that need it?
- Is the EV plug in solution relying on changing too many people's behaviour too much?
- How can we improve consumer protection in the EV market, to improve consumer experience and Public attitudes towards EVs as more people adopt?
- EV producers like Nissan and Tesla have a wealth of extremely detailed charging behaviour data - could we use this?
- Will on street charging lead to increased street congestion?
- Should we be focusing on vehicle ownership as a model or mobility packages which could alleviate some of the charging concerns?

### ECONOMIC IMPLICATIONS

A number of stakeholders expressed concerns around the implications of concessions and subsidies for EVs. Many local authorities incentivise EV car parking and the use of bus lanes, companies offer charge points at place-of-work and government have offered subsidies for new EV purchases. Questions arising from this were:

- What are the next steps for incentivising EV uptake and what affect will it have on buying behaviour in the future?
- Who is going to pay for Grid and infrastructure improvements, and what are the business models that make commercial sense?
- How will the government account for the loss in revenue from current fuel taxation and what impact will this have on EV purchase or leasing prices?
- What will the Vehicle Excise Duty and other taxation of future policy be?
- Will taxation differ between user groups and can/should taxis be exempted?
- How can we create a market around battery end of life and replacement?
- How do we incentivise businesses to use EVs as company cars?
- Who will pay for accommodating chargers, for example places to charge business fleets?
- What are the new business opportunities presented by EVs? Vehicle to grid revenue? Advertising?
- How should the billing and access to charging points be managed? Should this only be led by the private sector or do local authorities have a role? For taxis, could access be linked to the council's licensing?
- Is there standardised and pooled information for EVs and charging? For example, one app showing all types of charges, including leasing, parking, and charging.
- Will the investment and support needed to develop charging infrastructure come before the demand for EVs?

## ENVIRONMENTAL AND HEALTH CHALLENGES

- Logistics in cities causes a considerable amount of pollution and congestion. How might we speed up EV uptake in this sector?
- How can old vehicle materials be recycled and reused for the next generation of vehicles?

## POLITICAL LEADERSHIP

- How can we ensure that government aspiration and targets for EV deployment can be met by the vehicle manufacturers?
- What are the main barriers to infrastructure rollout? Cost? Legislative restrictions? Planning application process?
- What are the funding approaches for strategic investment that could be ahead of need? And how can we approach supporting EV uptake more generally by addressing prospective EV owners' perceived concerns, such as range anxiety (whether real or perceived)?
- Should national infrastructure be funded centrally or built into the electricity regulatory arrangements, network charging and market arrangements?
- What are the funding arrangements for charging infrastructure and charging points in general?
- What are the main drivers for charging infrastructure installation? Return on investment? Meeting demand? High-profile locations (visible, in areas where there is air pollution concern – i.e. from idling diesel taxis)?
- Will charging points continue to be owned on a proprietary basis or, in a comparable way to Automatic Teller Machines (ATMs), become an open network for all?
- What should the incentives be for businesses to provide EV charge point infrastructure?
- How do we standardise air quality targets across local authorities and still meet UK Government targets? And in what way will this influence EV purchasing?
- How will we enable disparate industries and stakeholders to work together to address these common problems?
- What role should Government play in arranging a platform for all stakeholders to work together?
- How do we get the right balance between promoting and investing in EVs and developing public transport?
- How do we encourage people to buy EVs, and at the same time discourage them from driving so much in congested areas?
- How does the UK progress compare with the rest of the world? Are there other countries we can learn lessons from?
- How do we work around local authority's inertia to solve the on-street infrastructure problems? The solutions exist but councils can't seem to make progress
- Should public money be used to fund charging points for vehicles likely to be owned by those in high income groups?

