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Decarbonization

Creating the infrastructure for zero-emission vehicles

Executive Summary

As a major source of carbon emissions, the UK's transport sector will need to undergo a significant and rapid transformation if the UK is to meet its goal of net zero emissions by 2050. On 14 July 2021 the UK Government released its Transport Decarbonization Plan with the aim of decarbonizing all modes of domestic transport by 2050. On that same day, policy makers, industry experts and representatives from local transport authorities spoke at a BSI-led webinar on transport decarbonization. This conversation has led to the production of this report, focussing on a few key areas of road transport decarbonization.

Providing sufficient electric vehicle (EV) chargepoint infrastructure and the grid capacity to deliver it, while overcoming public perceptions around range anxiety, are significant barriers to decarbonization. Technological development, regulation and standards will all play a role in overcoming these obstacles.

Energy Smart Appliances (ESAs) and Demand Side Response (DSR) will also be pivotal in providing a host of benefits and saving consumers money, while ensuring the electrical grid stability required to cope with the increased demand that will inevitably arise from growth in the use of EVs. This increased pressure on the grid will be compounded by the electrification of domestic heating, which is also essential in achieving net zero.

An added challenge beyond eliminating carbon emissions from the tailpipe of private cars is the decarbonization of heavy goods vehicles (HGV) and road freight. Decarbonization of different types of road transport is subject to different practical and technological barriers and constraints. Therefore, the full decarbonization of UK transport is likely to require a range of different solutions implemented in parallel.

The primary driver of change will be consumer demand, which will provoke innovation and drive down the costs of zero-tailpipe-emission vehicles. It is also essential that accessibility is at the heart of all decarbonization efforts, allowing all members of society to play a part in reaching the net zero goal as well as reaping its benefits.

Contributors

This report has been made possible by contributions from a panel of policy makers, industry experts and representatives of local transport authorities.

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Decarbonization and net zero

Net zero will not happen without decarbonizing transport, reducing the greenhouse gas emissions produced by our vehicles is a key part of our journey towards a cleaner transport system for everyone."

– Nick Fleming

In 2019, the UK became the first major economy to create a legally binding target for reaching net zero emissions, setting a deadline of 2050 by which the goal must be achieved and an interim target of a 78% reduction in emissions by 2035. The transport sector is one of the UK's largest emitters of CO2 and a major source of air pollution in cities. Decarbonizing transport is, therefore, essential if the UK is to meet its net zero target. While the path to solving these issues is far from certain, steps are being made to address this.

The UK government has already announced a ban on the sale of new petrol and diesel cars and vans by 2030 and the end of new hybrid car and van sales from 2035. On 14 July 2021 the government's Transport Decarbonization Plan was issued, defining a pathway for the decarbonization of all modes of domestic transport by 2050 as well as laying out the wider benefits that net zero transport will deliver.

Impacts of existing transport modes on greenhouse gas (GHG) emissions

Transport accounts for around one-quarter of the UK's GHG emissions. Close to 90% of transport-related emissions are caused by road transport. The greatest proportion of GHG emissions is produced by cars, although vans and HGVs produce greater amounts per-vehicle.

The majority of vehicles on the road are over eight years old, the oldest average age that our vehicles have ever been. Older car models tend to be less efficient. However, promoting the sale of new vehicles is not a solution in itself, as the embedded carbon emissions related to the manufacturing of a new car are significant. Decarbonization will require not just the replacement of fossil-fuelled vehicles with zero-tailpipe-emissions alternatives, it will also require an overall reduction in the number of vehicles on our roads.

Registrations of EVs are on the rise, however, they still represent less than 2% of the vehicles on the UK's roads. But sales are increasing and EVs now make up around 10%[1] of new registrations.

1. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1045962/vehicle-licensing-statistics-july-to-september-2021.pdf

90% of transport-related emissions are caused by road transport

Less than 2% of vehicles on the UK roads are electric

Drivers and enablers of decarbonization

Regulation and policy

Regulation and government policies, such as those outlined in the government's Transport Decarbonization Plan, are required to guide service providers, infrastructure owners and vehicle manufacturers and operators.

New technologies and alternatives to fossil fuels

This includes the improvement of technologies already on the market to boost performance and reduce cost, alongside the development of new fuels - such as hydrogen - improvements in battery technology, the development of more efficient supply chain processes and development of lighter materials that can contribute to making vehicles more efficient.

