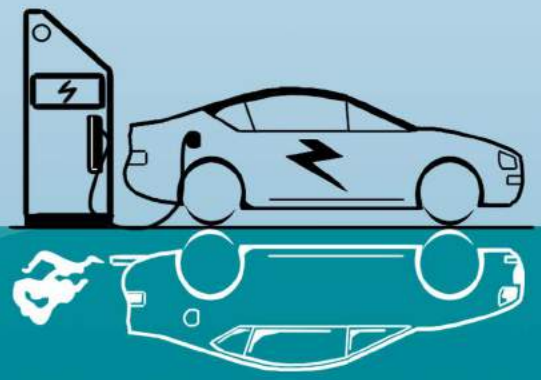
regen
transforming energy



Market insight series:

Harnessing the electric vehicle revolution

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Scottish and Southern Electricity Networks (SSEN) forms part of the FTSE-50 energy company, SSE. It operates the electricity transmission network in the north of Scotland, and the electricity distribution networks across central southern England and northern Scotland, including the Scottish islands, delivering electricity to over 3.7 million homes and businesses. SSEN also delivers a range of small and large-scale innovation projects which aim to ensure the UK has a high quality and affordable electricity network in the future, such as the £9 million My Electric Avenue project which revealed both the impact of EV charging on distribution networks and the ability to use managed charging to manage risks and defer or avoid costly and disruptive reinforcement. Our electricity distribution and transmission networks carry electricity to over 3.7 million homes and businesses across the north of the Central Belt of Scotland and also Central Southern England.

Burges Salmon is the independent UK law firm which delivers the best mix of advice, service and value. Burges Salmon is a market leader in the transport and energy sectors and uniquely well placed to develop the new commercial structures required to support EV networks. Burges Salmon is able to bring together unparalleled expertise in energy supply, battery storage, grid reinforcement, on-site generation and corporate energy contracting as well as an extensive knowledge of infrastructure projects, public transport operations, emerging mobility based products, smart ticketing and transport technology. The firm is closely involved in several Innovate-UK connected and autonomous vehicle projects - VENTURER, FLOURISH, CAPRI and ROBOPILOT - as well as a Vehicle to Grid (V2G) trial.

ZCM has a long history of project development in the renewable energy sector, having originated the London Array offshore wind farm, the Atlantic Array in the Bristol Channel and a number of onshore wind farms in the Orkneys, North Devon, Outer Hebrides and Pembrokeshire. Since 2015 ZCM have been running E-Car Hebrides, a fleet of 10 electric cars and vans based in Stornoway, as a joint venture with E-Car Club. Endorsed by Renault as being one of the greenest fleets anywhere, it is wind powered for the overwhelming majority of the time by the company owned wind farm on the Isle of Lewis. The E-Car Hebrides partners recently won funding from the Innovate UK V2G competition to assess the barriers to introducing a V2G car club operating throughout the Western Isles.

Thank you to contributors

This paper was produced using insights gained from the sector. A set of focused interviews and an industry roundtable with 20 stakeholders from manufacturers, chargepoint operators, aggregators, electricity network operators, local authorities, fleet operators, and academics were engaged. These organisations informed our thinking and we would like to thank those that took part in these activities. A full list of these organisations is available on page 31.

Inevitably the report draws on some published material which covers the same ground. We have referenced those where appropriate within the document and in the further reading section but apologise in advance if, in the interests of readability, we may have omitted to reference appropriately.

While Regen has sought industry and third-party input to inform the report, this report has not been subject to independent verification. All opinions and forward projections contained in the report are those of Regen, and do not represent the views of any third-party or sponsor organisation unless specifically ascribed.

Written and produced by Regen, April 2018 • All graphics produced by Regen • Document designed by Ingrid Kendall

Contents

Introduction

A transport revolution

The world is about to undergo another major transport revolution. Just as steam replaced horsepower and oil has replaced steam, 21st century transportation will be revolutionised by low carbon and low emission technologies.

Unlike previous revolutions, this one has been widely predicted because we have no choice. Climate change and air pollution, allied with the need to reduce the chronic congestion clogging up our cities necessitates radical transport solutions.

The UK government has announced a ban on the sale of all new petrol and diesel vehicles from 2040[1]. France has done the same. This is a radical step, which even a few years ago would have been unthinkable, especially from a government with such stock in the automotive industry. Yet the response has been positive, many in the automotive industry have been supportive and critics[2] have instead called upon government to be even more ambitious.

So, is this the beginning of the end for the Internal Combustion Engine (ICE)? Probably, yes. Certainly it will be replaced as the engine of the most ubiquitous mode of transport, which has been the cultural icon of the hydrocarbon era.

The speed of change, and the impact it will have will be explored further in this paper. For now, it will suffice to say that something seismic is happening which will require a fundamental shift in how we think about transport and energy.

The spark

"Dieselgate" was an international scandal and a watershed moment. There have been plenty of siren calls warning about the health risks posed by airborne pollution (including NO_2 emissions) but the widely held belief was that cars were becoming cleaner, and that measures taken would eventually bring pollution levels down. Probably only those who monitored air quality realised something was amiss, until it became clear that some vehicle manufacturers had rigged their emission tests.

The full ramifications are still to be played out but the immediate impact has been renewed curbs on diesel engines. Amongst the confusion and mistrust, the consumer reaction has led to a reduction in car sales and a shift back to petrol.

Less public, but still highly significant, was the publication of the latest greenhouse gas (GHG) emissions data[3] which showed that in 2016, the UK transport sector overtook power generation to become the largest contributor to GHG emissions in the UK, with a 26% share.

Taken together, the need to address emissions and climate change has created an imperative for change. Governments, city authorities and regulators are being forced to take action, while the global automotive, and energy industries have embarked on a journey of intense innovation and technology development.

The air that we breathe

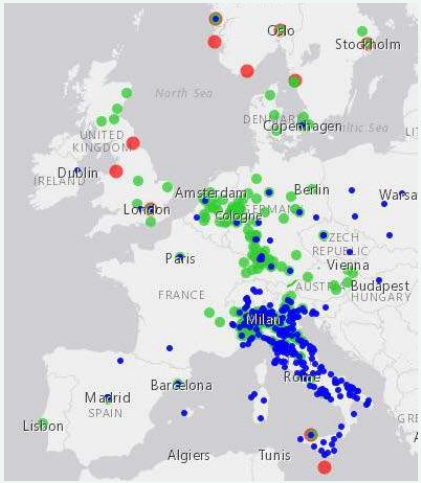
Air quality has become one of the biggest global issues of the 21 century. In China, and other rapidly developing countries, air pollution has reached levels where radical steps are needed to make cities habitable.

In the UK, and across Europe, governments and city authorities are under increasing pressure to recognise that, "poor air quality is the largest environmental risk to public health in the UK", and to mitigate the health impacts.

The pressure to act is growing; the High Court has ruled that the UK government's plans to tackle air pollution in England are "flawed" and "unlawful"[4]. A new, more ambitious, plan for England and Wales is promised for later in 2018, which will likely give the go ahead for more Low Emission Zones (LEZs)[5] within UK cities.

Meanwhile Scotland is pressing ahead with its own pollution reduction plans and across Europe, cities and regions are implementing a variety of schemes including LEZs, urban toll roads and access restrictions, which will begin to drive out polluting vehicles.

Europe's cities driving change



Source: CLARS

European Low Emission Zones

• Low Emission Zones • Urban Toll Roads • Access Restrictions

1 UK Government, 2017. UK plan for tackling roadside nitrogen dioxide emissions.
2 See for example Environment Audit Committee, 2018. Report on Improving Air Quality.
3 UK Government, 2018. Greenhouse Gas Emissions Annual Data.
4 UK High Court, 2018. Version of judgement between ClientEarth and UK Government.
5 See for example the London Low Emission Zone, 2018.

Future growth trajectory

People want clean air and they also want transport. Consumer demand for new transport solutions is growing, in part due to the actions of governments, and also in response to the innovation that is bringing affordable and highly desirable low emission vehicles to the market.

This report tracks the early growth of the industry, highlighting examples of innovation from around the globe, and in the UK. The report considers the uncertain future trajectory of growth, and the factors that will determine whether it will be exponential, explosive or stagnated.

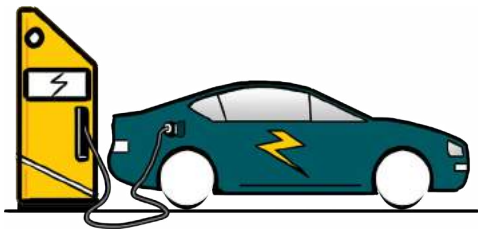
The report's conclusion is that, while governments and policy makers can play a vital role to influence early adoption of new technology, it will ultimately be consumers who will choose whether to embrace the transport revolution, and will therefore dictate the speed of change. Car manufacturers too must play their role in the vanguard of change or risk being replaced by new market entrants.

Regen's area of expertise is energy and as an organisation our mission is to transform energy through the decarbonisation, decentralisation and democratisation of future energy systems. This paper is therefore written from an energy perspective.

The focus of the analysis is on the role that could be played in the transport revolution by Electric Vehicles (EVs)*. Electrically powered vehicles would seem to have the best chance of replacing the ICE for widespread public and private use, They will also force the integration of transport and energy systems which will create further opportunities and synergies that will ultimately accelerate the transformation of both systems.

This is not to say that EVs are the only solution. Biofuel, Compressed Natural Gas (CNG) and hydrogen technologies could well play an important part in the wider transportation sector including buses, trains, HGVs and shipping.

Electrification of transport – and the new ownership and business models that it will encourage – should also be allied with increased use of public transport, walking and cycling. As this report sets out, to fully harness the EV opportunity, infrastructure investment and measures to manage vehicle charging ought to promote, and not displace, other low cost and low emission alternatives.



Understanding the challenges

Heralding revolution is an uncertain business. There will be challenges ahead and, although the occurrence of change is certain, the speed and point of destination is not.

It is still the case that only 2% of UK car sales were EV models (including plug-in hybrid EVs) in 2017. Market growth, therefore, has been steady, but nothing like the exponential growth that is anticipated. The paper asks why that is and how quickly barriers to growth will be overcome.

Change will be hard, especially for the automotive sector. How carmakers respond, whether they lead or follow, will greatly impact, not just the growth of the EV market, but also the rate of innovation that will create new high skilled jobs within a revitalised industry.

The big energy challenge, is how the electricity to power vehicles will be supplied in a secure, low carbon and low cost energy system. Failure to supply is not an option, nor is it viable to simply increase capacity, through costly infrastructure investment, to meet an increase in peak electricity demand.

The report addressed two key energy questions:

- At an energy system level, how can EV charging be integrated with overall energy demand and supply to ensure a secure and balanced system?
- At a local level, how can multiple vehicles charging be supported by a distribution network which has been developed to provide low voltage electricity to meet diversified demand?

Harnessing the opportunity

Being smart is the answer to both questions. Easy to say, but as the paper explores, there are different levels of smartness, some which can be implemented quite quickly with existing technology and business models, and some which will require a rethink of how we supply energy and mobility services.

The report's central conclusion is that the energy challenge can be met, and that solving this issue will in turn open up a myriad of new commercial opportunities and new business models within a new energy and mobility service sector.

Far from being a barrier, smart and flexible solutions that provide power for transport will also help make optimum use of renewable energy sources. The goals of clean energy and clean transport are complementary.

The prize is therefore massive – a cleaner, healthier environment - a new industry and new commercial opportunities for transport supported by a transformed and decarbonised energy system.

