HM Government

INDUSTRIAL STRATEGY

The Road to Zero

Next steps towards cleaner road transport and delivering our Industrial Strategy

July 2018

Department for Transport

The Road to Zero

Next steps towards cleaner road transport and delivering our Industrial Strategy

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Foreword

Last year the Government set out a bold and integrated Industrial Strategy, designed to help build a high-growth, high-productivity, green economy across the UK – an economy fit for the 21st century.

As part of that, our UK Plan for Tackling Roadside Nitrogen Dioxide Concentrations ('the NO_2 Plan') and Clean Growth Strategy will cut exposure to air pollutants, reduce greenhouse gas emissions and improve our energy security.

Now we want to go further still, through new measures set out in this strategy towards cleaner road transport and to put the UK at the forefront of the design and manufacturing of zero emission vehicles.

This adds up to nearly £1.5 billion of investment and one of the most comprehensive packages of support for the transition to zero emission vehicles in the world.

It is underpinned by our latest analysis, which appraises the environmental performance of the full range of road vehicle fuel and powertrain options available to consumers. We will use this analysis to work with industry and consumer groups to develop consumer advice, giving motorists the best possible information on the environmental impact of different vehicles and fuels, so they can make choices that are right for them.

The UK's low emission vehicle industry is a huge success story and a great potential source of strength in our economy. We want to take advantage of the unprecedented economic opportunities now emerging

globally, as countries embrace a cleaner future for road transport.

Government cannot deliver these ambitions alone. At the heart of this strategy is a commitment to work in partnership with industry, businesses, academia, environmental groups, devolved administrations, local government, consumers and international partners.

Cleaner air, a better environment, zero emission vehicles, a strong clean economy – those are our goals. This document explains how we plan to achieve them.

Rt Hon Chris Grayling MP
Secretary of State for Transport

Policies at a glance

Long-term ambitions

Our mission is to put the UK at the forefront of the design and manufacturing of zero emission vehicles, and for all new cars and vans to be effectively zero emission by 2040. As set out in the NO_2 plan, we will end the sale of new conventional petrol and diesel cars and vans by 2040. By then, we expect the majority of new cars and vans sold to be 100% zero emission and all new cars and vans to have significant zero emission capability. By 2050 we want almost every car and van to be zero emission.

We want to see at least 50%, and as many as 70%, of new car sales and up to 40% of new van sales being ultra low emission by 2030.

We expect this transition to be industry and consumer led, supported in the coming years by the measures set out in this strategy. We will review progress towards our ambitions by 2025. Against a rapidly evolving international context, we will seek to maintain the UK's leadership position and meet our ambitions, and will consider what interventions are required if not enough progress is being made.

We will reduce emissions from the vehicles already on our roads by:

1. Increasing the supply and sustainability of low carbon fuels in the UK through a legally-binding 15-year strategy to more than double their use, reaching 7% of road transport fuel by 2032.
2. Taking action against garages offering the removal of emissions reduction technology, working with the DVSA, VCA and industry to ensure our regulatory and enforcement regimes give us the levers we need to tackle this problem.
3. Extending the Clean Vehicle Retrofit Accreditation Scheme (CVRAS) beyond buses, coaches and HGVs to include vans and black cabs.
4. Taking steps to accelerate the adoption of fuel-efficient motoring by company car drivers, businesses operating fleets, and private motorists.

We will drive uptake of the cleanest new vehicles by:

5. Pursuing a future approach as we leave the European Union that is at least as ambitious as the current arrangements for vehicle emissions regulation.
6. Continuing to offer grants for plug-in cars, vans, taxis and motorcycles until at least 2020. The plug-in car and van grants will be maintained at the current rates until at least October 2018. Consumer incentives in some form will continue to play a role beyond 2020.

7. Consulting on reforming Vehicle Excise Duty to incentivise van drivers to make the cleanest choices when purchasing a new van.
8. Leading the way by ensuring 25% of the central Government car fleet is ultra low emission by 2022 and that all new car purchases are ultra low emission by default. Committing to 100% of the central Government car fleet being ultra low emission by 2030.[1]
9. Launching a 2018/19 Go Ultra Low campaign and continuing to work with industry on consumer communications about ultra low emission vehicles until at least 2020.
10. Setting up a new Road Transport Emissions Advice Group, bringing government, industry and consumer groups together to help ensure clear and consistent consumer messaging and advice on fuel and technology choices.
11. As set out in the Clean Air Strategy consultation, legislating to enable government to compel vehicle manufacturers to recall vehicles for an environmental nonconformity or failure, and to make tampering with emissions control systems a legal offence.
12. Supporting the early market for used ultra low emission vehicles by producing guidance, funding training and making appropriate changes to the DVLA V5 documentation.
13. Launching a call for evidence on particulate emissions from tyre, brake and road wear to improve our understanding of these emissions and consider options for how they might be reduced.
14. Continuing to take a technology neutral approach to meeting our ambitions.

We will reduce emissions from heavy goods vehicles (HGVs) and road freight by:

15. Introducing a new voluntary industry-supported commitment to reduce HGV greenhouse gas emissions by 15% by 2025, from 2015 levels.
16. Launching a joint research project with Highways England to identify and assess zero emission technologies suitable for HGV traffic on the UK road network.
17. Working with industry to develop an ultra low emission standard for trucks.
18. Undertaking further emissions testing of the latest natural gas HGVs to gather evidence that will inform decisions on future government policy and support for natural gas as a potential near-term, lower emission fuel for HGVs.

We will put the UK at the forefront of the design and manufacturing of zero emission vehicles by:

19. Making the biggest increase in public investment in R&D in our history (towards a target for total R&D investment of 2.4% of GDP by 2027) and increasing the rate of R&D tax credit to 12%.
20. Fulfilling our commitment to provide £246 million to research next generation battery technology through the Faraday Battery Challenge.
21. Working with industry to set an ambition for a UK content target for the ultra low emission vehicle supply chain that is at least as ambitious as for conventional vehicles, as we look to secure investment in battery manufacturing in the UK.
22. Launching a new supply chain competitiveness and productivity improvement programme targeting areas where key businesses need to improve to match the best in Europe.
23. Working with the Institute of the Motor Industry to ensure the UK's workforce of mechanics are well trained and have the skills they need to repair these vehicles safely, delivering for consumers.
24. Working with the Office for National Statistics to extend their data collection to include jobs and exports attributable to both low and ultra low emission vehicle technologies.
25. Making sustainable supply chains a key theme of our Zero Emission Vehicle Summit in September 2018.

We will support the development of one of the best electric vehicle infrastructure networks in the world by:

26. Launching a £400 million Charging Infrastructure Investment Fund to help accelerate charging infrastructure deployment.
27. Taking powers through the Automated and Electric Vehicles Bill to ensure:
    - that chargepoints are available at motorway service areas and large fuel retailers;
    - that chargepoints are easily accessed and used across the UK. This includes powers to provide a uniform method of accessing public chargepoints and refuelling points; make certain information publicly available in an open and transparent format and set reliability standards; and
    - that chargepoints are smart ready by giving government powers to set requirements prohibiting the sale or installation of chargepoints unless they meet certain requirements.

28. Ensuring the houses we build in the coming years are electric vehicle ready. It is our intention that all new homes, where appropriate, should have a chargepoint available. We plan to consult as soon as possible on introducing a requirement for chargepoint infrastructure for new dwellings in England where appropriate.
29. Future-proofing our streets. We want all new street lighting columns to include charging points, where appropriately located, in areas with current on-street parking provision.
30. Continuing to provide grant support through the Electric Vehicle Homecharge Scheme (EVHS) until March 2019, with installations becoming smart enabled.
31. Increasing the grant level of the Workplace Charging Scheme from £300 per socket to 75% of the purchase and installation costs of a chargepoint capped at a maximum of £500 per socket.
32. Reviewing the provision of residential chargepoint infrastructure for those who have communal parking facilities, or do not own their own home, as part of the Law Commission's work to review and reinvigorate the commonhold tenure in England and Wales.
33. Investing £4.5 million in the On-street Residential Chargepoint Scheme until 2020.
34. Consulting in summer 2018 on a proposal to increase the height limit for the Permitted Development Right in England for the installation of electric vehicle chargepoints in designated off-street parking spaces.
35. Ensuring local planning policies incorporate facilities for charging electric vehicles via the National Planning Policy Framework.
36. Consulting on amending Building Regulations to require relevant charging provision in new non-residential buildings.
37. Launching the process for a R&D programme of up to £40 million by summer 2018 to develop and trial innovative, low cost wireless charging and public on-street charging solutions that can be deployed across entire residential streets.
38. Continuing to future proof the Strategic Road Network by running a pilot to increase electrical capacity at a motorway service area working closely with Highways England.
39. Launching an Electric Vehicle Energy Taskforce to bring together the energy and automotive industries, in order to plan for future electric vehicle uptake and ensure the energy system can meet future demand in an efficient and sustainable way.