Zero-emission charging infrastructure

EV charging infrastructure must be reliable and accessible, with grid capacity able to cope with the huge increase in demand for renewable electricity required to meet decarbonization targets. Equally, the infrastructure for hydrogen vehicle re-fuelling and storage will require careful consideration.

Sustainable manufacturing: removing carbon emissions beyond the tailpipe

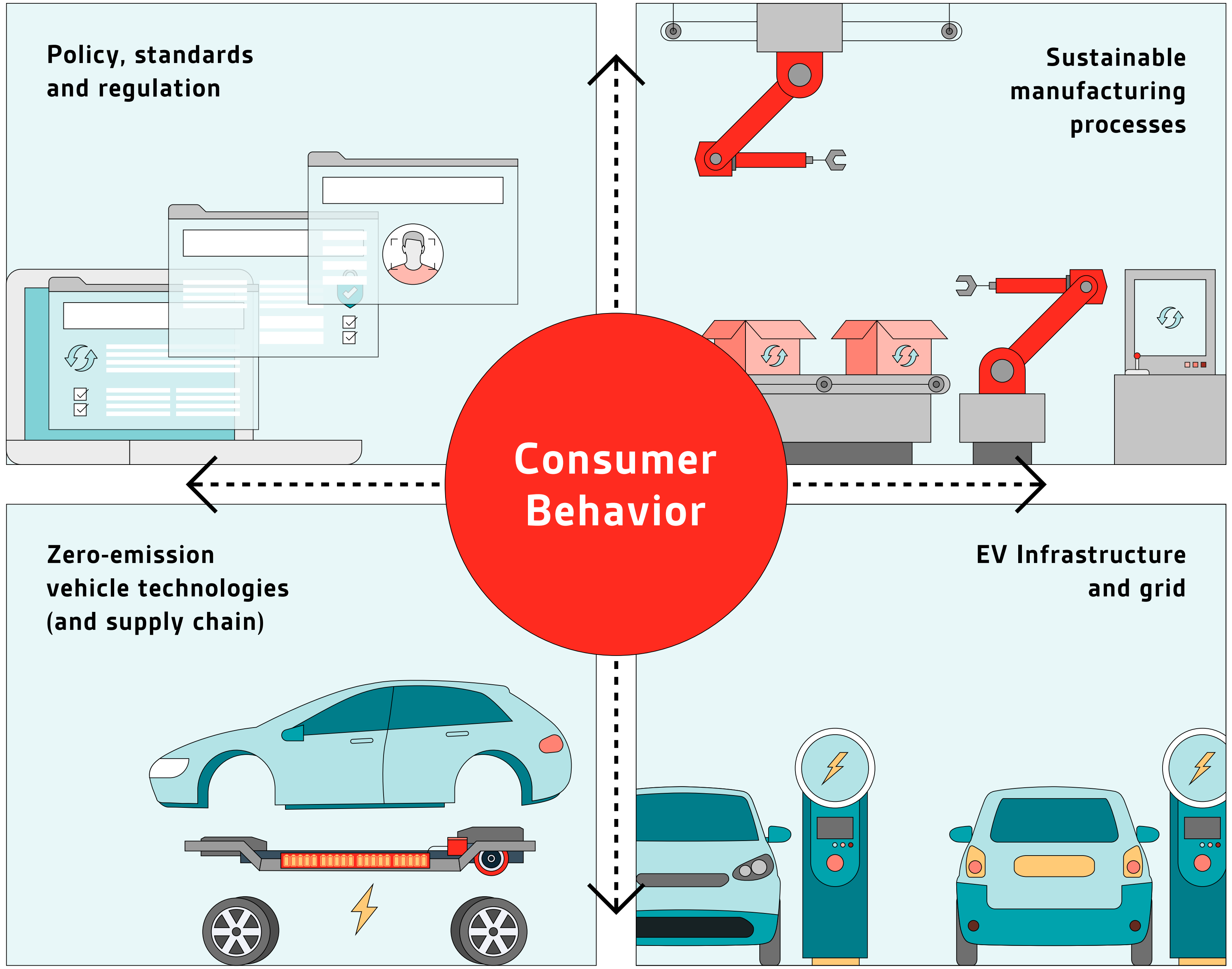
Sustainable manufacturing processes are needed to mitigate embodied carbon emissions over the lifetime of a vehicle and beyond, including end-of-life and second-hand use. This involves moving to circular economy principles and reducing carbon involved in manufacture as well as improving reuse and re-manufacture of parts and materials, including local responsible sourcing.