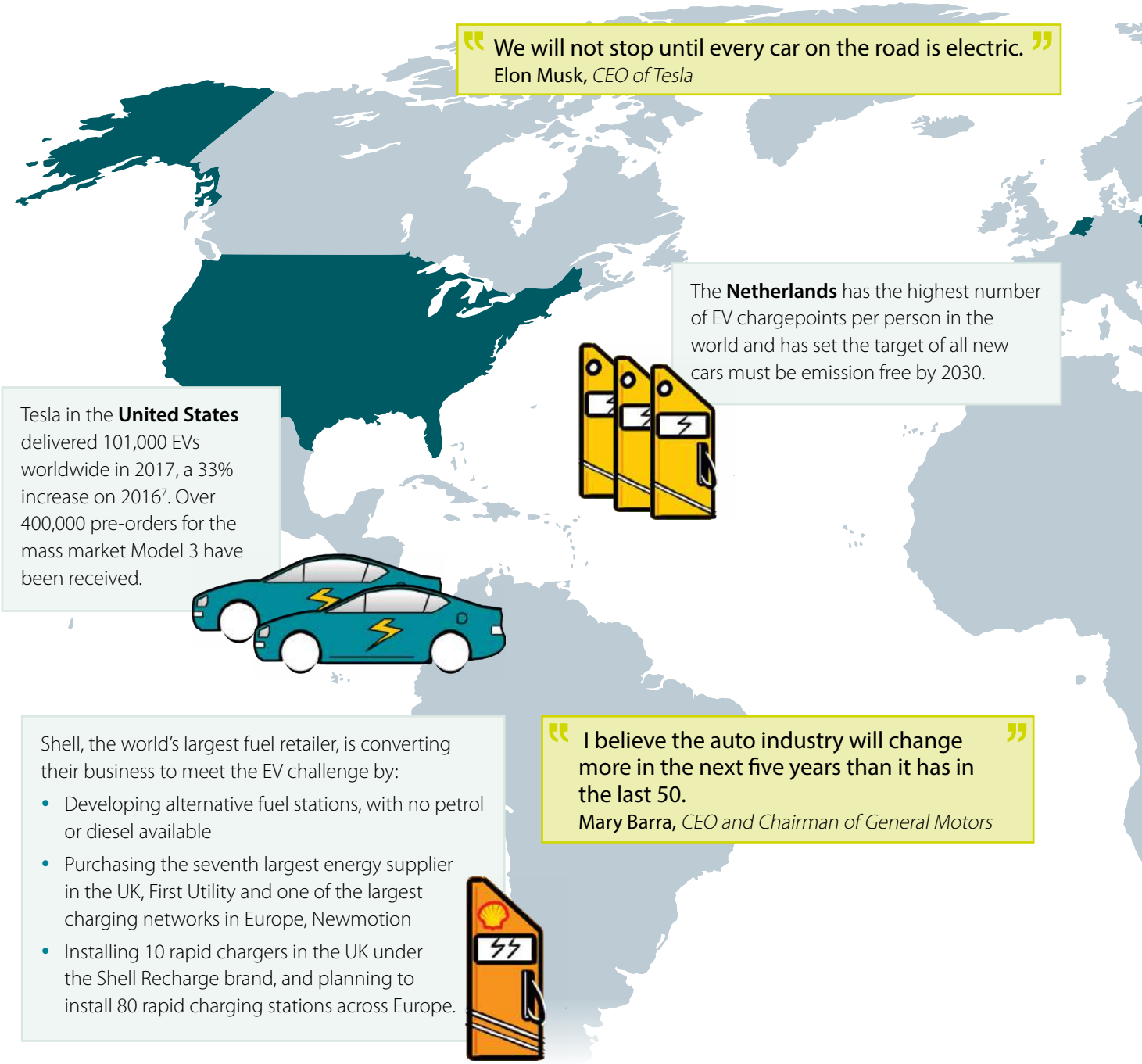
* The term EVs is used to refer to battery Electric Vehicles and plug-in hybrid Electric Vehicles, sometimes also collectively referred to as Plug-in-Vehicles (PIVs) – but not hybrids that do not plug in or vehicles that have some other electric efficiency features.

Global action and innovation is creating a new industry

The growing determination of governments to tackle climate change and emissions is aligning with technological progress to create the conditions for a rapid shift to EVs. Bloomberg recently predicted 530 million or 33% of the world's vehicles will be EVs by 2040[6], already this projection seems low considering the pledges that have been made.

China is taking a leading role, which is a sure sign of the direction of the global market, with half the world's EV sales and 70% of battery cell production. US companies are also active, Tesla's market capitalisation passed that of Ford and Fiat in 2017, a remarkable shift in the market perception of value.

The transport revolution is a global shift driven by multinational initiatives including the Paris climate summit, by national policies like the UK and France commitment to phase out fossil fuel powered cars and by a dizzying array of initiatives from leading cities such as Shenzhen's New Energy Vehicle Promotion that has created the world's largest zero-emissions fleet.



> We will not stop until every car on the road is electric.
> Elon Musk, *CEO of Tesla*

The **Netherlands** has the highest number of EV chargepoints per person in the world and has set the target of all new cars must be emission free by 2030.

Tesla in the **United States** delivered 101,000 EVs worldwide in 2017, a 33% increase on 2016[7]. Over 400,000 pre-orders for the mass market Model 3 have been received.

Shell, the world's largest fuel retailer, is converting their business to meet the EV challenge by:

- Developing alternative fuel stations, with no petrol or diesel available
- Purchasing the seventh largest energy supplier in the UK, First Utility and one of the largest charging networks in Europe, Newmotion
- Installing 10 rapid chargers in the UK under the Shell Recharge brand, and planning to install 80 rapid charging stations across Europe.

> I believe the auto industry will change more in the next five years than it has in the last 50.
> Mary Barra, *CEO and Chairman of General Motors*

6 Bloomberg, 2017. Electric Vehicle Outlook 2017. Executive Summary.
7 Tesla, 2018. Tesla Q4 2017 Vehicle Production and Deliveries.

China recorded 777,000 EV sales in 2017, around half of the global market in 2017. This is set to increase as car ownership rises from a very low base and minimum EV requirements on vehicle manufacturers are imposed.

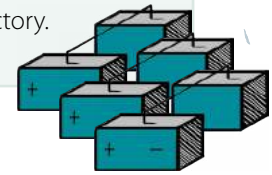
Global battery cell production is due to be dominated by China over the coming years, with close to 70% of the planned and existing battery cell production capacity[8]. Chinese companies are partnering with European brands for EV production. This positioning by China as the heart of global EV growth provides an inspiration as to what can be achieved, but also a challenge to other countries like the UK seeking to become a market leader.

GEELY

北京汽车 BAIC MOTOR

Japan is the leader in connecting EVs to homes. Over 7,000 homes have installations that can power the house in a blackout, a response to the earthquake and tsunami in 2011. Nissan have opened an EV battery recycling plant, capable of processing 2,250 battery packs a year, in a town devastated by the same event[9].

Poland is set to host Europe's largest Lithium-Ion factory for EVs thanks to a £1.17 billion investment from LG Chem. Production will begin in 2019 and is due to be around 10% the planned capacity of the Tesla Gigafactory.



The Organisation of Petroleum Producing Companies (OPEC) increased their assessment of EV growth by a striking 500% in 2017, up to 266 million EVs by 2040[10]. A strong statement from an organisation based on maintaining the status quo of fossil-fuelled transport.

EVs: A global opportunity

Technology developments in batteries, new models of mobility, and autonomous driving are pushing markets forward at a rate not seen for decades. As the global population rises and urbanisation increases the demand for low emission mobility will be a key feature of the coming decades.

The market opportunity from the shift to EVs is tantalising. EVs currently make up 1.5% of the 100 million vehicles sold globally each year[11].

8 Bloomberg, 2018. The breakneck rise of China's Colossus of electric-car batteries.
9 Reuters, 2018. Nissan spins up new plant to give second life to EV batteries
10 OPEC, 2017. OPEC World oil outlook 2040.
11 Allied Market Research, 2017. Electric Vehicle Market by type and Vehicle – Global Opportunity Analysis and Industry Forecast, 2017-2023.

UK leadership aspirations

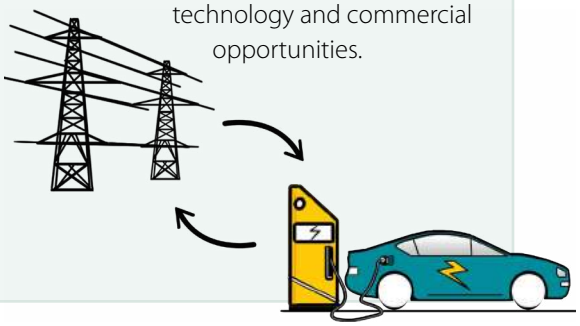
The UK has put leadership of transport revolution at the heart of its Industrial and Clean Growth strategies, stating, "The government will help British businesses and entrepreneurs to seize the opportunities...from electric vehicles to offshore wind."

These commitments are backed up by the Automotive Sector Deal which includes substantial innovation funding including £246m for the Faraday Battery Challenge, "to make the UK a world leader in the design, development and manufacture of batteries for the electrification of vehicles". The government is also acting to stimulate demand pledging, "25% of cars in central government department fleets will be ultra-low emission by 2022".

Turning aspirations into action is, however, proving challenging. The Department for Transport (DfT) has described local authority take up of funding for EV charging infrastructure as "extremely disappointing" and the High Court has agreed with campaigners that the government's Air Quality Plan is failing to protect public health and ruled further action is required.

The new Nissan Leaf, the bestselling EV model in the world, is being built in Sunderland for European markets generating £450 million investment and 2,000 jobs.

£30 million funding has been awarded to 21 Vehicle to Grid (V2G) projects looking to trial the technology and commercial opportunities.



Oxford has plans for the world's first Zero Emission Zone, banning polluting vehicles from central areas in 2020.

> "…our world leading electric car production… [shows] we can cut emissions in a way that supports economic growth."
> Prime Minister, *Theresa May, 2017*

Over 26 network innovation trials have looked at how EVs impact the electricity network including:

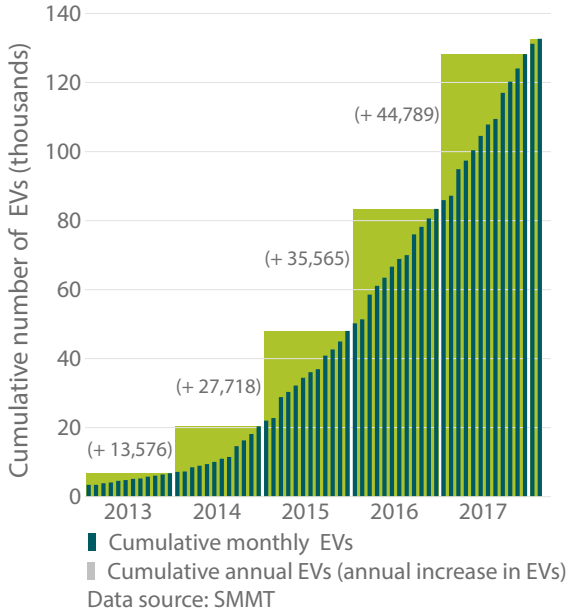
- My Electric Avenue, a £9 million trial looking at the use of a EV charging management at homes as an alternative to conventional network reinforcement
- Electric Nation, a £5.8 million trial with over 700 participants with varying types of EVs.

The first electric black cabs are on London streets. They are made in Coventry and save owners £100 a week in running costs (compared to diesel). Exports to Norway and the Netherlands are confirmed.

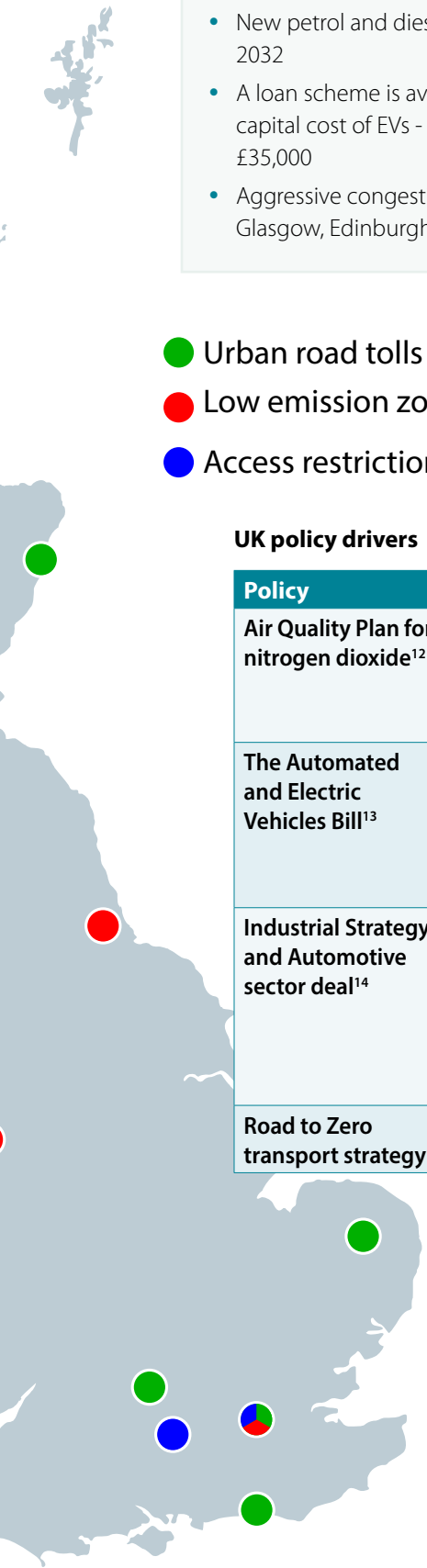
Scottish policy ambition

- New petrol and diesel cars to be phased out by 2032
- A loan scheme is available to cover the higher capital cost of EVs - interest free and up to £35,000
- Aggressive congestion charges are planned for Glasgow, Edinburgh, Aberdeen and Dundee

EV market growth 2013 to 2017



Data source: SMMT



UK policy drivers

Policy	Key points
Air Quality Plan for nitrogen dioxide[12]	• End the sale of all new conventional petrol and diesel cars and vans by 2040 • £255 million implementation fund and a £220 million Clean Air fund for local authorities to use • £89 million Green Bus fund
The Automated and Electric Vehicles Bill[13]	Legislation requiring EV chargepoints to be: • 'Smart' capable • A requirement at large fuel retailers and motorway service areas • Providing more information and data • Use a common access or payment method
Industrial Strategy and Automotive sector deal[14]	• 'Future of mobility' and 'Clean growth' set as two of the four Grand challenges emphasised by the government • £246 million for the Faraday Battery Challenge to help support the manufacture of batteries for EVs • £500 million to be invested over 10 years to industrialise new low-carbon automotive technologies
Road to Zero transport strategy	• Due to be published Spring 2018

EV leadership will take commitment to drive demand as well as innovation

With its successful automotive industry and strong government backing the UK is in an excellent position to play a leading role in development of EVs. However, EV growth in the UK is currently steady rather than spectacular, held back partly by the government's reluctance to commit to measures to tackle air pollution in towns and cities that would drive demand.

In a fiercely competitive global market the government will need to get serious about tackling emissions, continue its investment in EVs and, of course, get a Brexit deal that works for a sector that is integrated across Europe.