40. As part of the forthcoming call for evidence on last mile deliveries, gathering further evidence of any key network connection infrastructure barriers, which may prevent further uptake of ultra low emission vehicles, specifically for fleet operators.
41. Launching an electric vehicle chargepoint design competition.
42. Monitoring market developments to determine whether any significant gaps in charging infrastructure provision appear over the medium term, and considering whether there may be a case for direct central government support in areas of market failure, which may include rural areas.

We will support local action by:

43. Fulfilling a £48m ultra low emission bus scheme funding round to accelerate uptake and deployment of supporting infrastructure.
44. Launching a second round of funding for local authorities to roll out dedicated taxi charging infrastructure. We will make available a minimum of £6 million to support more local areas to make the switch.
45. Setting out definitions of ultra low and zero emission vehicles that local areas may adopt.
46. Running a series of roadshows across the UK on best practice approaches to driving the uptake of ultra low emission vehicles.

Executive Summary

Our strategy is built around a core mission: to put the UK at the forefront of the design and manufacturing of zero emission vehicles and for all new cars and vans to be effectively zero emission by 2040.

As set out in the NO_2 plan, we will end the sale of new conventional petrol and diesel cars and vans by 2040. By then, we expect the majority of new cars and vans sold to be 100% zero emission and all new cars and vans to have significant zero emission capability. By 2050 we want almost every car and van to be zero emission.

This level of ambition puts the UK at the forefront of the global transition to cleaner road transport. Petrol and diesel vehicles have dominated the market for over a century and still account for more than 99% of global sales.[2] But change has arrived: sales of ultra low emission vehicles are increasing rapidly and countries, regions and cities across the world have announced long-term plans for cleaner road transport. By some estimates, ultra low emission vehicles will make up over half of global car sales by 2040.[3] The transition will mean fundamental changes to the global automotive market, worth over £1.5 trillion a year, and new opportunities for the UK.[4]

Leading the industries of the future and building the UK's competitiveness in the face of major global economic trends are key parts of our Industrial Strategy. That is why our 2040 mission is central to the Future of Mobility and Clean Growth Industrial Strategy Grand Challenges.

Driving this change is the Government's commitment to be the first generation to leave the environment in a better state than we inherited it, and to improve the health and lives of people across the UK. Although today's new cars are more efficient than those bought in 1990, transport greenhouse emissions have fallen just 2% since 1990.[5,6] As a result, transport is now the largest sector for UK greenhouse gas emissions (27%), of which road transport accounts for over 90%.[7] Road transport is one of the biggest contributors to poor air quality in some of the UK's towns and cities.[8]

We have been one of the most successful countries in the developed world in growing our economy while reducing economy-wide emissions. Since 1990, we have cut greenhouse gas emissions by 41% while our economy has grown by two thirds.[9] This progress has altered the way that we see some of the trade-offs between investing in low emission technologies that help secure our future and growing our economy. Action to drive down emissions from road transport can be win-win: cutting consumer bills, improving our environment and quality of life, driving clean economic growth and creating high value jobs.

Progress towards our mission has already started. There are more than 150,000 ultra low emission vehicles and around 14,000 public chargepoints across the UK.[10] More than 15,000 people are employed in the low emission vehicle sector and 1 in every 8 zero emission cars bought in Europe in 2017 was built in the UK.[11,12]

But there is more to do building on progress so far and the great success story of the UK automotive industry. This document sets out the action government will take to support our mission. Our approach is deliberately holistic. Adequate vehicle supply, a strong consumer base, the right market conditions and a fit for purpose infrastructure network are all vital to meeting our ambitions.
This strategy also sets out the steps we will take to drive down emissions from conventional vehicles during the transition. The measures outlined amount to nearly £1.5 billion of investment and one of the most comprehensive packages of support for the transition to zero emission vehicles in the world.

Road transport is fundamental to the way people, goods and services move across the UK. More than 60% of UK journeys are by car.[13] More than 75% of the goods we consume travel across the UK in vans and trucks.[14] Therefore central to our approach are commitments to put consumers at the heart of everything we do and work with industry to deliver the maximum possible benefits to the UK economy from the transition.

This strategy is long-term in scope and ambition, considering the drivers of change, opportunities and risks out to 2050. But its central focus is on what the UK will do in the coming years to lay the foundations for the transition. It covers road vehicles from motorcycles to 44 tonne heavy goods vehicles (HGVs). The strategy considers air pollutant and greenhouse gas emissions together ("emissions").

This strategy is for the whole UK and builds on our existing commitments in the Industrial Strategy, the Automotive Sector Deal, the UK Plan for Tackling Roadside Nitrogen Dioxide Concentrations ('the NO_2 Plan') and the Clean Growth Strategy to build an environment and an economy fit for the future.[15,16,17]

Our 2040 mission

Our mission is to put the UK at the forefront of the design and manufacturing of zero emission vehicles and for all new cars and vans to be effectively zero emission by 2040.[18] As set out in the NO_2 plan, we will end the sale of new conventional petrol and diesel cars and vans by 2040. By then, we expect the majority of new cars and vans sold to be 100% zero emission and all new cars and vans to have significant zero emission capability. By 2050 we want almost every car and van to be zero emission.

We expect this transition to be industry and consumer led, supported in the coming years by the measures set out in this strategy. Against a rapidly evolving international context, we will seek to maintain the UK's leadership position and meet our ambitions, and will consider what interventions are required if not enough progress is being made.

Our approach has been, and will remain, technology neutral and it would be premature to speculate precisely which technologies might and might not be able to deliver our long-term ambitions.

The Clean Growth Strategy set out a broad range of possible ultra low emission vehicle uptake levels in 2030 (30-70% of new car sales and up to 40% of new van sales). Our ambition is to reach the upper end of these ranges. We want to see at least 50%, and as many as 70%, of new car sales being ultra low emission by 2030 to improve the air we breathe, help ensure we meet our future carbon budgets and to build a new market for zero emission vehicle technologies in the UK.

The EU Commission has proposed a minimum regulatory expectation on manufacturers of 15% of new car sales to be 'zero or low emission vehicles' (defined as having tailpipe emissions of less than 50g of CO_2 per km) by 2025 and 30% by 2030. This is below the UK's level of ambition.

By setting long-term ambitions, we want to send a clear signal of the UK's direction of travel to provide industry and consumers with certainty. There is significant uncertainty over some of the key drivers of the transition – including battery technology and new mobility services. So we will review progress towards our ambitions by 2025.

As a clear statement of intent to industry and consumers, this government wants to see new cars and vans delivering as many zero emission miles as possible, as fast as possible, starting today.

Our bold ambitions need to be matched by bold action. We will only achieve them with:

- **adequate vehicle supply**: adequate vehicle supply is currently a key constraint on the market. There are 38 cars eligible for the plug-in car grant, compared to hundreds of conventional vehicle options. Some of the recent announcements of vehicle manufacturer electrification plans are not specific about the planned volumes of ultra low emission vehicles. Supply is a particular challenge for commercial vehicles. There are only nine van models eligible for our plug-in grant available for purchase, all of which are 3.5 tonnes or less. Technologies for zero emission HGVs are less developed than for cars and vans. More innovation and investment is needed so that ultra low emission vehicles are ready for mass adoption across all vehicle types in a sustainable and affordable way. We welcome the billions of pounds industry is investing and look forward to seeing a greater range and number of ultra low emission options for sale in the UK in the coming years.
- **a strong consumer base and the right market conditions:** a recent survey indicated that around 38% of consumers considering a new car purchase would consider an electric car.[19] However, only around 2% of new car sales are currently ultra low emission.[20] Recent surveys indicate concerns and confusion around the technology; concerns about the higher upfront costs of the vehicles and infrastructure provision remains a barrier.[21] The right incentives and policy framework will be vital to increasing the numbers of consumers who want to buy ultra low emission vehicles.