New mobility and smarter transport

Alternatives to private car use such as increased mass transit or public transport can reduce pressure on roads and impact emissions, especially with cleaner and more efficient public services vehicles such as electric or hydrogen buses. This will be supplemented by new modes of micro-mobility, more active travel (e.g. walking or cycling), connected and automated vehicles and on-demand services or MaaS (Mobility as a Service). A more intelligent transport system can help ensure there is a more efficient use of road and air space.

Consumer behaviour will be the primary driver of decarbonization

The biggest driver underpinning all of this will be consumer demand. This will drive innovation of new products and bring costs down. Decarbonization must not become a niche topic, but a mainstream concern engaging all transport users.



At the heart of it is consumer demand and the behavioural change that needs to happen. To achieve that, we need a safe and accessible, reliable and secure charging network."

– Nick Fleming

To ensure charge points are designed to be accessible for all users, work is now in progress on a new standard supported by the Office for Zero Emission Vehicles, part of the UK Department for Transport, and Motability the consumer charity. Work on PAS 1899 started in late 2021 and will provide guidelines for manufacturers, designers and operators of public charge points to ensure the needs of people with disabilities are considered in the design and installation of charging facilities.

The role of standards

Standards are crucial to enabling decarbonization; providing common good practice and language agreed by all relevant stakeholders, defining expectations that a product or system should meet, enabling testing and measuring outcomes. Standards are also vital for ensuring interoperability between electric vehicles and DSR service providers to prevent consumer lock-in.

The safe, sustainable production of battery cells is an area in which standards are driving innovation, through BSI's participation in the Faraday Battery Challenge and the introduction of:

- **PAS 7060** Electric Vehicles. Safe and environmentally-conscious design and use of batteries
- **PAS 7061** Batteries for vehicle propulsion electrification. Safe and environmentally-conscious handling of battery packs and modules
- **PAS 7062** Electric vehicle battery cells. Health and safety, environmental and quality management considerations in cell manufacturing and finished cell

In the day-to-day practicalities of owning EVs, standards will be vital for ensuring a reliable and satisfying user-experience, addressing the built environment at charging stations, including parking bay size, charge-station height and cable weight. The recently published PAS 1878 and PAS 1879 support a technical framework that covers both energy smart appliances and DSR, to develop an end-to-end system for domestic demand side response as part of the BEIS and OZEV funded Energy Smart Appliances Programme. This will ensure that chargepoints and other domestic smart appliances can provide flexible services whilst following key policy principles of interoperability, data privacy, cyber-security and grid stability. This is discussed further in the chapter on developing chargepoint infrastructure.

"The new Energy Smart Appliances standards (PAS 1878 and PAS 1879) are a major step forward in the transition to a smart, flexible and low carbon energy system.

In response to the government's transformational energy plans, consumers are becoming more directly involved in managing demand in the electricity system through smart appliances that react to the availability of electricity and provide flexibility in the system.

The new standards will provide essential guidance and good practice for the fast-moving industry to roll out ESAs safely and responsibly, whilst also helping to protect consumers from new data and privacy risks."