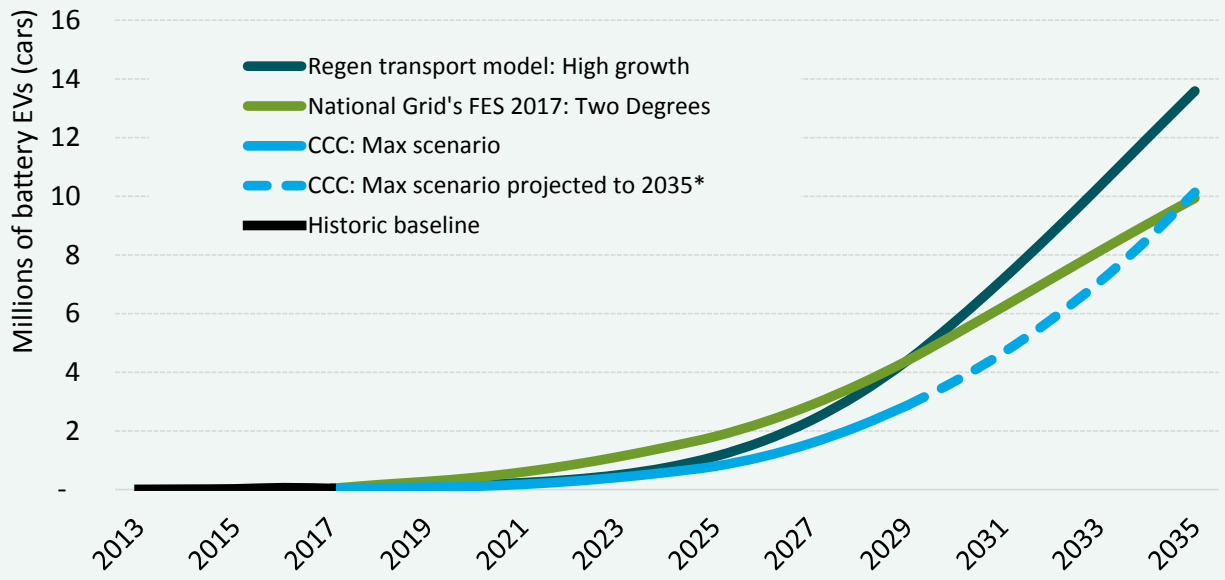
12 UK Government, 2017. Air quality plan for nitrogen dioxide (NO2) in UK.
13 UK Government, 2018. Automated and Electric Vehicles Bill.
14 UK Government, 2018. Automotive Sector Deal.

Growth is certain but the trajectory is less clear

The raft of announcements from government and manufacturers on the phase out of fossil fuel vehicles alongside subsequent investment in EVs, has spurred analysts to new heights of ambition in their projections for the increase of the number of EVs on our roads.

Behind many EV growth scenarios is the fact that transport is now the largest source of UK greenhouse gas emissions and that we need a rapid shift to low emission vehicles to decarbonise our economy.

Regen, Committee on Climate Change (CCC) and National Grid high battery EV scenarios



Regen high growth scenario

Regen has modelled what a high growth EV scenario could look like, based on an assumption that government sticks to the commitments to ban diesel and petrol cars by 2040 and adheres to the targets in the Climate Change Act.

This would see near exponential growth in new EV car sales from the mid-2020s. By 2035, 85% of new car sales would be battery EVs and a further 10% plug-in hybrids. EVs would make up over 40% of the total cars on the road.

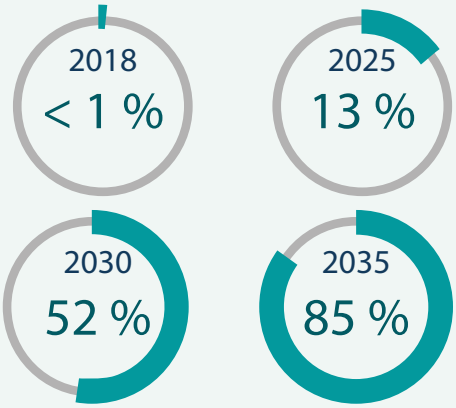
As EV sales grow an increasing proportion will be battery EVs rather than plug-in hybrid EVs.

A key question is when growth will accelerate from the current steady but unspectacular path shown by the latest registration data from the SMMT[15].

Speaking at a Regen event in November 2017, Francisco Carranza Sierra, managing director of energy services at Nissan, identified the tipping point as when consumers no longer had good reasons not to buy an EV.

2 million Number of battery EVs that could be sold in 2035

Percentage of new vehicles that could be battery EVs:



Source: Regen transport model

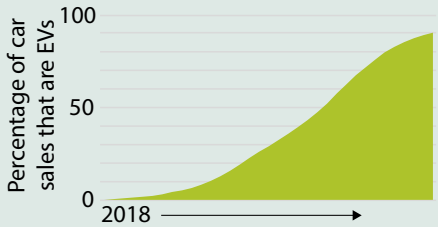
* CCC's High scenario is published to 2030. It has been projected to 2035 here on a pro-rata basis.

15 SMMT, 2018. EV and AFV Registrations.

With any growth projections there is a risk of groupthink. A key conclusion of our industry roundtable was that growth rates of EVs are far from certain. Change in such a core part of our society will be difficult and, at times, painful. A shift to EVs will fundamentally change the whole vehicle supply chain, destroying as well as creating value.

Instead of exponential growth we could hit a tipping point where explosive growth kicks in or, if consumer confidence is damaged, EV growth could stagnate.

Exponential growth

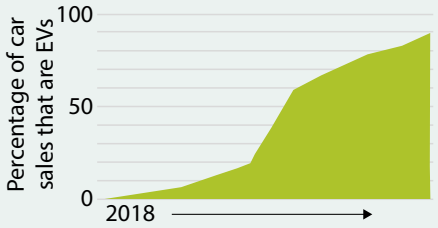


From a slow start exponential growth kicks in around 2020. By 2030 70% of new car sales are EVs.

EVs become the vehicle of choice towards the mid 2020s and dominate the market as the end date for petrol and diesels approaches due to:

- Manufacturers bringing out new models with greater range and efficiency
- Cost falling as manufacturing reaches scale
- Consumer acceptance of EVs driven by concerns over pollution and low running costs
- China continuing to set the international pace in market demand and supply

Explosive growth

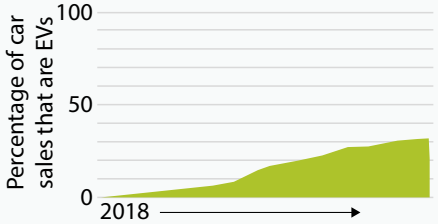


The EV market reaches a tipping point where an overwhelming consumer demand for EVs leads to a rapid and disruptive market expansion.

The EV market explodes as a tipping point is reached in the early 2020s driven by massive increase in consumer demand because of:

- Low running costs and price reductions
- Pollution and environmental concerns e.g. cities penalising petrol/diesels
- New models and marketing driving lifestyle choices
- New technology solving range and degradation issues
- Resale market for diesel/petrol collapsing

Stagnated growth



Initial growth is curtailed as the market fails to develop. EVs remain a relatively small part of the overall car market until the mid 2030s.

Initial growth is curtailed due to:

- Consumers remaining wary – perhaps driven by performance not living up to promise
- Incumbent manufacturers' opposition
- Running cost and price efficiency remain uncompetitive
- Battery degradation and poor second-hand market for EVs
- Support mechanisms are reduced as policy makers do not follow through on climate and pollution commitments

What will drive growth?

Discussion with industry has identified four key factors that will determine what rate of EV growth we see in practice:

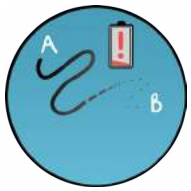
- Consumer views - when will price, attractiveness and range stack up?
- Manufacturers' response – how quickly will new models come out and supply chain constraints be overcome?
- Infrastructure investment – will there be a coherent network of charging facilities?
- A sustainable market – when will consumers have confidence in battery life and the second-hand value of cars?

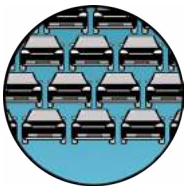
These factors are explored in the next section of the paper.

Consumer choice will drive market growth

To get beyond the 'early adopters', EVs need to provide a better offer to the consumer, be that a household or a business. This point was emphasised at our industry roundtable – "It's not just about the product, but the whole [consumer] package". Like any immature market, mistakes have been made. Early chargepoints were poor quality and not well maintained, leading to issues with reliability and availability. As one of the roundtable participants put it, "It's a mess and all very incoherent". Manufacturers, with government support, are working on addressing key aspects of the consumer offer with the aim of making an EV the obvious and logical choice for a consumer.

The main consumer issues in the EV market and proposed solutions





Range anxiety	Charger anxiety	Cost	Choice
Participants in our industry roundtable were clear that mainstream consumers won't shift to EVs until they can travel over 200 miles on one charge. They also noted that real world driving does not match the publicised range, causing distrust.	As more EVs get on the roads the ability to access quick, simple and reliable public charge points becomes critical. Current problems include diverse and complex payment methods, charge point reliability (13% are out of action), lack of on-street and workplace charging and queues at peak times.	Once EVs are cheaper in terms of total cost of ownership**, many more consumers will make the investment. This tipping point is predicted to occur in the early 2020s[16]. Higher initial capital cost could still remain a barrier making it important the government does not withdraw the plug-in grant too early.	The number of battery EV models is currently limited and is holding back growth. In 2017 only 20 battery EV models were on sale in Europe compared to 417 ICE models[19].
Solutions			
New models are being released in 2018 that deliver over 200 miles of range at an affordable price. A more realistic testing regime for range measurement comes into force in September 2018* for all new models, which should bolster consumer confidence.	The Automated and Electric Vehicles Bill is due to provide government powers to standardise charging infrastructure. Further funding for charging infrastructure is being made available, particularly for on-street solutions.	The cost of the main component of an EV, the battery, is falling as production increases. There was a 24% reduction in cost in 2017[17]. With only one moving part in a battery EV for every 30 in an ICE, maintenance costs are expected to be 60% lower[18].	13 new battery EV models are expected to go on sale in the UK in 2018, with a further 19 the year after[20]. Once consumers have more choice in EV models and types from manufacturers then they are much more likely to switch from ICE to EV.

Overcoming barriers for consumers

The key challenge slowing consumer uptake of EVs remains the higher up-front cost. Lower running costs are not yet balancing out the up-front costs, unless drivers have a high mileage, and there is limited evidence as to the actual whole life savings and resale value. At present, there are good opportunities for businesses to use EVs for fleet applications. Increased competition as more manufacturers enter the market can be expected to drive down costs.

As costs of EVs reduce, range and charging anxiety are likely to become the key barriers. These are both real concerns given the limited range of most current models in real world driving conditions and the plethora of different charging infrastructure. These issues create opportunities for those manufacturers that can address consumer concerns.

* The Worldwide Harmonised Light Vehicle Test Procedure (WLTP) laboratory test is used to measure fuel consumption and CO2 emissions from passenger cars, as well as their pollutant emissions. This replaces the poorly perceived and outdated New European Driving Cycle (NEDC).

** Total Cost of Ownership (TCO) is a measure over a three or five-year period that looks at the expenses on fuel, insurance, maintenance and depreciation.

16 CCC, 2018. Independent assessment of UK's Clean Growth Strategy.

17 Bloomberg, 2017. The Latest Bull Case for electric cars: the cheapest batteries ever.

18 UBS, 2017. UBS Evidence Lab Electric Car Teardown – Disruption Ahead?

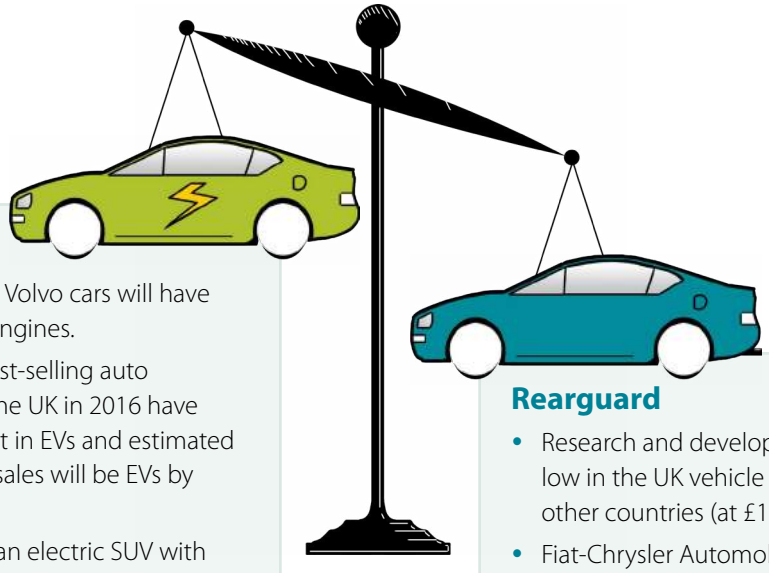
19 T&E, 2017. Slow electric car uptake due to lack of choice, availability and marketing spend – report.

20 The Guardian, 2018. Lack of models, not charging points, 'holding back electric car market.

Manufacturer response – vanguard or rearguard?

The response of traditional ICE vehicle manufacturers to the EV revolution will be key. Leading players have the market presence and political power to limit growth and stop disruptive new entrants. A telling statistic is that over half of global auto-executives believe battery EVs will fail commercially[21], evidence that despite the public announcements, many are not convinced by the EV revolution. It is notable that with existing stock of ICE vehicles to sell, advertising campaigns have not been aimed at EV models.