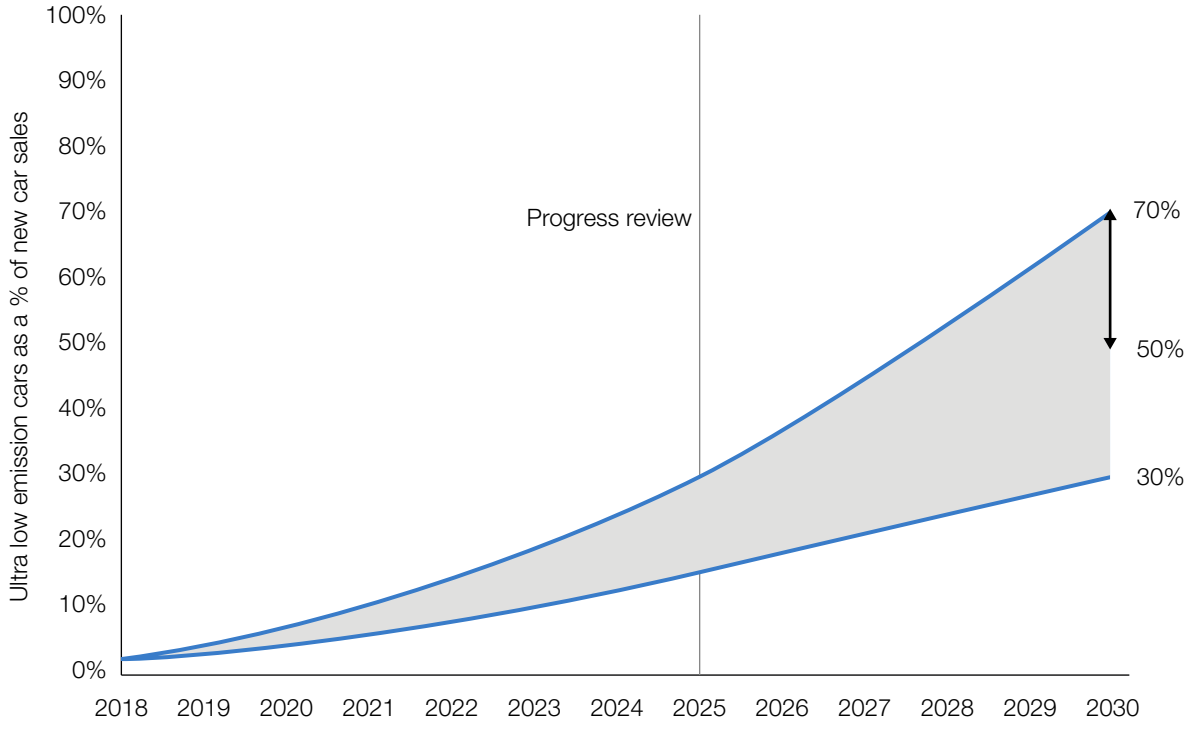
- **a fit for purpose infrastructure network:** as we move to the mass adoption of ultra low emission vehicles, more infrastructure will be needed and we want to see improvements to the consumer experience of using it. Our vision is for current and prospective electric vehicle drivers to be able to easily locate and access charging infrastructure that is affordable, efficient and reliable.

The Government will need to play its part to address these challenges. In this strategy, we set out how we will provide a world-leading and wide-ranging package of consumer incentives; research and development (R&D) and innovation support; support for the development of one of the best infrastructure networks in the world; and will take steps to ensure the energy system is ready to meet future demand.

The measures outlined amount to nearly **£1.5 billion** of investment and one of the most comprehensive packages of support for the transition to **zero emission vehicles** in the world.

But the Government cannot deliver a zero emission future for the UK alone. At the heart of this strategy is a commitment to work in partnership with industry, businesses, academia, environmental groups, devolved administrations, local government, consumers and international partners.

Figure 1: Illustrative ultra low emission car uptake trajectory as a percentage of new car sales



Understanding the challenge: assessing the options for road transport

The Government remains committed to policies and incentives that are technology neutral. But it is essential that we understand the relative environmental performance of different technologies in the real world. In addition, the diesel emissions scandal and the ongoing gap between laboratory and real world emissions performance of new cars has undermined public confidence and made it difficult for consumers to determine the environmental impact of their vehicle choices.

For these reasons we have conducted an independently verified assessment of the environmental performance of the fuels and technologies available to consumers. This document sets out the results of this assessment and government's view on the relative environmental performance of different fuels and technologies, in terms of both greenhouse gas and air pollutant emissions over the period to 2050. Further details of the assessment are provided in Annex A and in the Transport Energy Model Report, published alongside this strategy.

Battery electric vehicles are highly energy efficient and have zero tailpipe emissions. The assessment shows that they also have substantially lower greenhouse gas emissions than conventional vehicles, even when taking into account the electricity source and the electricity used for battery production. Assuming the current UK energy mix, battery electric vehicles produce the lowest greenhouse gas emissions of all the energy sources and fuels assessed, irrespective of vehicle type and operation.[22]

Between now and 2050, we project electricity grid emissions will fall by around 90%, with total greenhouse gas emissions from electric vehicles falling in parallel.[23]

Hydrogen fuel cell electric vehicles also have zero tailpipe emissions. Like battery electric vehicles, their well-to-wheel greenhouse gas emissions depend on the method of energy production.

Although the environmental performance of **range extenders, plug-in, and non-plug-in hybrids** depends on their use and zero emission range, these vehicles are amongst the cleanest vehicles on the market and can bring significant environmental benefits. They are an important way of helping motorists make the switch to a different way of powering their vehicles.

Petrol cars and vans tend to have higher greenhouse gas emissions than their diesel equivalents but significantly lower emissions of NO_X. Real world particulate emissions from petrol cars and vans are variable, with some petrol cars and vans (particularly those with direct injection engines) emitting higher levels of particulates than diesel equivalents. We expect this to be addressed by the introduction of the Real Driving Emission (RDE) standards.

Real world emissions of NO_X from **diesel cars and vans** that do not meet RDE standards are typically much higher than from petrol equivalents. Cleaner diesel cars and vans can play an important part in reducing CO_2 emissions from road transport during the transition to zero emission vehicles whilst meeting ever more stringent air quality standards. For diesel vehicles to play their part fully, their air quality impact must continue to be reduced. We want new

cars and vans to be as clean as possible as fast as possible. We welcome the continued innovation and investment by vehicle manufacturers to develop cleaner diesel vehicles that meet the more challenging RDE requirements, delivering critical improvements in NO_X emissions on the road.

Liquid petroleum gas (LPG) vehicles have similar well-to-wheel greenhouse gas emissions as diesel equivalents but generally have lower air pollutant emissions. Although a niche market, LPG vehicles may be a good current alternative to diesel in urban driving conditions. **Natural gas vehicles** also generally have lower air pollutant emissions than diesel equivalents but more efficient engines are required if they are to deliver significant greenhouse gas savings in heavy vehicles.

For **heavy goods vehicles** (HGVs), technology development is now moving towards zero emission options. However, these are not yet widely available and regulation has been successful at significantly reducing real world pollutant emissions from new diesel vehicles. So while work is underway to commercialise zero emission and other low emission options, diesel can be a sensible current fuel choice.

Whilst the focus of this assessment is on tailpipe air pollutant emissions, we recognise that vehicles also produce non-tailpipe pollutant emissions. We are committed to reducing these emissions and will launch a call for evidence on particulate emissions from tyre, brake and road wear to improve our understanding of these emissions and consider options for how they might be reduced.

There are more than 150,000 ultra low emission vehicles on UK roads and zero emission vehicles are an attractive option for many consumers today – offering the best environmental performance and in many cases cheaper running costs. As a clear statement of intent to industry and consumers, this government wants to see new cars and vans delivering as many zero emission miles as possible, as fast as possible, starting today.

If zero emission technologies are not currently practical for a consumer or business, the most appropriate vehicle technology will depend on individual circumstances, including location and usage pattern. For cars principally being used in urban areas where journeys tend to be shorter and at slower speeds, petrol hybrid, other alternatively fuelled or new conventional petrol cars are likely to be most suitable. Diesel is more suitable for cars that regularly drive long distances or carry heavy loads. Fleet turn-over to the newest, cleanest cars and vans will play an important part in reducing emissions from the vehicle fleet. In air quality terms, a new conventional vehicle will almost always be cleaner than an older one of the same fuel type.

To help provide consumers with the information they need about the environmental performance of different vehicle and fuel options we will, in partnership with industry, consumer groups

Range extenders, plug-in and non-plug-in hybrids are amongst the **cleanest vehicles** on the market and can bring significant environmental benefits.

and motoring organisations, set up a Road Transport Emissions Advice Group to work together to ensure clear and consistent consumer messaging and advice on fuel and technology choices.

Cleaning up the conventional vehicle fleet

Conventional vehicles on our roads have an average lifespan of around 14 years – so vehicles bought today could still be on our roads in the 2030s.[24] Without further action to reduce emissions from the vehicles already on our roads it will be difficult to meet our air quality and greenhouse gas reduction ambitions. We also expect conventional vehicles to continue to make up a large proportion of new sales. We will therefore also take steps to ensure that new conventional vehicles are as clean as possible.

We will renew action to encourage the widespread adoption of fuel-efficient motoring by businesses operating fleets, company car owners and private motorists. This will include the creation of a taskforce with the motoring and insurance industry to promote the use of vehicle telematics technology.