– Sebastiaan Van Dort

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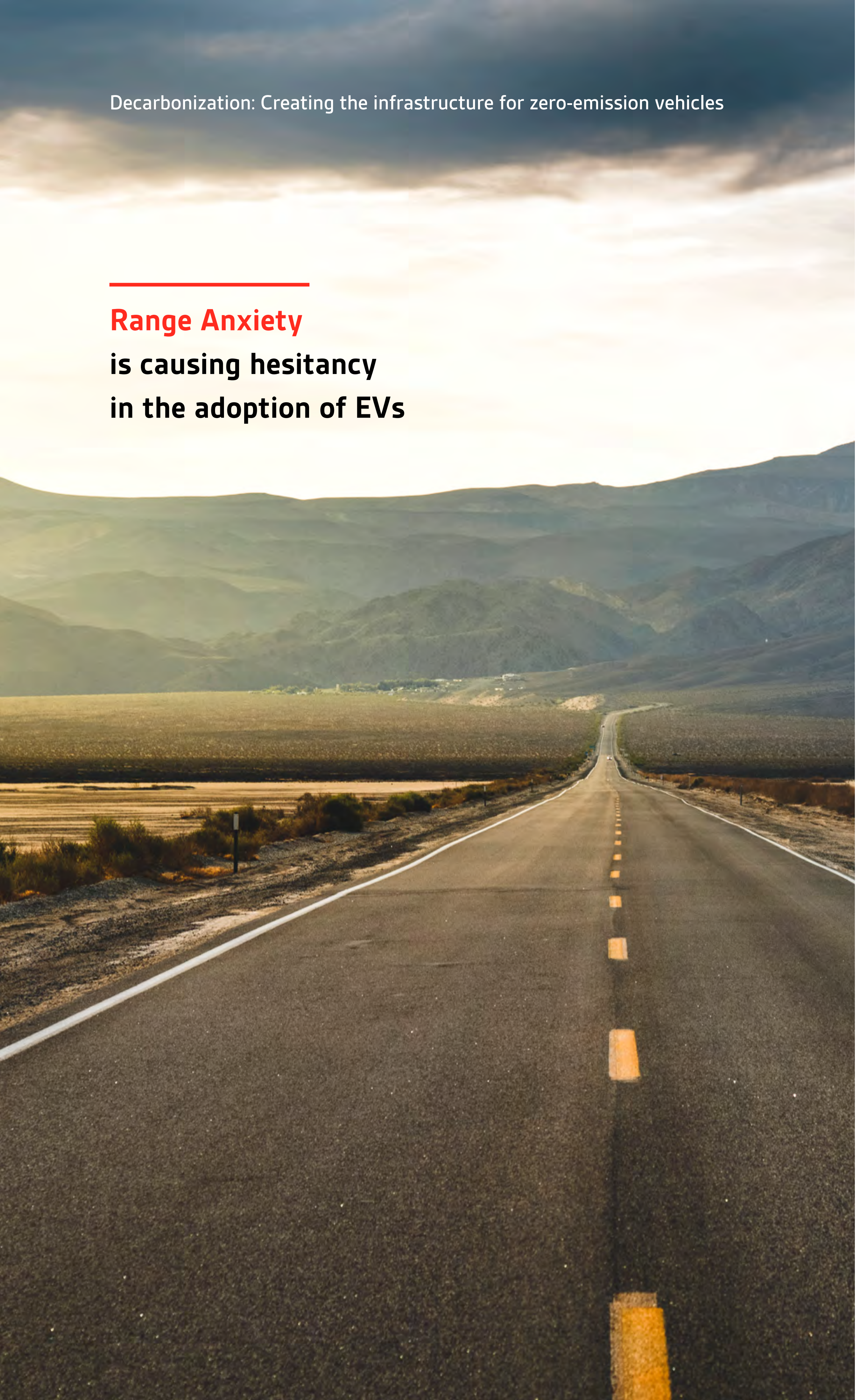

Range Anxiety is causing hesitancy in the adoption of EVs

Barriers to decarbonization

For the majority of road transport users, EVs are the most obvious example of zero-tailpipe-emissions transport. And among consumers, the greatest cause of hesitancy around the adoption of EVs is so-called range anxiety. Better charging infrastructure and improvements in range will help prove the viability of EVs in the eyes of consumers. However, educating users on behavioural change may be even more important.

Drivers are used to infrequently fully refuelling their cars at petrol stations and expect long range from their vehicle between fuelling stops. Part of the solution to range anxiety will come from a change in mindset away from this 'petrol station model.' The introduction of charging stations at locations such as supermarket car parks will allow EV users to fit charging around their daily routine, contributing to the resilience of the network while not incentivising additional journeys made solely for the purpose of recharging. The location of different types of chargers can be a driver of behavioural change. For instance, while it is possible to install rapid-charging infrastructure on high-traffic routes, this may not be desirable as it could reinforce habits learned from the petrol station model of car use, leading to drivers making otherwise unnecessary journeys to charge their cars.

Many EV users will be able to charge their vehicles at home and start each day with a fully charged car with a range in the region of 200 miles. During at-home charging, electrical smart appliance (ESA) chargepoints enabling demand side response (DSR) will help in minimising charging cost and making use of electricity from renewable sources by drawing power from the grid at the optimal time of day. This is discussed in detail in the chapter on developing chargepoint infrastructure.