However, recent evidence that £64 billion is due to be invested globally in EVs by manufacturers[22] suggests that many companies have concluded they are better off as leaders rather than let disruptive new entrants erode their market share.



Vanguard

- From 2019, all new Volvo cars will have electric or hybrid engines.
- Six of the seven best-selling auto manufacturers in the UK in 2016 have announced interest in EVs and estimated 15 to 30% of their sales will be EVs by 2025.
- The Jaguar I-Pace, an electric SUV with up to 300 miles of range, is due to take on the Tesla Model X in 2018. With a recognisable and desirable brand this will have an impact on the market.

Rearguard

- Research and development spending is low in the UK vehicle market compared to other countries (at £1.58 billion in 2015[23]).
- Fiat-Chrysler Automobiles are one of those that are behind the curve. Their CEO said, "…we're not betting the bank on going fully electric in the next decade. It won't happen"[24].

New entrants disrupting the market

dyson

Dyson is investing £2 billion, hiring 300 new engineers, and is looking to use solid-state batteries in three new EV models by 2020.

BYTON

The Chinese start-up formed by executives from Tesla, BMW and Nissan has ambitious plans to release a highly tech-focused and connected SUV in China in 2019 with Europe to follow in 2020.

Will manufacturers rise to the challenge?

The scale of the transformation from ICE to EVs is a huge challenge for manufacturers who will need support to transform their businesses, supply chains and workforces. The Industrial Strategy Automotive Sector Deal sets out the UK's plan for the government and manufacturers to work together to "accelerate the transition to the manufacture of ultra-low and zero emission vehicles".

The manufacturers that can lead this shift have huge opportunities to grow market share and profits. However, if the incumbent players do not respond quickly enough they open the way for new entrants, without the burden of sunk investment in ICE vehicles, to grab market share, as Tesla has already demonstrated.

21 KPMG, 2018. Auto executives, consumers skeptical of the viability of pure electric vehicles: KPMG survey.
22 Reuters, 2018. Global carmakers to invest at least $90 billion in electric vehicles.
23 Allianz, 2018. Euler Hermes Economic Outlook: The Auto World Championship.
24 Autoguide, 2017. FCA: There's Still No Viable Business Model For Electric Cars.

Delivering the right EV charging network

Consumers won't shift to EVs in large numbers until they can trust that charging facilities are available and accessible.

There has been little coordination in the early roll out of charging facilities with different companies competing to establish market leadership. There are 11 major public electric vehicle charging networks within the UK and a further 10 minor networks. The lack of standardisation between these networks creates an obvious barrier to EV adoption with consumers confused by the systems of membership payments, cards and apps.

Chargepoint power types

Chargepoint category	**Standard** 	**Fast** 	**Rapid** 	**Super/Ultra rapid** 
Typical power capacity	3 or 7 kW	22 kW	43/50 kW	120/150 kW +
Charging speed	10 or 5 hours	4.5 hours	30 - 40 mins	15 - 20 mins
Required power supply	Single phase	Three phase	Three phase	Three phase
Current EV charger connector numbers from Zap-Map (March 2018)	10,516	1,832	3,031	

The uneven regional distribution of rapid EV chargers

Number of rapid chargers per billion miles driven in region

Number of rapid chargers by region

Despite the number of charger networks there remains a lack of public rapid chargers in some regions. Resolving this issue would help build consumer confidence.

Effects of growing power demands

It is vital that the right charging facilities are available in the home and at work, alongside publicly available chargepoints.

With EVs featuring larger batteries to increase range, higher power charging will be needed. The early 3 kW home chargers are now being replaced by 7 kW versions as standard.

Public charging facilities are moving to ever higher voltage and power ratings in response to calls for ultra/super rapid charger hubs at strategic locations. A 350 kW (800V DC) charger provides a range of 250 miles in less than 20 minutes. However, the six charge points planned will create a 2.1 MW demand on the electricity network which cannot always be accommodated without expensive reinforcement. One of our industry roundtable participants working internationally expressed the view that, "the UK is the hardest place to install the [charging] infrastructure". This is a key challenge for the UK to overcome.

In the next section we explore in more detail where people will charge and the implications for the electricity network of the increase in demand.

Creating a sustainable EV market

As growth in the EV market accelerates, maintaining and sustaining consumer confidence will be critical. The EV sector cannot afford to repeat Dieselgate or have scandals that damage consumer confidence. Environmental concerns surrounding batteries and limited resources of rare earth materials have started to permeate the public consciousness and need to be addressed.

Consumers will also want to see a healthy second-hand market for EVs. Company cars are a crucial part of that equation. As one participant in our industry roundtable put it, "companies buy cars that a lot of private buyers are unable to and they become used cars very quickly. The choices of company cars are, therefore, influential as it filters down the market". This was recognised by government in the Autumn Budget with the introduction of a beneficial company car tax benefit in kind rate in 2020/21 for certain EVs.

Two other key factors in the second-hand market will be battery degradation and the rate of depreciation compared to ICE cars.

Battery degradation and depreciation

The performance of batteries reduces over time. This means that the use of any battery has a cost per cycle. Warranties associated with EVs provide some guidance on the level of performance degradation that is due to occur. In general warranties cover up to eight years under a defined mileage of 60,000 – 100,000 miles. This is normally combined with a minimum capacity guarantee, so that if the battery capacity falls below 70 – 80% a replacement is offered.

Researchers have proposed better charging profiles that could help reduce the rate of battery degradation. By modifying the pulse of current and voltage during charging and aligning this with defined battery manufacturer limits, they estimate battery life could be extended by 17%[25]. This could be included as one of a package of services for EV owners to take advantage of as new opportunities and business models start to take shape.

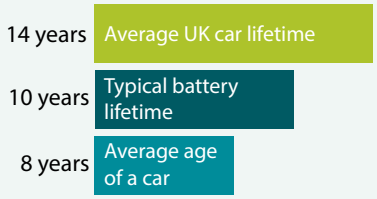
Some EVs have experienced high levels of depreciation[26]. This is thought to be due to:

- The plug-in car grant increasing the gap between the cost of new models and the resale value
- Technology improvements in newer models, particularly relating to range
- Lease models for batteries being used by lower cost battery EVs
- Early EV consumers being motivated by novelty and getting the latest model.

Rates of depreciation of vehicles are well understood by consumers as an important part of purchasing decisions. High depreciation for some of the popular EV models is a problem for confidence in the market that manufacturers need to address.

The second-hand market for EVs

In the UK the average car on the road is eight years old and likely to be scrapped at 14 years. This does not easily align with the lifetime of a battery at 10 years. Manufacturers will need a clear offer to address confidence in battery ownership and performance in second-hand vehicles to address these concerns.



Growth in new EV sales is well publicised but not enough attention has been paid to the second-hand market which could be argued to be more important. There were 8 million second-hand vehicle transactions in the UK in 2017 compared to 2.5 million new cars sold[27].

The second life of EV batteries is a new area of opportunity. Examples of repurposing batteries for domestic energy storage applications at a reduced cost have started to materialise. The Chinese government and European Battery Association have both implied that manufacturers will be responsible for the recovery of batteries. This should allay consumer concerns on EV sustainability and help the second-hand market.

25 UPEC ,2015. A Method of Electric Vehicle Charging to Improve Battery Life.
26 WhatCar, 2018. The 10 fastest depreciating cars of 2018.
27 SMMT, 2018. Vehicle data.

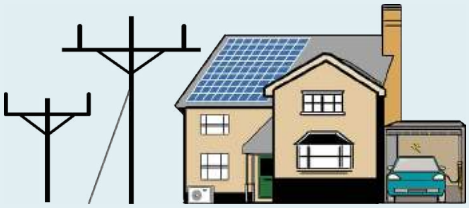
The energy challenge

The anticipated growth of the EV market represents a very significant shift in energy usage from petroleum fuels to electricity. This will have a profound impact in terms of the overall demand for electricity, and the peak demand for power that must be delivered to vehicle charging points throughout the country.

This new energy challenge is multifaceted; from the optimisation of the energy system, ensuring that there is sufficient capacity to meet energy demand and maintain security of supply, to the hundreds of thousands of low voltage substations that must continuously provide power to an individual street, workplace or commercial premise.

Our future energy system must be able to provide secure, low carbon and cost efficient energy. Failure to supply new demand from EVs is not an option. Nor is it acceptable to just throw money at the problem by investing in evermore capacity and infrastructure to meet an unmanaged spike in peak demand.

The Energy Challenge – how big is it?

The Energy Challenge – how big is it?	
Energy system challenge 	Integrating additional EV electricity demand, alongside existing and new demand coming from the electrification of heat and the digital economy, to ensure a secure and balanced energy system. By 2035 EV electricity demand could total between 25 and 28 TWh per year, with a seasonal increase during winter months*. This level of demand represents between 1.9 and 2.2 MWh per year per EV based on current average mileage.
Local energy challenge 	The challenge for the local network is how to support multiple electric vehicle charging at a low voltage substation level which would typically serve 20 to 100 households. A home EV charging station delivering 7 kW would require a similar level of power as an electric shower. The difference is diversity; householders are not expected to shower for several hours, and not all households are expected to shower at the same time.

Energy system security

At face value the additional electricity load requirement at both a national and a local level could be expected to have a significant impact on the network. Indeed, there have been several horror stories in the media about householders not being able to boil a kettle while the EV charging demand spikes up to 30 GW.

Some of these claims have been so outlandish and misguided that National Grid felt the need to issue a very useful myth-buster document. This report highlighted that, although there could be an increase in peak demand, it is likely to be much lower, at around 5 GW by 2040[28], than the worst-case scenarios that have been presented. National Grid has in fact stated that the electricity network could be reinforced to meet a higher growth rate of EVs if the UK government decided to bring forward the petrol and diesel ban to 2030.

Local network management

Although local networks supplying households are typically sized with a degree of spare capacity, the charging issue at a local low voltage level is probably the more pressing.

Ongoing trial studies such as Electric Nation and My Electric Avenue suggest that, without optimisation of charging and smarter charging management, a high proportion of current EV users will tend plug-in and charge in the early evening when they get home from work. If this continued to be the case, then a mass uptake of EVs could lead to a high proportion of low voltage substations (typically those designed to supply diversified demand of 1.5 kW per household) breaching their constraint levels.

The trials highlight that some form of smarter vehicle charging and other mitigation strategies will be needed to avoid unnecessary network reinforcement.

* National Grid Future Energy Scenarios 2017 Gone Green scenario projects electricity demand at 25 TWh in 2035 from 9.9 million EVs and 3 million hybrids. Regen's exponential growth scenario projects demand at 28 TWh with 13 million EVs with a winter weighting, due to lower mileage efficiencies despite more miles being driven in the summer time.

28 National Grid, 2017. EV Myth Buster.

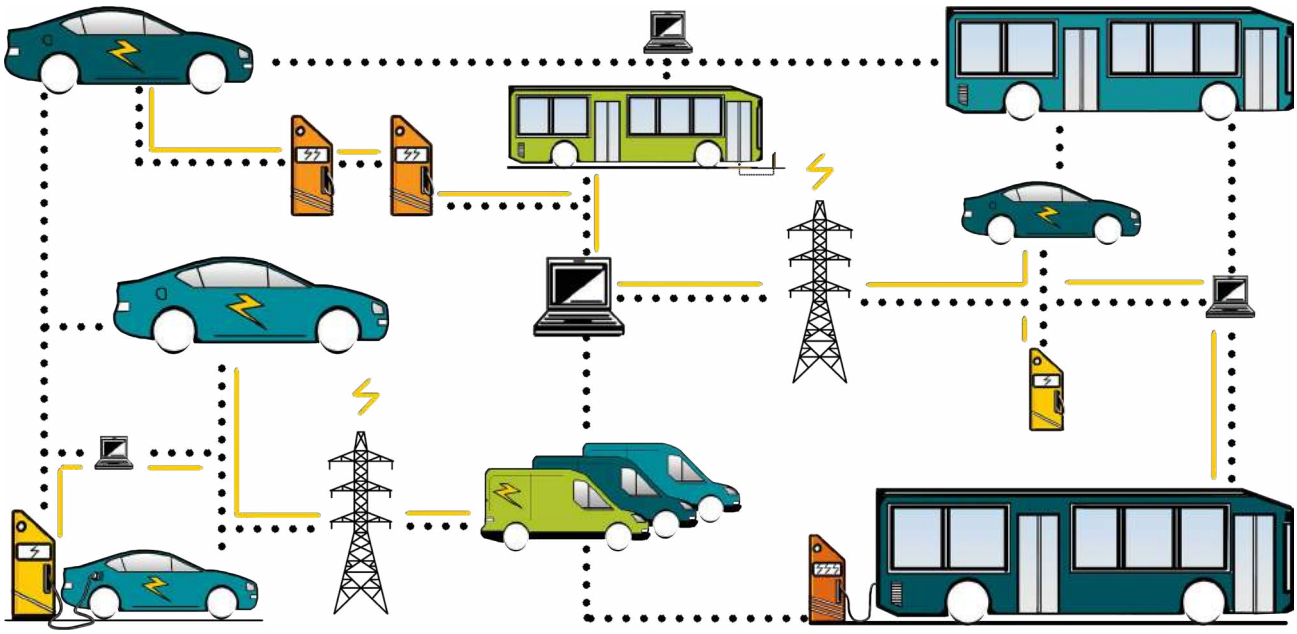
Strategies to mitigate potential grid impacts

Innovation will be needed as part of a rethink in the way energy supply is managed will be needed. Fortunately, there are mitigation strategies that can be adopted and which, in combination, will help to address energy network issues and create new opportunities for economic value.