Low carbon fuels will continue to be vital to drive down emissions from conventional vehicles, and in sectors which are harder to decarbonise such as heavy goods vehicles. We want to increase the supply and sustainability of low carbon fuels, doubling use by 2020 and increasing it further to 2032.[25] We will also provide policy and funding incentives to encourage the production of advanced low carbon fuels. Government will continue to consider further expansion of bioenergy use in transport in the context of demands across the economy, given its potential importance to other sectors such as heat.

Retrofitting new technologies to existing vehicles can reduce emissions in the short term at lower cost than purchasing a new vehicle. The Low Carbon Vehicle Partnership has extended the Clean Vehicle Retrofit Accreditation Scheme to cover a range of vehicles including buses, HGVs, vans and black cabs.

To ensure that we have only the cleanest new vehicles being rolled out onto UK roads, as we leave the European Union, we will pursue a future approach that is at least as ambitious as the current arrangements for vehicle emissions regulation.

Moving to zero: cars and vans

The technology to deliver our ambitions for cars and vans exists and is being driven today: ultra low emission vehicles made up 1.8% of new car sales in 2017 and continue to gain market share.[26] The zero emission range of today's plug-in hybrid and range extender vehicles can already cover the vast majority of UK journeys. For example based on the National Travel Survey, a 50 mile continuous zero emission range could cover up to 98% of all UK journeys and a 25 mile continuous zero emission range could cover up to 94%.[27] We are on track to meet our previous forecast that 3-7% new car sales would be ultra low emission by 2020.[28] Further uptake will be driven by adequate vehicle supply, a strong consumer base, the right market conditions and a fit for purpose infrastructure network.

Adequate vehicle choice and supply of existing models is currently a key constraint

on the market.[29] We welcome the billions of pounds industry is investing into new ultra low emission technologies and the announcement of long-term electrification plans by a number of vehicle manufacturers, and look forward to seeing a greater range and number of ultra low emission options for sale in the UK in the coming years.

We will continue to encourage more consumers to make the switch to ultra low emission vehicles by providing one of the most comprehensive package of incentives in the world. This includes continuing the plug-in car, van, taxi and motorcycle grants until at least 2020 to reduce the upfront price premium of ultra low emission vehicles. Consumer incentives in some form will continue to play a role in driving uptake beyond 2020. As the market becomes better established and more competitive, the need for direct government financial support will decrease. We therefore expect to deliver a managed exit from the grant in due course and to continue to support the uptake of ultra low emission vehicles through other measures.

We will continue to ensure the tax system incentivises the purchase of the cleanest vehicles, and in particular zero emission vehicles. We have launched a consultation on a new VED approach for vans to ensure that this system incentivises the cleanest options.

We will continue to work with industry on messaging to consumers and fleets about the benefits of switching to ultra low emission vehicles until at least 2020. We will launch a 2018/19 Go Ultra Low campaign.

Government leadership is also vital. We have already committed to 25% of central government's car fleets being ultra low emission vehicles by 2022 and for all new central Government car fleet purchases to be ultra low emission by default.[30] In this strategy, we set out our aim for 100% of the

Zero Emission Vehicle
Source: Go Ultra Low

central government car fleet to be ultra low emission by 2030. We want to see similar ambition from other public sector fleets.

Moving to zero: Heavy Goods Vehicles

Although the new emissions standards for HGVs have achieved significant air quality improvements, CO_2 emissions from HGVs have remained relatively constant in recent years and zero emission options must be developed and made available commercially for all types of HGVs.

That is why we are launching a joint research project with Highways England to identify and assess zero emission HGV technologies and their suitability to the UK road network and freight operations. We have extended the plug-in van grant to cover vehicles weighing more than 3.5 tonnes, and will collaborate with industry to develop an ultra low emission truck (ULET) standard to provide certainty on emission standards and encourage industry R&D in this area.

We also need to reduce emissions from existing HGVs significantly. We have agreed a new industry-wide voluntary target for reducing HGV greenhouse gas emissions by 15% by 2025, from 2015 levels. We will collaborate with and support industry in achieving this goal. We are funding the Energy Saving Trust to develop a freight portal that will ensure HGV operators have access to reliable information on cost-effective measures to improve fuel efficiency and reduce their emissions in the short-term. We have also recently announced changes to the HGV levy to help improve air quality across the UK alongside work to consider long term changes.[31]

We are also working with industry to test the environmental performance of the latest gas HGVs. The results of this testing will be used to assess further the potential for gas HGVs to deliver emissions reductions in the short to medium term while zero emission options are being developed and deployed.

Supporting the development of one of the best electric vehicle infrastructure networks in the world

The transition to zero emission vehicles does not just require the vehicles to be available and affordable. An infrastructure network needs to be in place that is easy for current and prospective drivers to locate and use, and is affordable, efficient and reliable. This is part of our wider plans to have high quality infrastructure to support economic growth and prosperity across all regions of the UK. We will support the development of the infrastructure for electric vehicles as well as for hydrogen fuel cell electric vehicles, where the market is at a much earlier stage of development.

For electric vehicles, we will continue to provide grants to encourage people to charge at home overnight, both on and off streets. This is how we envisage the majority of charging will take place. It is our intention that all new homes, where appropriate, should have a chargepoint available. We plan to consult as soon as possible on

We have agreed a new industry-wide voluntary target for reducing **HGV greenhouse gas emissions** by **15%** by **2025**, from 2015 levels.

introducing a requirement for chargepoint infrastructure for new dwellings in England, where appropriate, and will look at how to achieve this in the most cost effective way, mindful of the Government's Housing supply objectives. To future-proof our streets, we want all new street lighting columns to include charging points, where appropriately located, in residential areas with current on-street parking.

We will consider how to best ensure all types of residential property owners, including leaseholders or legal occupants with private off-street car parking, are able to access a chargepoint for their electric vehicle and are not disadvantaged merely on the basis of having communal parking facilities or not owning their own home. We will review the provision of chargepoint infrastructure for these groups as part of the Law Commission's work to review and reinvigorate the commonhold tenure in England and Wales.

Workplace and public infrastructure will also be vital. There are already around 14,000 public chargepoints (including more than 1,300 rapid chargers) across the UK, and these numbers are increasing at pace. There have been hundreds of millions of pounds of investment into the UK charging infrastructure sector in the last year alone.

But more chargepoints will be needed. Highways England are committed to ensuring there is a chargepoint every 20 miles along the strategic road network by 2020.[32] We will support the development of the public chargepoint network working with local areas, including the eight Go Ultra Low Cities, and through the £400 million Charging Infrastructure Investment Fund. We will consult on amending Building Regulations to require relevant charging provision in new non-residential buildings. And we will increase the grant level for the workplace charging scheme.

But government will not own or operate a chargepoint network now or in the future: the private sector is already delivering. Our role is to create the right enabling conditions.

We will take steps to improve the consumer experience of public infrastructure to ensure charging is straightforward. The Alternative Fuels Infrastructure Regulations 2017 and the Automated and Electric Vehicles Bill will improve the experience of using chargepoints by enabling government to mandate a common minimum method of accessing public chargepoints, allowing recharging without a pre-existing contract; compel operators to make the geographic location of their chargepoints publicly available; and mandate minimum technical specifications for connectors to ensure greater interoperability. The Bill provides powers to central government to mandate the installation of charging infrastructure at key strategic locations if required, and enables Metro Mayors to designate chargepoint provision at large fuel retailers.

We will continue to monitor market developments to determine whether any significant gaps in charging infrastructure provision emerge in the medium term and whether there may be a case for direct central government support in areas of market failure, which may include rural areas.

The global market for hydrogen fuel cell electric vehicles is at an earlier stage of development than for plug-in electric vehicles. But there is also potential to use

hydrogen in applications beyond transport. We will ensure the UK retains its leadership position through our £23 million Hydrogen Transport Programme.[33]

Powering the transition – preparing the electricity system

The electricity system of 2050 will look very different from today's. There will be more low carbon generation, and new technologies such as battery storage and onsite generation will play a bigger role. Decarbonising how we heat our homes and businesses will also bring further changes to the demands placed on the energy system.

Electric vehicles are a key part of our future smart and flexible energy system, supporting the use of storage in homes and potentially providing power back to the grid – which we are supporting through a £30 million vehicle-to-grid R&D competition. We will ensure the electricity system now and in the future is ready and that we maximise the opportunities that electric vehicles present, in terms of vehicle-to-grid, flexibility services and demand-side response.

We are confident that existing market mechanisms will be able to meet additional electricity demand from electric vehicles. The powers we have taken in the Automated and Electric Vehicles Bill – that will allow government to bring forward regulations so that all new chargepoints are smart – will help to reduce and manage the impact of electric vehicles on the electricity system. We are launching an Electric Vehicle Energy Taskforce, bringing together the energy and automotive industry, to bring forward proposals for government and industry to take to ensure the energy system is ready for the transition.