Price point is another potential barrier to market update, along with uncertainty around the long-term future of EVs versus hydrogen. The creation of a local, sustainable supply chain and production capability for battery technologies along with electric motors and drivers, supported by standards, can help with supporting a reduction in cost.

The challenge of providing grid capacity to deliver electrification of transport infrastructure will be compounded by the demand created by the simultaneous electrification of other areas, such as domestic heating. As we will see, ESAs and DSR will be key in enabling these transitions.

Developing chargepoint infrastructure

> How do we enable all customers using the public charging infrastructure to have a seamless experience no matter where they are in the UK?"
>
> – Sophie Adams

OZEV's customer experience consultation explored the issues facing the introduction of public charging infrastructure in the built environment. This included a section on inclusive design looking at the weight of the charging cable, size of the parking bay and the height and ease of use of the charger.

Accessibility is a central consideration in designing chargepoint infrastructure. It is essential to know how drivers and passengers manoeuvre around the chargepoint and how this will change as new forms of charger are developed. The OZEV consultation included sections on improving pricing transparency so consumers can compare prices across networks; ensuring that consumers can locate the right chargepoints for their needs, streamlining the physical and digital payment methods offered and improving the reliability of the UK charging network so consumers can confidently travel and get support when something goes wrong while charging.

The infrastructure in the UK should be inclusively designed, which is why BSI, working with OZEV and Motability, will later in 2022 publish PAS 1899, the first standard for accessible EV chargepoint design. PAS 1899 will help to ensure public EV charging is accessible for all.

> The UK could save between £17 and £40 billion by 2050 by ensuring we have a smart and flexible energy system."
>
> – Dr. Nina Klein

As discussed in the chapter on barriers to decarbonization and in the case study on Transport for Greater Manchester, this infrastructure must be designed in a way that doesn't reinforce unsustainable behaviours. A further constraint on infrastructure design is the mitigation of grid stability issues. This will require open and accurate data-sharing between providers, third parties and users. This includes static data, such as chargepoint location, as well as dynamic data, including chargepoint availability and operational status.

Data-enabled ESAs and DSR will offer flexibility to the grid and lower costs and carbon emissions for consumers. DSR allows ESAs to automatically draw power from the grid at the optimal time, enabling appliances to take advantage of time-of-use-tariffs, or to maximize the use of renewable power while compensating for fluctuations in the availability of wind or solar power. ESAs are designed to respond to customer override; consumer preference is always prioritized, ensuring that the user's needs are always met.

DSR will also minimise system costs by reducing the need for investment in grid reinforcement and will reduce the requirement for the overbuilding of renewable capacity.

The two PASs cover different aspects of delivering electrification. PAS 1878 sets out a specification for ESAs, while PAS 1879 sets a framework for DSR operation. The two specify minimum requirements to deliver domestic DSR, allowing for innovation to continue on top. The two standards are underpinned by four key policy principles; interoperability, data privacy, grid-stability and cyber-security.

The Smart Charging Consultation Response published in July 2021 highlighted that Phase 1 regulations are compatible with the standards established in PAS 1878 and 1879. Mandating both PAS 1878 and 1879 will be considered as an option for Phase 2 legislation.

Case Study:

Transport for Greater Manchester

Transport for Greater Manchester (TfGM) and Arup have engaged in a city-region scale interaction with a range of stakeholders in order to identify a route to decarbonization at the scale and pace required to meet the UK's targets.

The project's stated vision is "**To be an exemplar city region for enabling the electrification of transport in the context of a smart, integrated, sustainable mobility network. By 2030, Greater Manchester's residents and businesses and visitors to the region, who choose to travel by car or light goods vehicle, will be able to use EVs with the confidence that they will be able to conveniently recharge them (via public or private chargepoints) and in doing so will help to improve air quality and reduce carbon emissions across the conurbation.**"

While TfGM's main strategic goal is to reduce overall car-use as much as possible, EVs are part of their vision and TfGM has had a publicly funded chargepoint network since 2014. TfGM has made a plan for the introduction of a clean air zone, aimed at the most polluting commercial vehicles rather than private cars. Initially set to be implemented in 2022, this plan has been delayed and is currently under review.