Meeting the energy challenge - mitigation strategies

Maintaining demand diversification	It is critical for the low voltage network to maintain diversification of demand both in terms of time of charging and also geographic location. This also means avoiding strategies that might cluster or concentrate demand.
Peak demand shift	Peak electricity demand has been falling* - this trend should continue by encouraging EV charging, and other demand sources, to shift from peak time periods.
Smart charging and price optimisation	Smart chargers linked to dynamic price tariffs could play a significant role to push EV charging towards periods of lowest energy cost, benefiting the consumer and also reducing network imbalance.
Local supply and balancing	Local supply options[29], to sell electricity locally via peer-to-peer, private wire, energy clubs and other solutions can alleviate network flows if more demand can be nudged towards times of local energy generation.
Managed charging (or intervention)	There will be a role for managed charging, or intervention by network operators or their agents, to reduce or stagger charging profiles during extreme imbalance periods in a way which is all but invisible to the end user.
Smart chargers and standards	As a starting point to enable many other strategies the mandatory deployment of smart chargers and implementation of standards will be critical.
Targeted grid and network reinforcement	The UK needs to invest in its electricity infrastructure, not just to support EVs, but also to support the electrification of heat and a host of other new sources of electricity demand that will come with the digital economy. Policy makers should not shy away from the need to invest and harness the opportunities that this will bring.

Smarter integration of transport and energy systems will be critical



* Winter GB peak demand, as measured during Triad periods has fallen from an average of 57 GW in 2010/11 to just under 50 GW in 2016/17 – more than the expected increase from EVs.

29 For more details see Regen, 2017. Local Supply options 3rd edition.

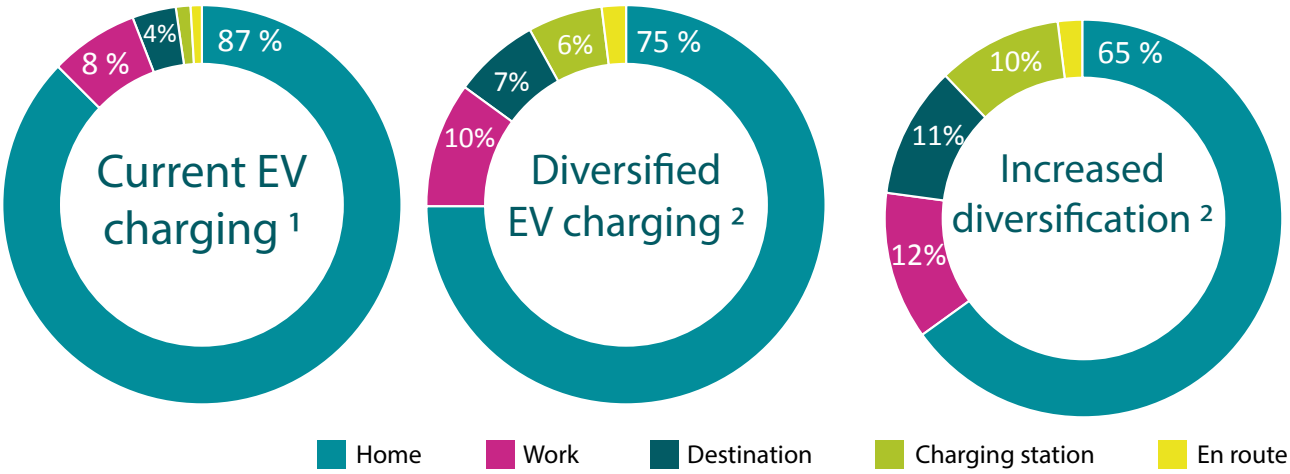
Understanding when and where people will charge vehicles is key

There is no point in working against the trends of people's behaviour, mitigation strategies need to work with and incentivise behaviour to encourage smarter, better outcomes. To achieve this, it will become increasingly important to understand and anticipate future charging patterns.

Current charging data and evidence from trials suggests that; the great majority of charging currently takes place at home, the majority of EVs are not charged on a daily basis and that many users charge their vehicles at the most convenient time without much regard to electricity price or demand. The trials also found typically low daily vehicle mileage and trip distances. To an extent this is hardly surprising since, even the larger trials that have involved several hundred vehicles will have been skewed because of the typically low vehicle range, high proportion of hybrid vehicles, limitations of the current charging network and higher proportion of second cars amongst early EV adopters.

There is also variation between the trials. At 87% the Electric Nation trial[30] has a higher percentage of home charging (since participants had to have a smart home charger), while the Low Carbon London trial in an urban setting has a slightly higher incidence of charging at destination and charging stations[31].

A graphical representation of illustrative charging patterns for different locations



¹ Based on Electric Nation trial data 2018
² Regen transport model - illustrative

Regen anticipates that home-based charging will continue to be the primary charge option for car owners with off-street parking, offering ease of use as well as access to competitive electricity tariffs, but that the proportion of at home charging will reduce as vehicle ranges increase, rapid and fast charging becomes more widely available at destinations, roadside and at work.

More diverse charging options will also become important as the EV market extends to the 30 to 40%* of households without off-street parking. Based on discussions with charging providers it is also anticipated that more competition, and price deals at destination locations, will encourage more diverse charging behaviour.

30 Western Power Distribution, 2018. Electric Nation Customer Research and Trial Update.

31 UK Power Networks, 2015. Low Carbon London Innovation project.

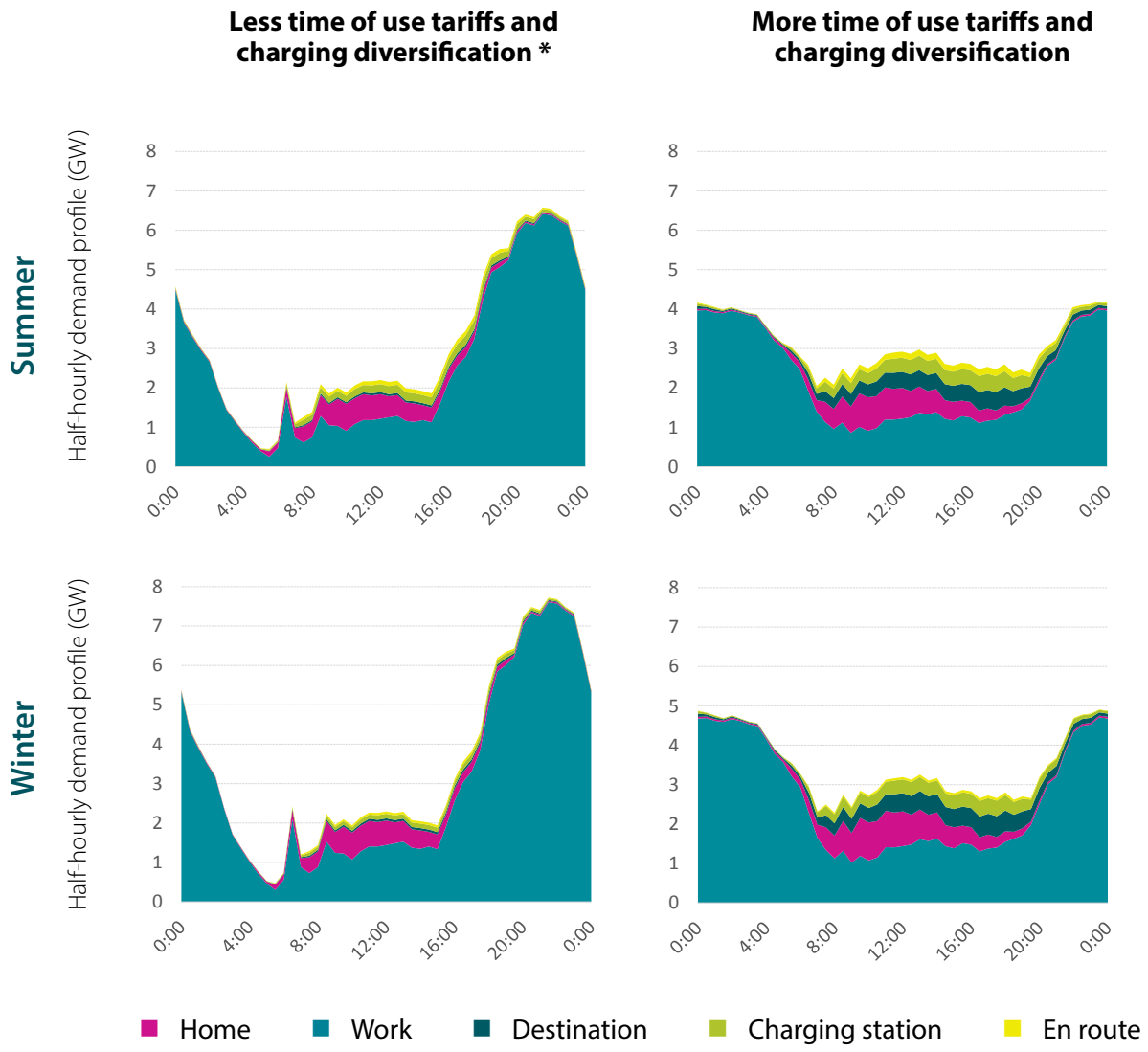
* Government statistics suggest 30% of households in England do not have off-street parking although this statistic is hard to verify and varies depending on the definition used.

Peak demand reduction and diversity will help

A more diverse portfolio of charging options and especially the use of workplace and destination charging will help to spread demand load both geographically and over time. The introduction of time of use tariffs, which offer lower energy costs during off-peak periods, enabled by half-hourly metering will also help to shift EV (and other electricity demand) away from demand peaks.

More diverse charging and time of use tariffs are expected to have a significant impact on EV charging. Regen's modelling illustrates the combined impact of these measures which could reduce peak EV demand by circa 30% from 6.6 to 4.2 GW (summertime) and 7.7 to 4.9 GW (wintertime).

Illustrative seasonal charging demand profiles with varying time of use tariffs to shift peak demand and greater levels of charging diversity



Source: Regen transport model - illustrative

* Source of less time of use tariff's profiile: National Grid

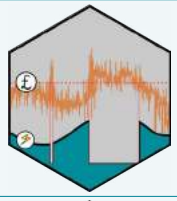
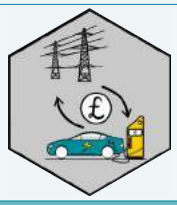
Smarter solutions – enabled by automation and new energy/mobility service platforms

In a future low carbon energy system with higher levels of renewable energy generation from variable sources, demand flexibility and responsiveness will be of increasing value. Price volatility in the wholesale market (and even more volatility in the spot price or system balancing market) will create greater opportunities for price arbitrage. Dynamic price tariffs will enable EV owners to take advantage of very low, or even negative prices, which typically occur overnight.

The net result of this type of dynamic energy model would be to further shift EV charging towards periods of higher generation and lower electricity demand, thereby increasing the value of renewable energy and system balancing.

Will consumers accept and embrace such a change? This is a key question to which the answer, based on anecdotal discussions with EV owners, is generally positive provided that the process to access these value streams is entirely seamless to the consumer. Automation is therefore critical. Smart chargers, linked to control systems and price signals must operate invisibly and efficiently, without impacting on charging outcomes.

Types of chargepoint management

Peak demand shift		
	**Time of Use Tariff**	Influences charging behaviour, shifting demand from set peak times, but price signals are not dynamic and charge choice is otherwise unconstrained.
Dynamic smart tariff and value optimisation		
	**Smart charger managed with "smart price" signals**	Dynamic tariff that interfaces with smart charger to optimise charge profile based on energy cost and car owner preferences (with owner override).
	**Optimised "smart price" and other enhanced value signals**	Optimised charging based on price and other enhanced value signals opening the potential for integration with renewable energy generation, solar PV and/or a third-party mobility/energy service providers.
	**Third party aggregation and mobility/energy service providers**	Harness additional value streams such as V2G, price arbitrage, balancing and flexibility services. Potentially also responding to local grid constraint and local supply markets.
Network managed using local flexibility services and intervention		
	**Network managed with intervention**	Potentially combined with above. Network operators (or their agents) have the ability to: • Procure or create a market for local flexibility services • Manage or cycle (ration) charging to mitigate local constraints or national stress event.

Managing the network and demand intervention

Even with smarter solutions and greater demand flexibility, as the population of EVs increases there will be instances when demand will need to be managed. Most electricity distribution networks were designed many years ago, to cope with diverse demand patterns that are very different to what we will see in the future. Those networks with least spare capacity (typically sized based on an average or diversified domestic power demand of 1.5 kW) will be most vulnerable especially if there are local hotspots or clustering of chargepoints.

Unintentional local network issues could also arise if price signals and other smart energy solutions had the effect of reducing demand diversity or causing instant "ramping" of power demand in specific areas. For example, if multiple vehicles in the same location and using the same optimisation logic, began to charge at the same time in response to a price or local generation signal.

To address these issues local network management strategies are currently being developed in three key areas:

- **Targeted network investment**
- **Charging management, using flexibility services and intervention**
- **Charging standards, connection controls and access to data.**

Targeted network investment

A degree of network reinforcement is inevitable, not just to support the growing EV sector but also to support other sources of demand growth such as the electrification of heat and new digital applications in the home, in cities and at work. It is noteworthy that Norway's EV expansion has been built on a network with more local capacity and householders typically on three-phase connections.

It is important that policy makers and network operators have the data needed to forecast demand and make an informed investment appraisal as well as to consider alternative solutions to traditional reinforcement.