We do not want grid connections to be a barrier to the further development of the UK's charging infrastructure and will take action to ensure this is not the case. As part of the forthcoming call for evidence on last mile deliveries, we will gather further evidence of any potential key network connection infrastructure barriers, which may prevent further uptake of ultra low emission vehicles, specifically for fleet operators. To continue to future proof the Strategic Road Network, Highways England will run a pilot, working closely with OLEV to increase electrical capacity at a motorway service area.

There are more than **150,000** ultra low emission vehicles and around **14,000** public chargepoints across the UK.

Delivering our Industrial Strategy

The UK is not alone in recognising the benefits of cleaner road transport. Many countries, regions and cities now have long-term targets for cleaner road transport, creating a new and multi-billion pound industry across the world. In response, we are seeing extraordinary innovation and investment from industry and new market entrants bringing fresh ideas and competition. The size of the opportunity is huge: some estimate the global market for low emission vehicles could be worth £1.0–2.0 trillion per year by 2030, and £3.6–7.6 trillion per year by 2050.[34]

That is why we want to put the UK at the forefront of the design and manufacturing of

zero emission vehicles. We also want the UK to lead the world in associated technologies – including infrastructure and vehicle-to-grid systems.

The UK is well placed to seize these new opportunities as home to the manufacture of the fastest selling electric vehicle in Europe (the Nissan LEAF in Sunderland), the world's first electric black cab (made by the London Electric Vehicle Company in Coventry), a world-class R&D ecosystem and supply chain and a number of new ultra low emission vehicle manufacturers, including Arrival and Tevva.[35] This strategy provides a long-term direction for the UK to help provide industry with certainty.

In our Automotive Sector Deal, we made major new commitments to research and development in zero emission vehicle technology, and to developing competitive UK supply chains. This included the £246m Faraday Battery Challenge, which is already supporting the development of battery technology in the UK. We will continue to support our established multi-million pound research and development programme for ultra low emission vehicles, which has been running since 2007 and has been estimated

to have a rate of return of £8 for every £1 invested.[36]

The Automotive Sector Deal set out industry's ambition to increase the level of UK content by value in domestically-built vehicles to 50% by 2022. Our ambition is to work with industry to set a target at least as ambitious for the ultra low emission vehicle supply chain as we look to secure investment in battery manufacturing in the UK. We will launch marketing materials later this year on the UK's strengths in zero emission technologies to help highlight some of our leading companies to the world.

Leadership at all levels

This is a strategy for the whole UK and all the measures outlined (except where indicated) are available across the UK.[37] We will continue to collaborate closely with the devolved administrations in Scotland, Wales and Northern Ireland, and partners in local government.

The devolved administrations and local authorities have a crucial role to play during the transition to zero emission vehicles and addressing local air quality issues. Many local authorities are already taking action to accelerate the transition to zero emission road transport, including the eight Go Ultra Low cities.

To support the move to cleaner buses, we have launched a new ultra low emission bus scheme in England and Wales. We are also launching a second round of funding for local authorities to roll out dedicated taxi charging infrastructure. We will work with local authorities and others to disseminate good practice, in particular from the eight Go Ultra Low cities, across the UK through a series of roadshows during 2018.

Finally, we will work with the international community to accelerate the global shift to cleaner transport. The UK wants to play an active, leading role internationally. At the Zero Emission Vehicle Summit in September 2018 we will bring together the international community to discuss how to seize collective opportunities and tackle our shared challenges.

The Future of Mobility

The move to zero emission road transport will not be the only shift in the way we move goods, people and services around our towns, cities and countryside over the coming decades. Significant investments are being made in the automation of road vehicles, while new business models, such as ride-hailing services, ride sharing and new mobility services are challenging our assumptions about how we travel.

The way we travel and who owns vehicles in the coming years will affect the trajectory of ultra low emission vehicle uptake, the infrastructure these vehicles will need and emissions from conventional vehicles. Relevant trends include:

- **Connectivity and automation**: vehicles where some or all of the driving task is automated may result in smoother more efficient drives. In addition, vehicles which communicate with each other and with infrastructure could improve traffic flow and therefore reduce emissions.

- **New business models**: fewer young people are learning to drive and buying cars.[38] Digitally enabled, on-demand and shared transport services are already changing how people consume mobility in the UK. This could signal a shift to fewer vehicles on the road with higher utilisation rates. Some analysts forecast dramatic declines in individual car ownership in the coming decades.[39]
- **Changing travel demand**: people increasingly work from home and fewer people commute Monday to Friday.[40] This means the patterns of road vehicle use and levels of congestion in urban areas are changing.

We launched the Future of Mobility Grand Challenge to recognise the magnitude of changes such as these on our transport system and will launch a call for evidence on the Future of Mobility shortly ahead of publishing a strategy later in 2018. We are committed to monitoring these developments and will consider their impact on our strategic approach to support the transition to clean road vehicles, including when we review our progress by 2025.

Part 1

Drivers of change

Part 1: Drivers of change

Strategy structure

Part 1 considers the factors that are driving the global transition to zero emission vehicles. **Parts 2** and **3** focus on the key strategic challenges for the UK and what government will do to address them. **Part 2** sets out how we will drive supply and demand of ultra low emission vehicles and the cleanest conventional vehicles. **Part 3** sets out how we will ensure a fit for purpose infrastructure network and prepare the energy system. **Part 4** sets out how we will support leadership at all levels during the transition to zero emission vehicles. **Annex A** provides the details of our appraisal of the current fuel and powertrain options available.

Action to support modal shift

Enabling people to choose the most sustainable mode of travel for their journey is vital for reducing emissions from road transport. The steps we are taking are not within scope of this strategy.

We published the first ever statutory Cycling and Walking Investment Strategy in 2017. The strategy identified £1.2bn that may be invested in cycling and walking from 2016 to 2021, with a goal to double the level of cycling by 2025 and to reverse the decline in walking.[41]

We have run two freight grant schemes to encourage the use of rail or water instead of road, helping remove more than 800,000 HGV journeys a year from Britain's roads.[42] The £1.7bn Transforming Cities Fund will provide investment on public transport and cycling and walking infrastructure in some of England's largest cities, to reduce congestion and increase productivity, with benefits for air quality. £840 million has already been allocated to the six mayoral combined authorities, and a 'Call for Proposals' for access to the remaining funding was launched for non-mayoral city regions in March 2018.[43]

Source: Transport for Greater Manchester

Strategy scope and vehicle terminology

The strategy focuses on the emissions that result from the way in which road vehicles are powered – considering air pollutant and greenhouse gas emissions together.

Air pollutants are any particles or chemicals that are released into the atmosphere with the potential to cause harm to human health or the natural environment. A wide range of substances are released as a result of human activities. These can have a localised impact or can cause harm considerable distances from their sources. Air pollutants can be chemically converted into different compounds, often mixing with other pollutants. This strategy focuses on reducing vehicle exhaust emissions of air pollutants (also known as tailpipe emissions).

We will publish a call for evidence on non-exhaust emissions of particulates from road transport – including tyre and brakewear particulate emissions – shortly. The Clean Air Strategy set out action to reduce emissions from energy production and manufacturing.[44]

Greenhouse gas emissions have a global impact. This strategy therefore looks at both direct and indirect emissions of greenhouse gases. This includes those from the vehicle tailpipe, and from the production and distribution of the fuels or energy sources (known as 'well-to-wheel' for fossil fuels). We have also completed a sensitivity test to take account of the emissions associated with electric vehicle battery production. Annex A sets out the relative greenhouse gas emissions of different vehicle technologies, fuels and energy sources and this is used to underpin the policies and actions set out in this strategy.

Action to reduce greenhouse gas emissions from energy production and manufacturing were set out in government's Clean Growth Strategy, published in October 2017.

Motorcycles: 2-wheel vehicles powered by an engine. Includes scooters and mopeds.

Cars: 4-wheel vehicles including people carriers and all passenger-carrying vehicles that can carry no more than eight passengers (excluding the driver). Includes private hire cars (PHV – Private Hire Vehicles) and taxis (hackney carriages) that are car based.

Vans/Light goods vehicles: 4-wheel vehicles constructed for transporting goods. Must have a gross weight of less than 3.5 tonnes.

Heavy goods vehicles: Larger vehicles constructed for transporting goods. Must have a gross weight more than a light goods vehicle.