TfGM objectives:

- Spark demand for EV uptake among users, which will stimulate involvement from the private sector
- Create a financially sustainable, accessible chargepoint network that decouples itself from public subsidy
- Ensure the network is scalable to growth in demand and flexible to changes in vehicle technologies
- Provide a charging network that accelerates EV transition among businesses, residents and visitors
- Minimise car dependency and private car ownership
- Achieve improved air quality and carbon neutrality in line with targets
- Set strategic principles and delivery criteria, using publicly funded EV chargepoint infrastructure as a representation of the types of infrastructure and charging locations that will be supported in principle by TfGM and Greater Manchester local highway authorities

Moving away from the 'petrol station model' of car-use is vital for improving sustainability. For example, while schemes such as park and ride will be a part of TfGM's strategy, installing rapid chargers at park and ride locations would encourage EV drivers to linger unnecessarily. With this in mind, Arup and TfGM have created detailed models to identify suitable sites for charging infrastructure based on the constraints of grid stability, sustainable use patterns by EV owners and traffic patterns. These models have demonstrated the dynamic nature of the problem and identified that a shortage of suitable chargepoint sites could soon become a barrier in further developing the network.

Case Study:

Heavy Goods Transport

Heavy goods vehicles (HGVs) are an important part of our transport system moving our goods and services but are responsible for 16% of UK domestic transport GHG emissions. To meet the UK's decarbonization goals, these emissions need to be reduced to zero by 2050. But this is even harder to decarbonize than domestic transport.

Connected Places Catapult is a not for profit, neutral and independent force for innovation and growth. The catapult's initial investigations into decarbonization of long-haul HGV transport aimed to develop an evidence base for the cost and performance of the available options. This forms the basis of a strategic outline business case for a program of demonstration activities to prove performance of each viable option in a commercial environment, enabling long-term infrastructure decisions to be made. The next stage of the process will be to develop a proposition for the initial design phase of a demonstration programme. The program focuses on the largest and hardest to decarbonize vehicles, 44 tonne articulated lorries.

Battery technologies that are well-suited to electric cars are not necessarily well-suited to use in HGVs due to vehicle downtime during charging and the weight of batteries required to power large vehicles over long distances. The catapult's industry research suggests that there is enthusiasm for hydrogen fuel cell technology as a potential solution to decarbonizing HGVs. Benefits include short refuelling times and well-established technology. And, although large-scale investment in infrastructure will be required, the HGV use-case allows for hydrogen refuelling infrastructure to be focussed around transport hubs.

Another possible option is electric road systems, with HGVs connecting to overhead electric lines via pantographs. Such a system uses existing technology and benefits from minimal equipment weight on-board the vehicle. Trials of such systems are already taking place in Europe.

Successful decarbonization of HGV transport by 2050 will require scaling-up of infrastructure and vehicle numbers by 2040, when sales of fossil fuel HGVs are due to be banned. BSI is also supporting this initiative by working with the Connected Places Catapult to identify and map existing standards in this space.

Next steps and opportunities

> To inform the forthcoming major investment decisions, progress towards large-scale evidence gathering on the promising zero-emission technologies is needed urgently."
>
> – Alan Nettleton

- Ensuring that grid stability is maintained as transport is electrified is a major challenge. DSR goes a long way to meeting this demand. DSR has further benefits in terms of optimising the use of renewable energy when it is available on the grid.

- Finding suitable sites for EV chargepoint infrastructure will become increasingly difficult. TfGM's Jason Smith identifies that "Cheap connections are going to be drying up over time." A cross-industry approach is required to drive innovation and create common understanding across professions of the challenges ahead.

- In order that all HGVs can be net zero compliant by 2050, the sale of fossil-fuel HGVs is set to end in 2040. Nationwide deployment of zero-emission infrastructure, hydrogen or electrically powered, must therefore begin by 2030. This means that large scale demonstrators need to be operational by around 2027, making the design of such demonstrators an urgent priority.

- Ensuring the accessibility of this infrastructure should be a priority, it must be available to all. Decarbonization of transport cannot be allowed to become a niche topic, engagement across all of society is vital in reaching the UK's goals.

- Standards will provide essential guidance and good practice for the transport sector to decarbonize safely and responsibly, while helping to protect consumers during the transition.

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