The question of who pays for network reinforcement will, of course, be challenging. Given that the UK government wants electric vehicles to become ubiquitous, has mandated a shift from diesel and petrol, and has a wider digital economy goal it would make sense for a high degree of cost socialisation.

This could be combined with an approach that new developments and higher capacity charging (commercial or domestic) make a contribution.

> As we continue to transition from a distribution network operator to a distribution system operator, understanding and managing the impact of electrical vehicles and other low carbon technologies is an increasingly important aspect of how we operate our two electricity distribution networks in central southern England and the north of Scotland.
>
> While the speed and scale of the transition to electric vehicles remains unclear, it is our job to ensure this transition is as smooth as it can be, avoiding disruption to customers and any unnecessary increase in costs.
>
> Richard Hartshorn, *electric vehicle readiness manager, Scottish and Southern Electricity Networks*

Charging management using flexibility services and intervention

An alternative to network investment is for network operators to directly manage network constraints either:

- procuring (or creating a market for) local flexibility services or
- making a direct intervention to manage charging profiles.

Flexibility services

The first of these approaches is already in progress as network operators transition to become Distribution System Operators (DSOs). DSOs will have the ability to procure flexibility services from demand and generation customers and to manage those services in order to alleviate network constraints and defer investment[32]. This could allow charger operators, energy supply companies or community groups to contract to sell flexibility services to DSOs.

Managed charging

Network operators have also asked for the ability to intervene to manage charging profiles at certain times in constraint areas. Three trials currently under way have explored both the extent of the problem and potential mitigation which would involve use of smart meter technology to stagger or cycle EV charging to reduce peak demand below constraint levels.

Managed charging intervention, does raise questions around data, commercial models and controls. EV owners however do recognise the logic. A survey of EV owners in the Electric Nation trial found that 56% of respondents were "not at all concerned" about having their vehicle charging managed while 26% were "slightly concerned"[33].

The key success factor will be how managing charging works in practice and the degree to which it is invisible to the end customer.

Managed charging among neighbours on a street showing different levels of constraint

Case Study

Managed charging trials

My Electric Avenue 2012 – 2015
Lead: Scottish and Southern Electricity Networks

Over 200 participants used a Nissan Leaf EV over an 18-month trial period. Findings indicated that 32% of Low Voltage (LV) feeders across the UK would require some form of intervention once over 40% of customers have EVs. New demand management technology, and using managed charging could reduce the cost of managing this extra demand by around £2.2 billion up to 2050.

Electric Nation 2016-2019
Lead: Western Power Distribution

This larger trial of 700 participants builds on the findings of My Electric Avenue and is investigating the impact of EVs on LV networks and the best solution to the issues created, including; demand management, V2G and network reinforcement. The specification, policies and commercial arrangements for such technologies will be trialled. Early analysis shows that managed charging would only be needed on some early evening (4-7pm) winter days and that most consumers are not worried about managed charging.

Smart EV 2016-2018
Scottish and Southern Electricity Networks

This trial aims to create an engineering specification and an evidence base on customer views for managed charging deployment. SSEN is consulting on an interim solution that installs devices at the substation and each chargepoint to protect networks from overload, and a longer-term solution using smart metering infrastructure.

Initial modelling has shown that on one type of network with 50% EV uptake an instance of managed charging would only last 20 minutes, which could also allow 20% more EV uptake without reinforcement. The consultation also proposes the governance around elements of use, such as the maximum amount of charge management in 24 hours or per 30 day period.

32 As an example of this type of service provision see; SSEN's (2017) Constraint Managed Zones in Yeovil and Standlake, UK Power Network's (2017) Expression of Interest for flexible capacity for locations in the south east, and Western Power Distribution's (2017) Flexible Power Trial as part of project ENTIRE.

33 Western Power Distribution, 2017. Electric Nation Customer Research and Trial Update.

Charging standards, connection controls and access to data

The growth of the EV market is focusing the minds of regulators, policy makers and energy companies on how to integrate a new source of energy demand within the energy network.

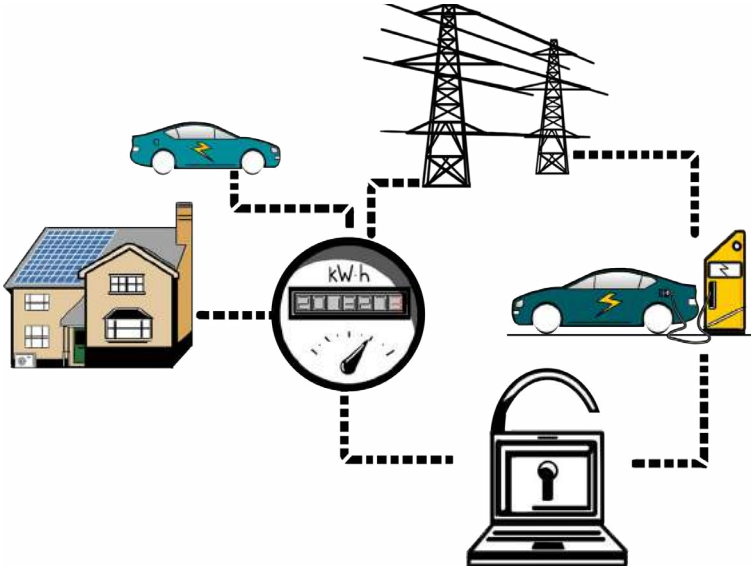
Most, if not all of the strategies discussed above envisage a world where smart technology works effectively, new digital platforms are created and high quality data is readily available.

To make this happen additional standards and controls will be needed. The Automated and Electric Vehicle Bill[34] includes provisions that will require that:

- all new chargers should be "smart" in the sense of being able to transmit and receive data and respond to external signals.
- chargepoint operators provide publicly available data on the location and live availability of chargers and to provide consistent data to National Grid, DNOs and others, to help manage the electricity network.

Other proposals include a modification[35] to the Smart Energy Code that allows network operators to issue commands to EV smart chargers using smart meter communication infrastructure which would then pave the way to allow the management of charging at certain peaks of demand, depending on the LV feeder and circuit characteristics.

Access to energy flow data, not just from EVs but from the totality of network demand and generation, will also be critical. Historically data from household demand and the low voltage network has been sparse. The roll-out of smart meters will improve visibility but there is also a need to access data at the low voltage substation level, hence projects such as Open LV[36] are trialling new forms of remote data access and software platforms to support new applications.



Unlocking access to data both from the charger network and the low voltage electricity network will be essential to enable effective network management.

Solving the energy challenge

Regen's analysis, informed by the discussion and engagement we have had with our member organisations and stakeholders, is that there is nothing in the energy challenge that is impossible to solve. Investment and innovation will be needed to provide new technology, smarter systems, access to data and new business models. This investment will create new opportunities for individuals, communities and businesses to harness. These opportunities are discussed in more detail in the next section of this report.

34 UK Government, 2018. Automated and Electric Vehicles Bill.

35 Scottish and Southern Electricity Networks, 2018. SECMP 0046: Allow DNOs to control Electric Vehicle chargers connected to Smart Meter infrastructure.

36 Western Power Distribution, 2018. Open LV. Regen is a partner in the Open LV project along with Western Power Distribution, EA Technology, CSE, Lucy Electric and Nortech to develop software platforms and ICT to improve access to local electricity data.

Harnessing the opportunity

EVs are a disruptive technology that can enable a much cleaner transport system and open new ownership models to consumers - they could also be the key to a decentralised, decarbonised and more democratic energy system.

By using the flexibility inherent in a fleet of millions of batteries we can reduce energy costs; optimise the use of renewables; and enable communities to generate, supply and balance energy locally.

We can't know what a clean and smart transport and energy system will look like in the decades ahead, but we can start to see some of the opportunities emerging.

Fleet vehicles as a forerunner

Participants in our industry roundtable were clear that with the right support, fleets could play the leading role in the shift away from ICE vehicles. Fleet vehicles make up over half of new sales in the UK and an estimated 22% of fleets already include EVs[37]. Fleet operators benefit from established usage networks and the ability to plan upgrades and usage on a strategic basis, opening up new commercial and financial models.

Go Low Ultra estimates a fleet of 10 EV cars could cost £14,000 lower annually than ICE vehicles[38] on a whole life basis, due to lower fuel costs and a reduction of up to 50% in maintenance costs. The benefits of EVs are particularly attractive for fleet vehicles involved in short range urban driving trips. Those with a need for longer range and larger loads may look at CNG or other alternatives.

Alongside reduced costs the benefits of EVs for fleet operators include:

- Reduced carbon emissions and air pollution as part of corporate social responsibility.
- Chargepoints that enable workplace charging for employees. From April 2018 this benefit is tax exempt.
- For organisations with onsite renewable energy charging EVs can increase the value of the power generated.
- Potential to provide V2G services in the future to generate further revenues.
- Retail sector organisations can use chargepoints as an attraction for customers.

Maximising the opportunity for fleets to lead the shift to EVs will, however, need support.

Government leadership: the UK's Industrial Strategy commitment that, "25% of cars in central Government department fleets will be ultralow emission by 2022". This ambition could be increased.

Network connections and load management: getting a suitable connection to the electricity network that can meet the demands for fleet charging has already become a barrier in some instances.

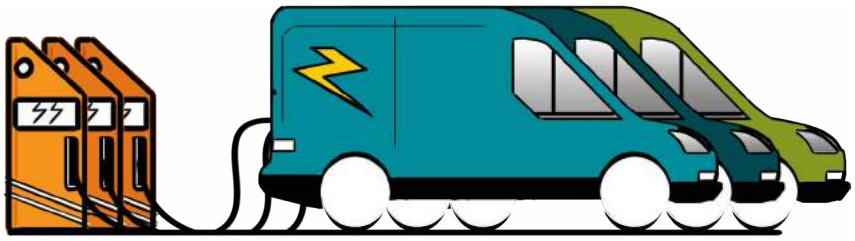
Fleet owners potentially can use load management as a solution and have opportunities to generate value from providing energy services. These solutions can, however, be complex. There are opportunities for partnerships between experts in the energy sector and fleet operators to roll out charging infrastructure and energy projects.

> "We are seeing the older models of fleet financing being challenged by offerings from energy market players seeking to leverage the greater reliability of new vehicle technology as well as the capital investment and know how required to support network reinforcement."
>
> Edward Barratt, *legal director, Burges Salmon*

Case Study

Trialling fleet V2G

The e4Future trial is testing the technical viability and commercial value of V2G for companies that run a fleet of electric vehicles. Partners include Imperial College, Nissan and National Grid.



37 Hitachi, 2017. Future of Fuel report.
38 Go Ultra Low, 2018. Electric car whole life costs.

Optimising value from renewable energy

A fleet of millions of batteries is a natural fit with a high level of renewable generation in our energy system, potentially providing a range of services. With the right cost signals new operating models that realise this value will become viable.

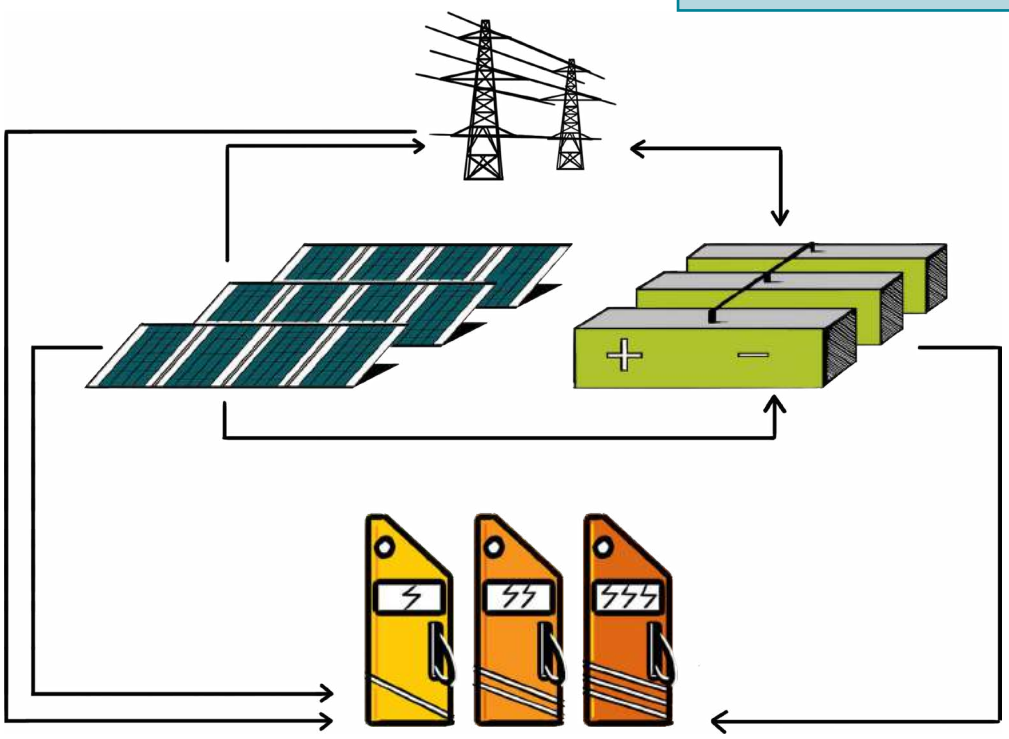
- **System balancing:** solar PV and wind provide more power than we need at times, as can already be seen from negative prices on electricity wholesale markets. Using dynamic tariffs linked to smart chargers EV owners could be incentivised to 'soak up' excess generation.
- **V2G:** the energy stored in batteries could be returned for consumer use or to the grid at times of high demand and low generation (explored in the V2G section of the paper).
- **Island solutions:** islands and remote areas can face particularly expensive network reinforcements. These locations are likely to be some of the first where EVs are used for balancing the network.
- **Constraint management:** at a local level, constraints on the electricity network could be addressed by EV batteries soaking up excess generation or meeting high demand.
- **Commercial and Industrial:** organisations with onsite solar PV or wind turbines could get better value from their asset by charging fleet and employee EVs and potentially providing energy services back to the network.
- **Domestic:** the 850,000 UK households with solar PV can charge an EV from their own power. Our modelling suggests households whose cars are at home during the day could save around £100 per year by using their solar PV to charge their EV.
- **Local supply and peer-to-peer:** as new direct and local supply models start to emerge EVs can support local balancing to improve those models (explored in the local supply section of the paper).
- **Co-location of car parking and charging:** Carparks could use onsite renewable energy to power chargepoints. This model could be expanded using the many solar farms near major roads to provide power direct to charging facilities.