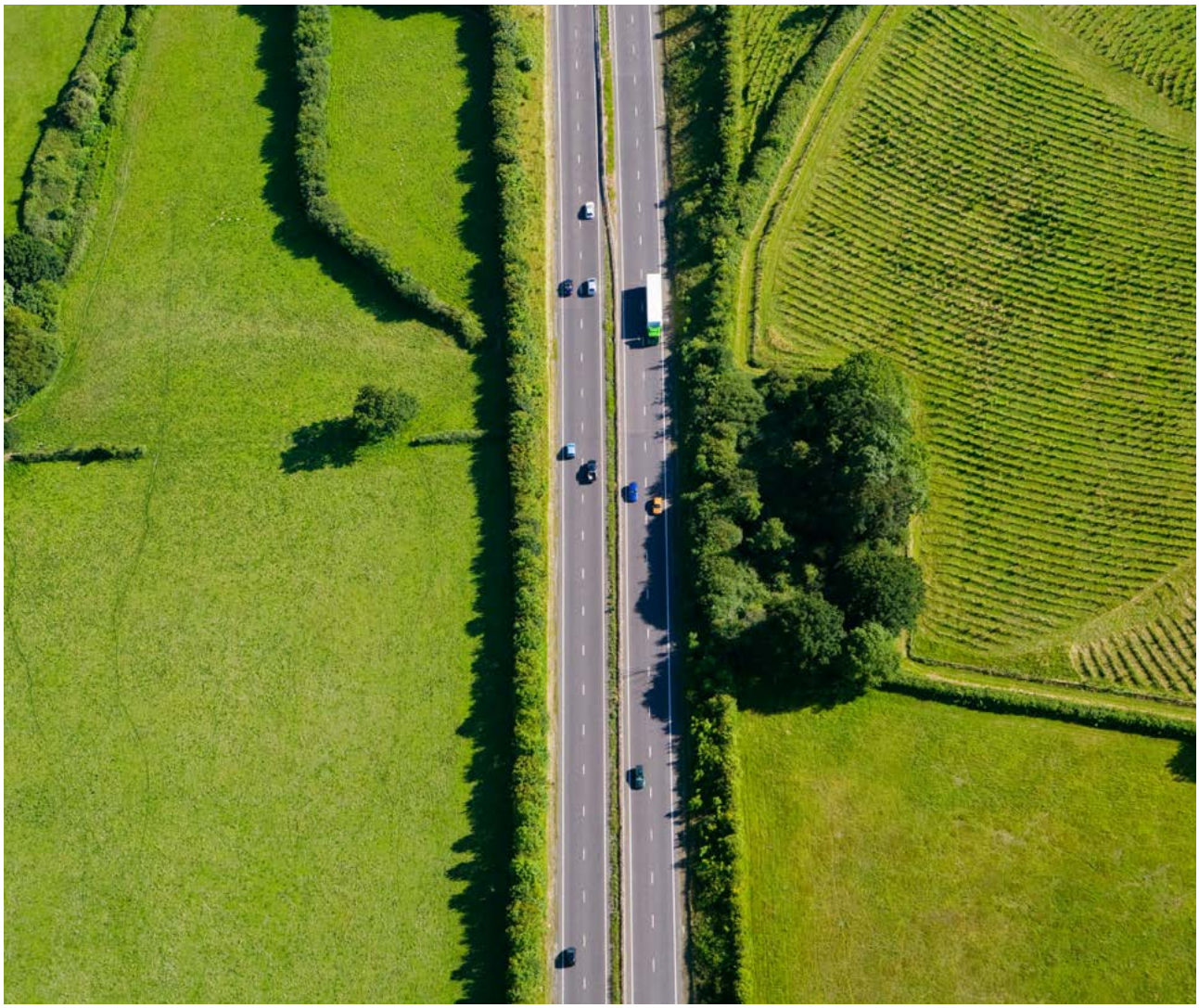
Buses/coaches: Vehicles designed to carry more than 8 passengers, in addition to the driver.[45]

Ultra low emission vehicles (ULEVs): Since 2009, the Office for Low Emission Vehicles has considered an ultra low emission vehicle to be a car or van that emits less than 75 grams of CO_2 from the tailpipe per kilometre driven measured against the European test cycle.

Recognising advancements in technology, from 2021 we expect to define an ultra low emission vehicle as a car or van that emits less than 50 grams of CO_2 from the tailpipe per kilometre driven measured against the relevant test cycle.

Part 2c commits to the development, in partnership with industry, of a definition of an Ultra Low Emission Truck (ULET). The definition of an Ultra Low Emission Bus (ULEB) is set out in the Ultra Low Emission Bus Scheme, launched in March 2018.

Zero emission vehicles: vehicles with no greenhouse gas or air pollutant tailpipe emissions.



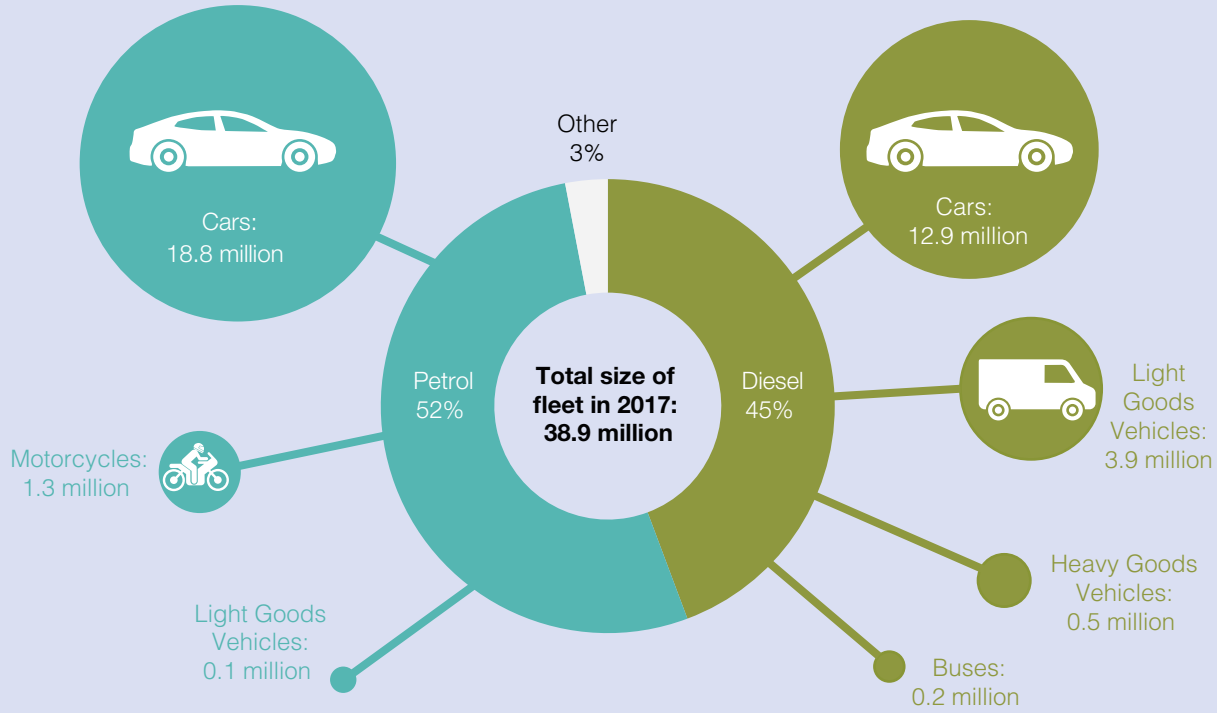
The current UK road vehicle market

There are 38.9 million vehicles on UK roads. In the UK fleet, cars and vans are on average 8.1 years old and HGVs are on average 7.5 years old.[46,47] In 2017 the following new vehicles were registered:

- 2.5 million cars
- 362,000 light goods vehicles
- 52,000 heavy goods vehicles
- 115,000 motorcycles

In 2017, over 8.1 million used cars were sold in the UK, of which over 10,000 were zero emission (an increase of 77% from 2016).[48]

Figure 1.1: The vast majority of the vehicles currently on UK roads are petrol or diesel fuelled[49]



Source: DfT, Vehicle Licensing Statistics 2017

The size of the opportunity is huge: some estimate the global market for low emission vehicles could be worth **£1.0–2.0 trillion** per year by **2030**, and **£3.6–7.6 trillion** per year by **2050**.