## TECHNOLOGY

- Where should smart charging capability be installed? In the car or charge point?
- EVs typically have induction motors or brushless DC drives with attendant power controllers that convert DC power from the battery to variable speed AC supply to the motor. Can the EV motor controller (inverter) also include smart charging and V2G capability able to intelligently connect to DC and AC charge points?
- Can we enable the incumbent automotive industry to move faster towards pure EV transportation?
- How will we ensure that charging is interoperable and seamless for the customer?
- How will we address the battery raw material supply challenge to ensure battery (and vehicle) supply can meet future demand?
- How can we develop an innovative UK supply chain to support both our niche and high-volume manufacturers, and secure jobs?
- Which on-vehicle battery technologies will 'win' in the future?
- What is the impact of rapid charging on the long-term life of batteries? There is need for understanding to alleviate customer concerns, akin to the concerns over mobile phone battery life.
- Is there value in deploying a large network of fast charging infrastructure? How will it interplay with other emerging technologies such as CAV?
- V2G relies on the CHAdeMO connectors which is fitted by Nissan whereas most OEMs are fitting CCS. If this doesn't change then isn't V2G doomed?!
- If I buy an EV today, will developments in battery technology make it obsolete in 2 years' time?
- How can we best get the vehicle manufacturers really on board with this in creating the seamless digital experience that is needed

## ENERGY SUPPLY

- What are the roles and responsibilities in influencing, managing and controlling EV charging behaviour between DNOs, suppliers, aggregators and other parties to deliver the charging experience desired by EV users in a secure and efficient manner?
- What is the method and communication infrastructure that the electricity market and settlement, network and system operator use to buy, sell, control and settle flexibility from EVs? Is it smart meter infrastructure, internet, mobile network, or other?
- How can EV charging behaviour be forecast in operational timescales?
- What is the charging behaviour and needs of fleet and 24-hour operators such as delivery vehicles and taxis?
- What are the suitable ways to influence charging behaviour to manage network congestion, capacity sharing and energy market surplus or peak periods? Are they price signals, payment for services, user capacity allocations, local energy market, softer methods (social and societal conscience), or more direct control?
- Will the resulting charging behaviour be visible to those that need it and what data needs to be exchanged between parties?
- Can charging behaviour be integrated into other lifestyle activities such as supermarkets shopping, visiting retail outlets and entertainment centres?
- What incentives and inducements are effective and commercially viable? For example, increased retail footfall and sales with discounted charging?
- Will charging infrastructure and charging convenience (for example, rapid charging) be more efficiently delivered to commercial and retail centres?
- What spare network capacity is available within the lamppost infrastructure and what number and rate of charge can it support?

- At a national level, what is the right number, type (rapid, V2G, and other) and location of charging points to address EV user journeys of all types, range anxiety, charge anxiety and parking convenience? How rapid should EV residential charging be?
- What are the optimum locations for on-street parking and charge point facilities to deliver a convenient service and take into account network connection costs?
- What 'time of use' tariffs and network capacity allocations will be applied to EV charging? Will they be integral to home tariffs or separate add-ons? Will there be minimum levels of capacity guaranteed?
- Do we need an early surplus of charging infrastructure to encourage adoption
- What are the main drivers for charging infrastructure installation? Return on investment? Meeting demand? High-profile locations to alleviate range anxiety or visibility in areas where there is air pollution concern – e.g. from idling diesel taxis)?
- Who should be defining what's needed from the energy infrastructure?
- People refer to Urban a lot and I understand why, but is much research looking at rural and market towns and if power infrastructure could cope with demand?
- It is most important that all future charging systems installed are 'Smart'
- Should a distinction be drawn between 'energy users' and 'EV energy users' in terms of consumer protections?
- What are the charging network operators doing to improve the user experience? I.e PAYG, roaming agreements, removing membership / subscriptions?
- How can we make public charging a good user experience? Currently 4+ apps & payment regimes
- Forecasting of charging behaviour: difficult as the public charger market is fragmented/reluctant to share data on charging behaviours. How can this be solved?
- What can garages do to improve user experience? Currently, many are unsure how to adapt.
- Do you think Street light post charging points are feasible?







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