Case Study

Solar carparks

Devon County Council is exploring investing in solar PV on car parks and using that power to charge EVs, providing a better revenue for solar PV installations and improving charging facilities.

Co-location of renewable energy, energy storage and chargepoint infrastructure linked to the electricity network.



Vehicle to Grid

The potential value from millions of batteries that can be drawn on at times of electricity system stress has received enough interest to warrant its own acronym, V2G.

DfT is providing £30 million of public funding for 21 V2G trial projects. In March 2018 Nissan unveiled a strategic partnership with energy giant E.On to develop V2G charging capabilities across Europe

Possible V2G value streams include:

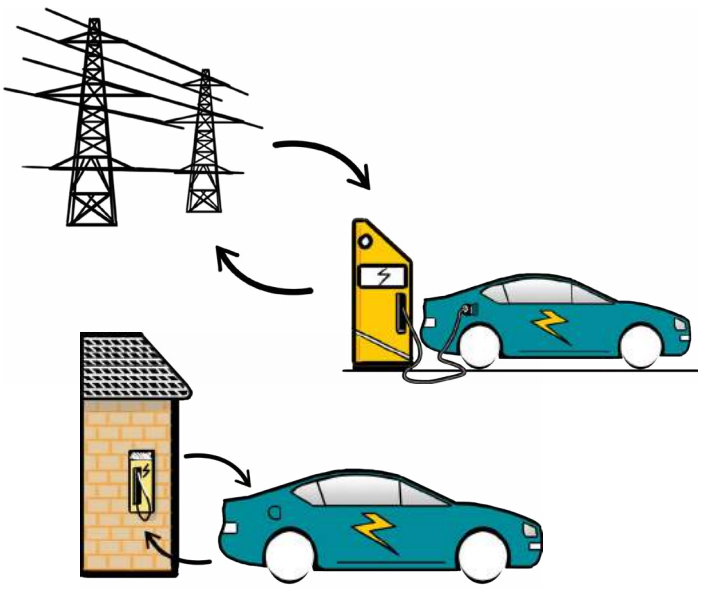
- Price arbitrage – especially during very high price periods
- Demand side response to system stress events
- Local constraint avoidance – responding to DSO calls to address demand peaks
- Frequency response services – these are proving very competitive
- Vehicle to Consumer (V2Consumer) – using the storage in their cars to power household demand at high price periods.

However, having paid retail price for the power in your car battery the business model for putting it back onto the grid is challenging. More work is needed on the value V2G can provide, including:

- How EV charging patterns will fit with demand for V2G services. EV owners may be happy to provide V2G services overnight, but less keen when it would be useful at peak time periods
- Better understanding of the impact on battery life of providing V2G services.

V2Consumer, avoiding high peak retail costs may be a more obvious source of value.

The two main models of using EVs to provide services - V2G (below) and V2Consumer (bottom).



Regen analysis suggests that a targeted approach may be a good starting point for V2G:

- **Fleet chargers** – chargers where fleet cars/vans/LGVs are parked up from late afternoon would fit well with peak time V2G services. Larger fleets could also provide flexibility services to transmission and distribution system operators.
- **Workplace chargers** – cars are connected during the day and, as part of an employee incentive, could be signed up to provide flexibility services.
- **Long stay parking** – locations such as airports and ports where vehicles are parked on a long stay basis, and their pick-up time and date is known, could also provide flexibility services.

Possible future

Having proven the model at specific locations, V2G could become an important part of the overall flexibility and energy balancing service market as EVs become more widespread.

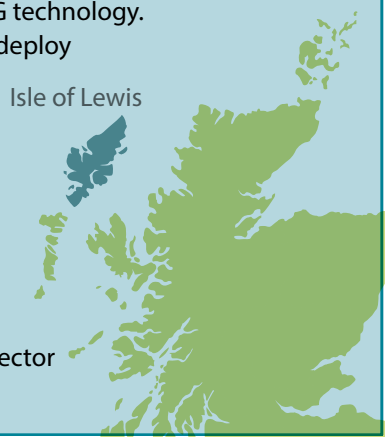
Case Study

Western Isle V2G trial

The Isle of Lewis in the Outer Hebrides experiences many problems with its electricity network that are typical of such remote areas. The electricity connection to the mainland is at peak capacity, meaning further development of the island's prolific renewable energy resources is difficult. Furthermore, the existing wind farms on the island are constrained and back-up diesel generators are required when there are outages which affect the connection to the mainland.

Regen is a partner, with Cenex and E-Car, on an innovative study led by Zero Carbon Marine, co-funded by OLEV and BEIS in partnership with Innovate UK, that will use the Isle of Lewis as a living laboratory. The study will assess the potential for the Isle of Lewis to decarbonise its power and transport markets through the use of V2G technology.

The ultimate aim is to deploy V2G technology to make the island's electricity infrastructure more robust and self-sufficient and maximise the export of zero carbon power through the interconnector to the mainland.



New ownership models

Many argue that changing ownership models rather than the power source will be the real transport revolution. Private cars are idle 90% of the time. Simple fixed subscription Mobility as a Service (MaaS) models that maximise the utility of vehicles, rather than leaving them parked, are becoming more common. Looking further ahead autonomous vehicles could accelerate the trend to MaaS models.

The development of the EV looks set to go hand in hand with new ownership models. The low running costs and zero tailpipe emissions are key for the development of future consumer offers.

New ownership models could reduce congestion if they increase the marginal cost of car usage and therefore incentivise consumers to consider alternative options. However, as we have seen with the growth of home delivery and shopping platforms, new ownership models could increase congestion if they encourage more urban journeys or inefficient vehicle use.

It is important that policy makers and planners do not overlook the role of mass transport which remains the option which produces the lowest congestion and pollution. Enabling smart, clean Transport as a Service, is likely to be at least as important as MaaS.

Supporting local supply models

With households, business and communities across the UK generating their own power locally a natural next step is to sell that power to others through peer-to-peer trading or as part of a local community energy scheme.

Regen's paper on 'Local supply: options for selling your energy locally'[39], explores how local energy schemes could better balance supply and demand for power at a local level, trading with electricity market for the imbalance and providing flexibility services to the local network. Examples include:

- Local energy clubs
- Local generation tariffs
- Peer-to-peer trading
- Microgrids and private wire.

Bringing EVs into local energy schemes will provide a source of flexibility that could help improve the business model.

Virtual communities are also emerging - the sonnenCharger scheme in Germany enables a residential customer that does not have enough energy stored in their battery from their own solar-plus-storage system to charge their car, to dip into the sonnenCommunity pool and draw excess power generated and stored by their neighbours.

Case Study

Autonomous Chevy Bolt

In the US, General Motors has asked federal government to allow the production of its Chevy Bolt battery EV without a steering wheel or pedals for 2019. Possibly making it the first mass market, affordable, and autonomous EV.

Case Study

Share & Charge

Share & Charge is a blockchain* based peer-to-peer service that allows EV users with chargepoints to exchange value. The chargepoint owner sets a tariff for other EV users who use that charge point. Users of this network have a wallet which they can 'cash out' or use to charge their vehicle at other locations.

With over 1,200 registered chargepoints in Germany and a Californian launch in late 2017, this type of peer-to-peer network is looking to grow rapidly into new markets.

Source: Share&Charge

39 Regen, 2017. Local Supply: Options for selling your energy locally (3rd edition)

* Blockchain is a digitised, decentralised, public ledger of transactions that can be applied to energy and other transactions.

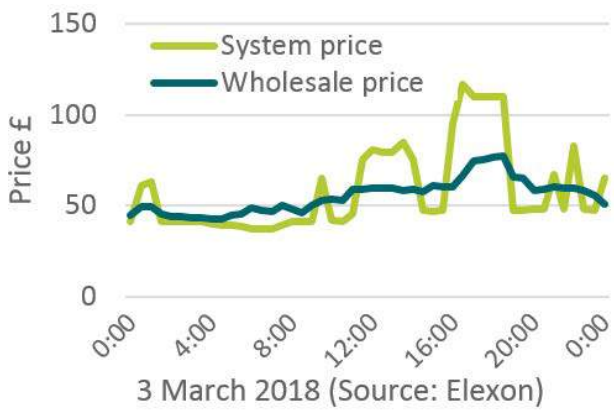
Maximising consumer value

Regen's modelling indicates that consumers with an EV will increase their electricity use by at least 2,000 kWh a year, of which more than three quarters could be charged at home, leading to a 40 to 50% increase on the 3,800 kWh annual demand of an average GB household. However, an EV provides consumers with the opportunity to be flexible in when they use this electricity, opening potential new sources of value.

We are already seeing electricity suppliers responding by offering new services to EV owners. Ovo Energy, Ecotricity and Good Energy all have specific EV tariffs. Octopus Energy offers a dynamic tariff that reflects the volatile wholesale price of electricity (below), including paying consumers to use energy if the price goes below zero – an obvious opportunity for EV owners.

Key to consumers accessing value from these tariffs will be automated control systems that charge at cheap periods (and possibly discharge at high price periods). The Regen managed Sunshine Tariff innovation trial[40], found that automation is crucial to enable consumers to achieve a significant shift in electricity use away from peak time. EVs could be the factor that incentivises consumers to install smart automation controls that can then maximise the opportunities of dynamic tariffs.

A day in the life of the electricity price



Dynamic tariffs linked to smart chargers could enable consumers to take advantage of energy price volatility.

Smart cities and public transport

EVs are only one form of mobility service and smart cities will need to integrate them with public transport, cycling and walking to provide clean and effective urban transport services.

Public transport operators will retain a major role in providing a transport service which addresses the constraints on modern urban road use. New technology could enable compelling mass transport products which can compete with MaaS models from a cost perspective and promote a virtuous circle of lower pollution and reducing congestion.

Smart cities can plan charging infrastructure locations to encourage better transport integration – for example providing charging at park and ride facilities and at train stations. The £400 million Charging Investment Infrastructure Fund is an opportunity to support this integrated approach.

Case Study

Nottingham, UK

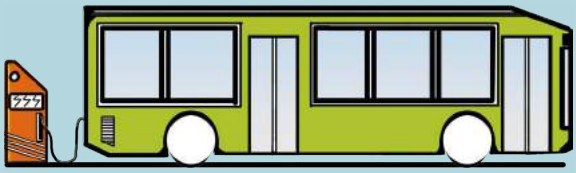
Nottingham has an all-electric Park and Ride service and has operated electric buses since 2012, travelling over a million miles to date[41].

Electric buses could provide an opportunity for smart demand management and V2G balancing.

Case Study

Shenzhen, China

The megacity of 12 million people, north of Hong Kong, has completely electrified its 16,000 buses and installed 510 charging stations to service them. Home of the Chinese company, BYD, which manufacturers EVs, Shenzhen leads the word in electric bus adoption.