Delivering our Industrial Strategy

Although there are ultra low emission vehicles available today, more innovation and investment will be needed before these technologies are available for mass adoption across all vehicle types. Our mission is to put the UK at the forefront of the design and manufacturing of zero emission vehicles. The size of the global opportunity is huge: independent analysis estimates the global market for low emission vehicles could be worth £1.0 – 2.0 trillion per year by 2030, and £3.6 – 7.6 trillion per year by 2050.[50]

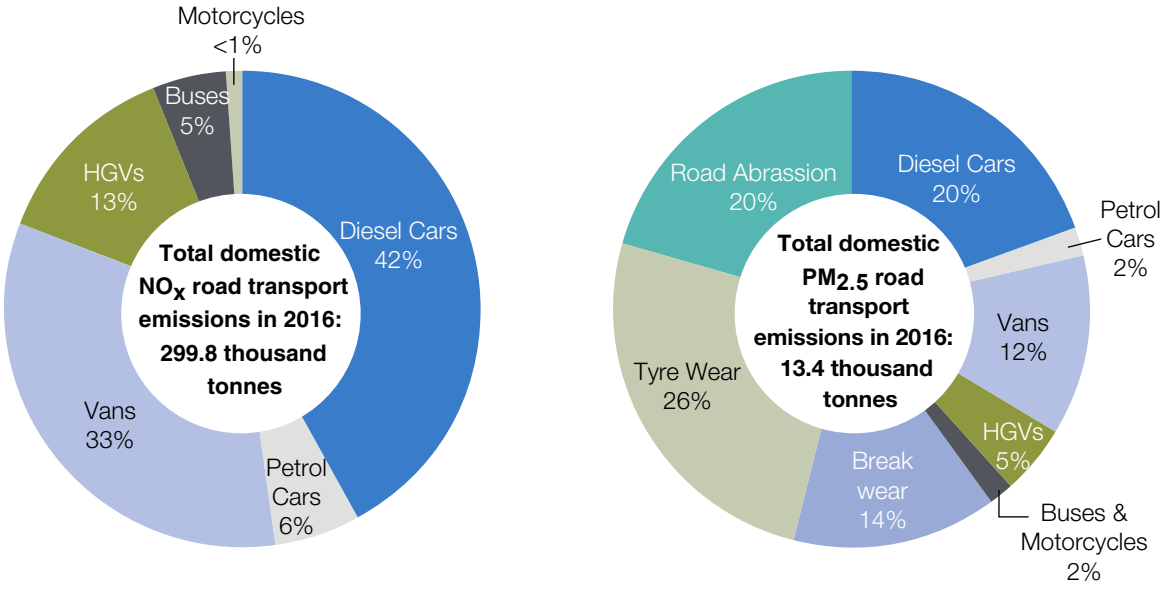
The UK is well placed to seize these new opportunities as home to the manufacture of the fastest selling electric vehicle in Europe (the Nissan LEAF in Sunderland), the world's first electric black cab (made by the London Electric Vehicle Company in Coventry), a world-class R&D ecosystem and supply chain and a number of new ultra low emission vehicle manufacturers, including Arrival and Tevva.

Low carbon fuels also offer economic opportunities. For example the UK is now producing over £250 million worth of low carbon biodiesel from waste each year.[51] Looking ahead, we expect the global market for advanced low carbon fuels to be worth up to £15 billion by 2030, with significant demand for such fuels from hard-to-decarbonise sectors such as aviation and heavy freight.[52] A strong domestic industry will provide highly skilled jobs in this sector and contribute to economic growth in the UK.

Improving Air Quality

Over recent decades, UK air quality has improved significantly thanks to action at all levels. Total UK emissions of nitrogen oxides (NO_x) fell by almost 72% between 1970 and 2016 and by over 27% between 2010 and 2016.[53]

Figure 1.2: UK road transport NO_x emissions are primarily from diesel cars and vans; most road transport $PM_{2.5}$ emissions are not from the tailpipe [54]



Source: National Atmospheric Emissions Inventory

Key air pollutants from road transport

Nitrogen oxides (NO_x) – Compounds formed when nitrogen and oxygen combine. NO_x, which comprises nitric oxide (NO) and nitrogen dioxide (NO_2), is emitted from combustion processes. The main sources include power generation, industrial combustion and road transport. At high concentrations NO_2 is an irritant to the airways. NO_2 can also make people more likely to catch respiratory infections (such as flu), react to allergens, and over a long period, affect how well our lungs function.[55]

Particulate matter (PM) – Small airborne particles. PM may include materials such as soot, wind-blown dust or secondary components which are formed within the atmosphere as a result of chemical reactions. Some PM is natural and some is man-made. PM can be harmful to human health when inhaled, with the World Health Organization classifying it as carcinogenic to humans.[56] In general, the smaller the particle the deeper it can be inhaled into the lungs, and the greater the risk that it is transferred to the bloodstream or body tissues. PM_{10} is particulate matter 10 micrometres or less in diameter, $PM_{2.5}$ is particulate matter 2.5 micrometres or less in diameter. By way of comparison, a human hair is about 100 micrometres in width. Ultrafine particles, classified as being 0.1 micrometres or less in diameter, are covered down to 0.023 micrometres in vehicle emissions regulation (the limit of the current detection technology), but there is increasing interest around the world in their effects and how they can be mitigated.

Non Methane Volatile Organic Compounds (NMVOC) – Can cause irritation to eyes, nose & throat and organ damage. React with other pollutants to produce ground level ozone and therefore cause inflammation of the respiratory tract, eyes, nose & throat. Ozone produced by VOCs can travel large distances and reach high concentrations far from the original source. It affects plant growth and can impact on biodiversity and climate change.

Hydrocarbons (HC) – Organic compounds often found in fuels including crude oil and natural gas. Unburnt hydrocarbons react with NO_x to produce harmful pollutants.

Carbon monoxide (CO) – A colourless, tasteless, odourless and toxic gas. Carbon monoxide vehicle emissions are produced through inefficient fuel combustion. Although outdoor concentrations do not generally reach dangerous levels, they may still have adverse health effects for vulnerable people.

Despite this, poor air quality remains the largest environmental risk to public health. Recent research commissioned by Public Health England found that the health and social care costs of air pollution ($PM_{2.5}$ and NO_2) in England could reach £5.3 billion by 2035.[57] This is a cumulative cost for diseases where there is a strong association with air pollution such as coronary heart disease, strokes, lung cancer, and child asthma. When diseases with weaker evidence of association are also added,

including chronic obstructive pulmonary disease, diabetes, low birth weight, lung cancer, and dementia, the costs could reach to £18.6 billion by 2035. We know that the effects of poor air quality are felt disproportionately by the most vulnerable groups in society and that the public are concerned.[58,59]

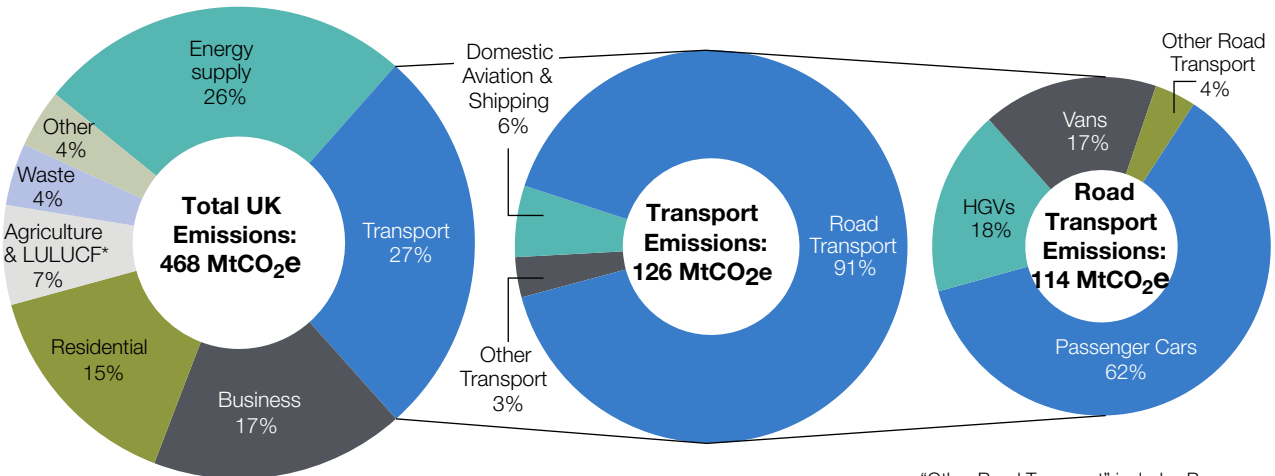
Road transport is a major source of air pollutants, including 34% of NO_X (contributing to 80% of concentrations at the roadside), 12% of $PM_{2.5}$ and 4% of non-methane volatile organic compounds (NMVOCs).[60] Investing in clean air and taking action to tackle poor air quality are key priorities.

That is why in 2017 we set out our plan to bring roadside NO_2 concentrations in line with legal limits in the shortest time possible and are currently consulting on our long-term Clean Air Strategy.

We know that there are no safe levels of the particulate matter that petrol, diesel and other internal combustion engine vehicles emit, and that the UK still has more to do to reduce emissions of all major air pollutants to meet longer-term legal limits. The measures set out in this strategy and the transition to zero emission road transport are therefore vital parts of any long-term solution to the poor air quality in our towns and cities.