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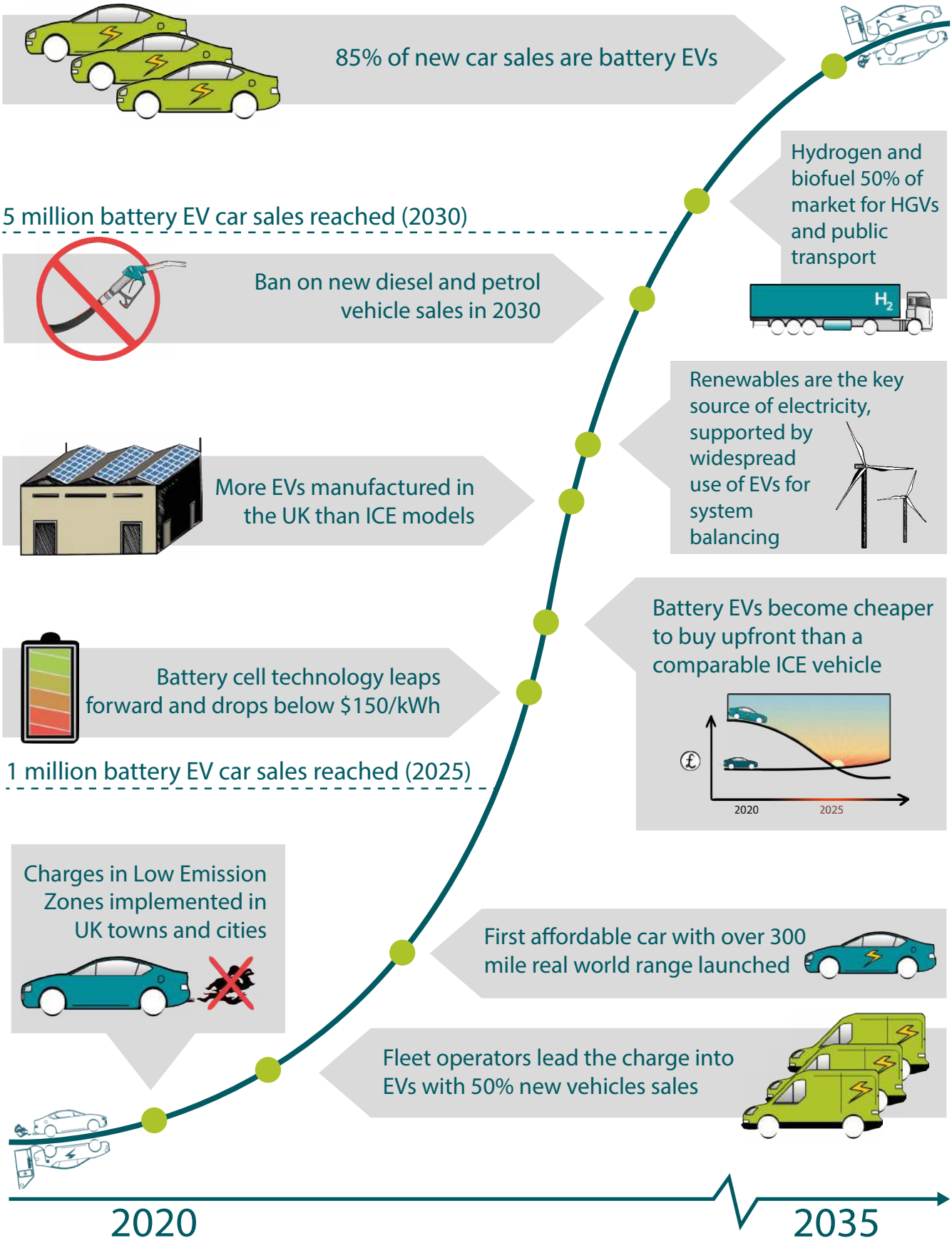
41 Go Ultra Low, 2017. New electric buses power Nottingham's clean air ambitions.

Journey to a clean and smart transport system - how the revolution could unfold



Policy priorities for a smart transport system

The government's Road to Zero policy, due shortly, is a critical opportunity for the UK to build on its strong position in the global EV market. Our analysis and interaction with the sector, through our industry roundtable and interviews, has identified thirteen policy recommendations:

Drive change

1) **Ban on new petrol and diesel vehicle sales from 2030, rather than 2040.** With Volvo already committed to no more petrol or diesel cars from 2019, government could send a much stronger signal to business and consumers.
2) **Support low emission zones with charges in city centres.** Government should back local authorities to deliver comprehensive local air quality plans – including emissions charges.
3) **Deliver on automotive sector deal.** Channel innovation funding and support for skills development to transition manufacturing to low emission vehicles.
4) **Maintain consumer plug-in grant support beyond 2020.** Focus on affordable higher range battery EVs by amending grant criteria.

Enable smart integration of EVs and electricity system

5) **Make smart charging mandatory.** Powers in the Automated and Electric Vehicles Bill should be implemented promptly to require smart charging infrastructure.
6) **Speed up roll out of smart meters, half hourly metering and time of use tariffs.** Smart technology can reduce the burden of EVs on the electricity system.
7) **Remove barriers for the co-location of renewable generation with EV chargepoints.** Local supply of electricity from renewable generation to EV chargepoints should be exempt from requiring a supply licence.

Incentivise fleets

8) **Accelerate the changes to company car tax benefits for EVs.** Changes have been announced but do not occur until 2020. Accelerating these changes will benefit EV car sales and the second-hand market.
9) **Shift 100% of central government's and local authority fleets to EVs by 2022.** The fleet sector could lead the take up of EVs if the government takes a lead.

Develop charging infrastructure

10) **Implement a planning requirement for EV charging infrastructure in new developments.** Building regulations should require chargepoint facilities in new developments – retrofit will be costly.
11) **Use the £400 million Charging Infrastructure Investment Fund for the development of rapid EV chargepoint hubs.** Strategically located rapid chargepoint hubs will be needed and the significant cost of a network connection is limiting the market.
12) **Mandate network operators to include EV charging infrastructure and management measures within strategic investment plans.**
13) **Provide funding to support chargepoints in rural areas.** Commercial models are unlikely to address rural needs.

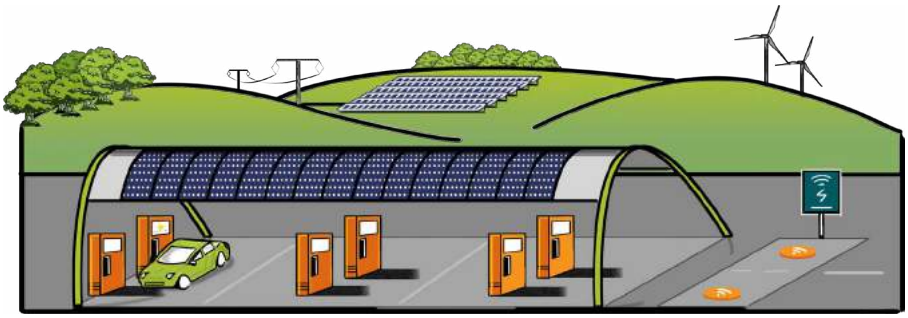


Illustration of a rapid charging station linked to renewable generation (inspired by FASTNED in the Netherlands)

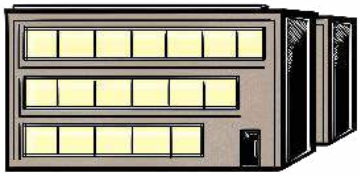
Appendix – Chargepoint locations

Home – off-street

With around 85,000 home charge-points installed36, evidence from trials and charging data suggests that 85 to 90% of charging (measured by kWh) is currently happening at home. Regen's industry engagement suggests that, for ease of use and access to competitive electricity tariffs, charging at home is expected to continue to be the primary form of EV charging for most consumers. The proportion of home charging is expected to reduce as vehicle ranges increase, more destination and workplace charging is supported and EV ownership spreads to people reliant on on-street parking.

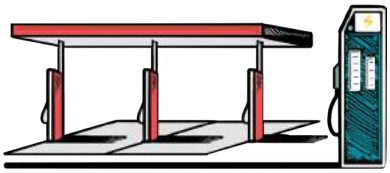
Home – on-street

On-street charging, for those without driveways or dedicated parking bays, is more problematic. Local authorities can be requested to install charging units and funding is available to support this, however, the uptake so far has been low. Using existing street furniture, such as lampposts, is a novel solution that has been used in around 100 locations in London.



Workplace charging

Workplace charging, where vehicles are parked for an extended period, is expected to become an important charge point locations for commuters. Overnight fleet charging for employer owned vehicles (including LGV's) could shift demand to off-peak periods. Grant funding for workplace charging points has been available since November 2017, with 1,300 sockets installed so far[42].



Charging stations

Existing petrol stations that are close to destination and travel hubs could continue to play a role for rapid charging. These, and other prime locations, are being targeted by rapid charge point providers and Shell have launched their own offering – Shell Recharge, with BP following their lead. The government is due to use the Automated and Electric Vehicles Bill to mandate rapid charge points for large fuel retailers.

En route – motorway and trunk road service stations

Motorway service stations have a key role to play in making long distance trips a reality for EVs. In 2017, 95% of motorway service areas are equipped with at least one rapid charge point. The government is due to use the Automated and Electric Vehicles Bill to increase this service provision.

Commercial, leisure and carpark destinations

In a bid to bring more consumers to their location, commercial destinations such as supermarkets and retail centres are likely to offer low cost charging with variable durations. Park and ride schemes offer the opportunity to link EV charging to wider transport schemes and alleviate urban congestion.

42 Office for Low Emission Vehicles, 2018. Level Network Presentation.

Appendix – List of contributors

Regen would like to thank those who contributed to the paper through attending an industry round table or through focused interviews. While the technical content in this paper may have been influenced by industry contributors and the sponsors of this paper, all views and opinions expressed are Regen's and not those of the sponsoring partners.

Regen would particularly like to thank Zap-Map for providing their latest chargepoint data.

Bath and North East Somerset Council
Bristol City Council
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Devon County Council
DriveElectric
FASTNED
FirstGroup plc
Highways England
Instavolt
Limejump
Marks and Spencer Energy
National Grid
Next Green Car/Zap-Map
Open Energi
Siemens
SmartestEnergy
South Gloucestershire Council
Tesla
University of Bath

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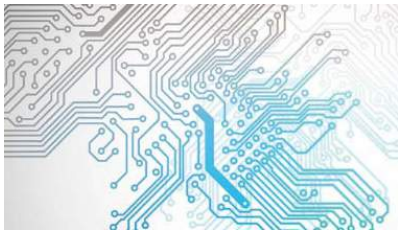
About Regen

Regen passionately believes that sustainable energy has a vital role at the heart of a successful economy and in thriving local communities.

Regen has a clear goal – accelerating the transition to a decarbonised, decentralised and democratic energy system.

We are an independent not for profit. We are ambitious on the scale of our impact. From our base in the south west of England we share our knowledge and experience of driving radical change in our energy system, nationally and internationally.

RENEWABLE DEPLOYMENT



SMART ENERGY AND STORAGE

DECARBONISATION AND ENERGY STRATEGY

HEAT

OFFSHORE RENEWABLE ENERGY

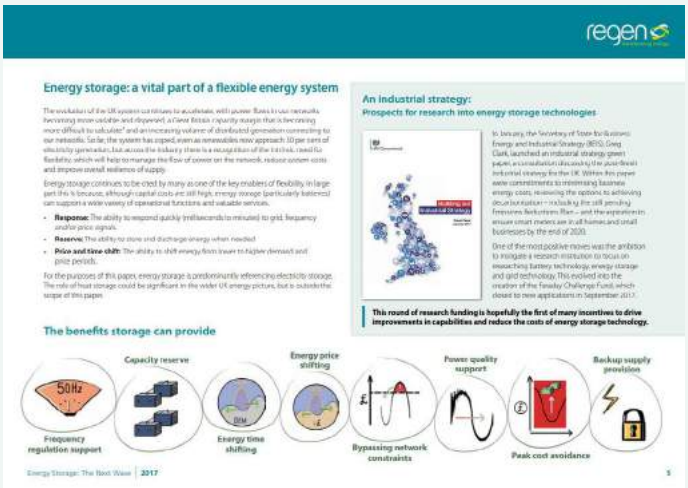
WOMEN IN RENEWABLES

COMMUNITY ENERGY

GRID AND NETWORK MANAGEMENT

TRANSPORT

Other relevant Regen publications

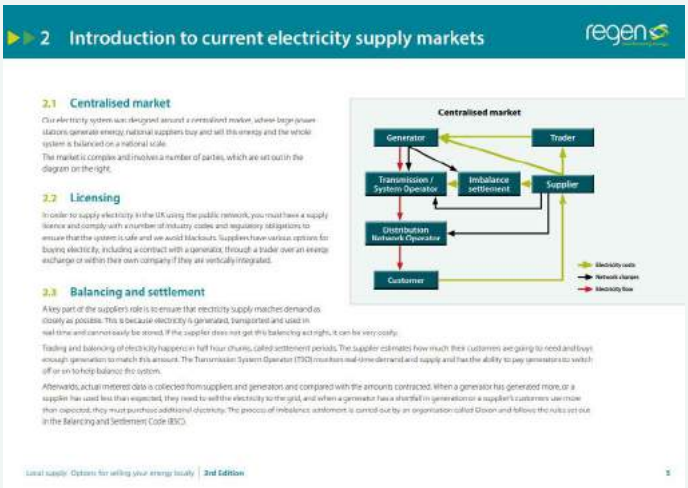


Energy storage: The Next Wave

The paper Energy Storage: The Next Wave looks at the key role of energy storage in providing flexibility as the transformation to low carbon and more decentralised energy continues. The paper sets out the key challenges for government and market to overcome if energy storage is to achieve its potential to play a key role in the smarter energy system.

Open networks project animation

Regen worked with the Energy Networks Association (ENA) to create an animation to explain the Open Networks project. This national project has been identified by BEIS and Ofgem as a key energy industry initiative to drive progress towards a smart and flexible network. The project brings together nine of UK and Ireland's electricity network operators, respected academics, NGOs and Government departments along with the energy regulator Ofgem.



Local supply paper: Option for selling your energy locally

The third edition of this paper focuses on the most recent innovations and thinking in local supply models. It looks at where there are sources of value from a more local approach, which can then be reflected in lower tariffs for demand customers and a better price for local generation. The purpose of this paper is to help community organisations and suppliers understand how the electricity supply market is changing, what the emerging local supply models are and the key considerations and challenges to making them work.

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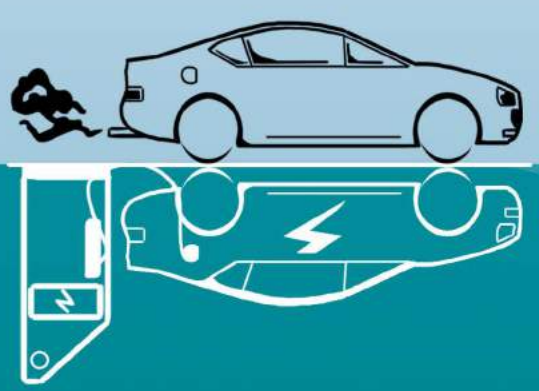
transforming energy



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