Poor air quality is also a result of the way we currently generate power, heat our homes, produce food and manufacture consumer goods. Better, cleaner technologies and simple changes in behaviour can improve air quality while boosting the economy. We are consulting on a Clean Air Strategy, which will set out actions to cut damaging air pollution from a range of everyday sources.[61]

Figure 1.3: In 2016, road transport accounted for 91% of UK greenhouse gas emissions from transport



"Other Sectors" includes emissions from Public and Industrial Processes sectors

*LULUCF – Land Use, Land Use Change and Forestry

"Other Transport" includes emissions from Rail, Military Aircraft and Shipping, and Aircraft Support Vehicles

"Other Road Transport" includes Bus, Motorcycle, Other (vehicle engines), Urea Use and LPG emissions

Figures may not add up to 100% due to rounding

Source: BEIS final UK greenhouse gas emissions 1990-2016

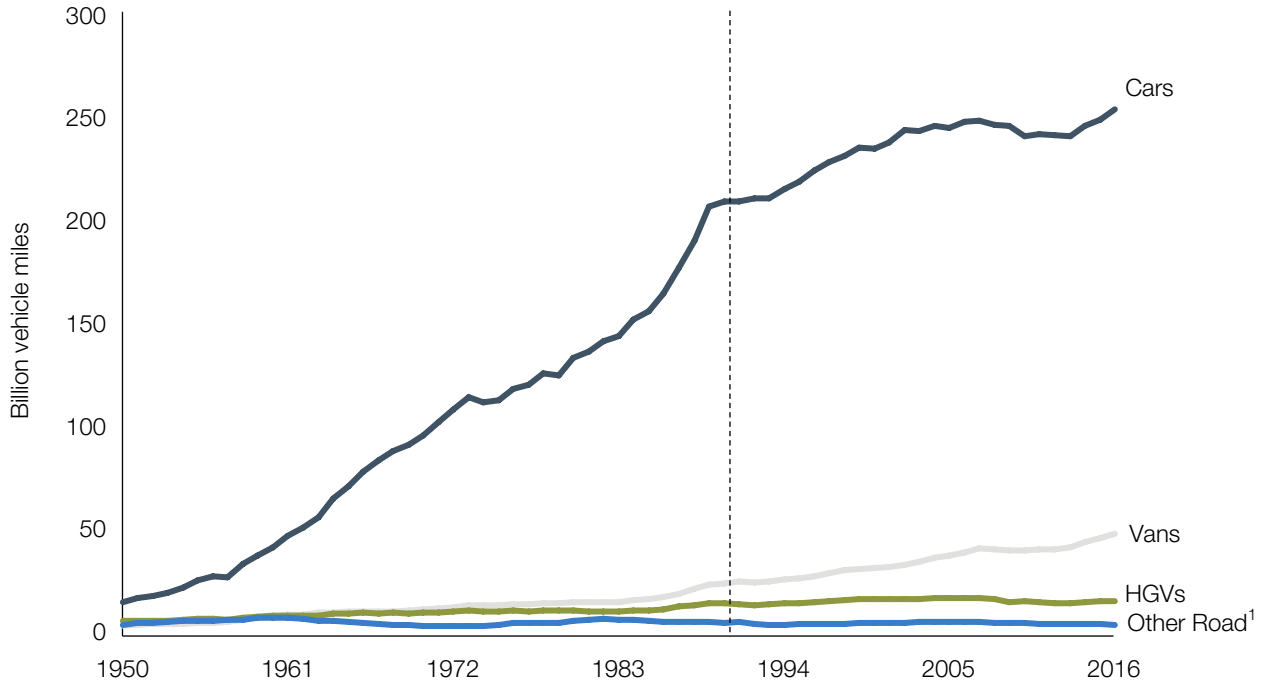
Reducing greenhouse gas emissions

The UK is a world leader in clean growth, which is at the heart of our Industrial Strategy. Clean growth means reducing our emissions while growing our economy. We have a series of legally binding carbon budgets that track progress against our long-term ambition to reduce economy-wide emissions by 80% by 2050.[62] Today, transport is the largest greenhouse gas-emitting sector in the UK, accounting for 27% of greenhouse gas emissions. Road transport accounts for 91% of this.[63]

Average laboratory-test based CO_2 emissions from new cars have fallen by over one third since 1997.[64] However, in the real world, total greenhouse gas emissions from road transport have fallen only slightly (by around 2%) since 1990.[65,66] Over the last three years greenhouse gas emissions from domestic transport have started to rise. We urgently need to reverse this trend and reduce road transport emissions.

Ultra low emission vehicles can deliver substantial greenhouse gas emission savings compared to conventional vehicles (see Annex A). The transition to zero emission vehicles and reducing emissions from new and existing conventional vehicles is crucial to meeting our long-term greenhouse gas reduction goals.

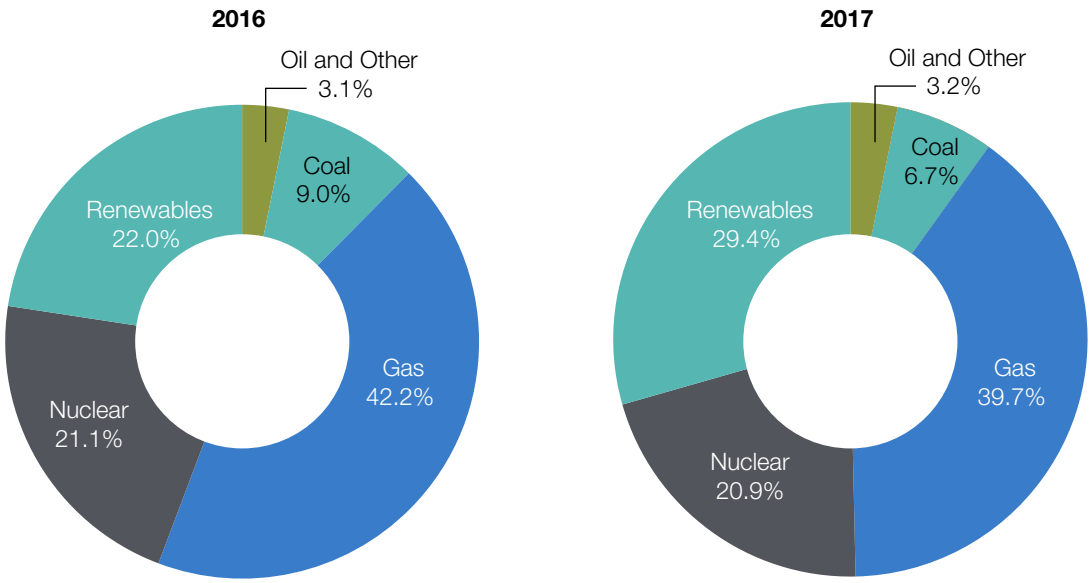
Figure 1.4: Annual car and van mileage has increased since 1990. Road transport greenhouse gas emissions have only fallen slightly since this date.



Source: DfT Road Traffic Statistics 2016 – Traffic volumes (miles)

[1] Includes Motorcycles, Buses & Coaches

Figure 1.5: The UK electricity grid is increasingly powered by renewable sources[67]



Source: BEIS (2018). UK energy statistics: statistical press release – March 2018

Lowering costs for consumers and businesses

Today, owners of electric vehicles can have substantially lower fuel and maintenance costs compared to those with conventional vehicles.[68] More fuel-efficient vehicles and operations, and the use of alternative fuels can help drive down the cost of driving. Improvements to the efficiency of automotive engine technology have meant that a new car bought in 2015 will save car owners up to £200 on their annual fuel bill, compared to a new car in 2000.[69] These savings will increase as cars become ever more efficient.

Use of alternative fuels, such as road fuel gases, can also generate savings, in part because these fuels benefit from a lower duty rate than diesel or petrol. The Government has committed to review whether current fuel duty rates for alternatives to petrol and diesel are appropriate, ahead of decisions at Budget 2018.

The Energy Saving Trust estimate that efficient driving alone could save drivers up to 5-10% of their annual fuel bill – on average around £95.[70] For the freight industry, improving the overall efficiency of operations can have significant costs savings as well as overall emissions reduction benefits.

Improving energy security

Since 2013/14, the UK has become a net importer of oil. Imports of road transport fuels have also increased over the last decade, in particular to meet the growth in demand for diesel.[71] In 2016, the costs of these imports were £1bn and £5bn for petrol and diesel respectively.[72]

Ultra low emission vehicles can help reduce the UK's reliance on oil, and exposure to the volatility of global markets. The transition to zero emission vehicles could partly replace our reliance on imported oil with largely UK generated energy sources, helping to

improve the UK's long-term energy security.[73,74]

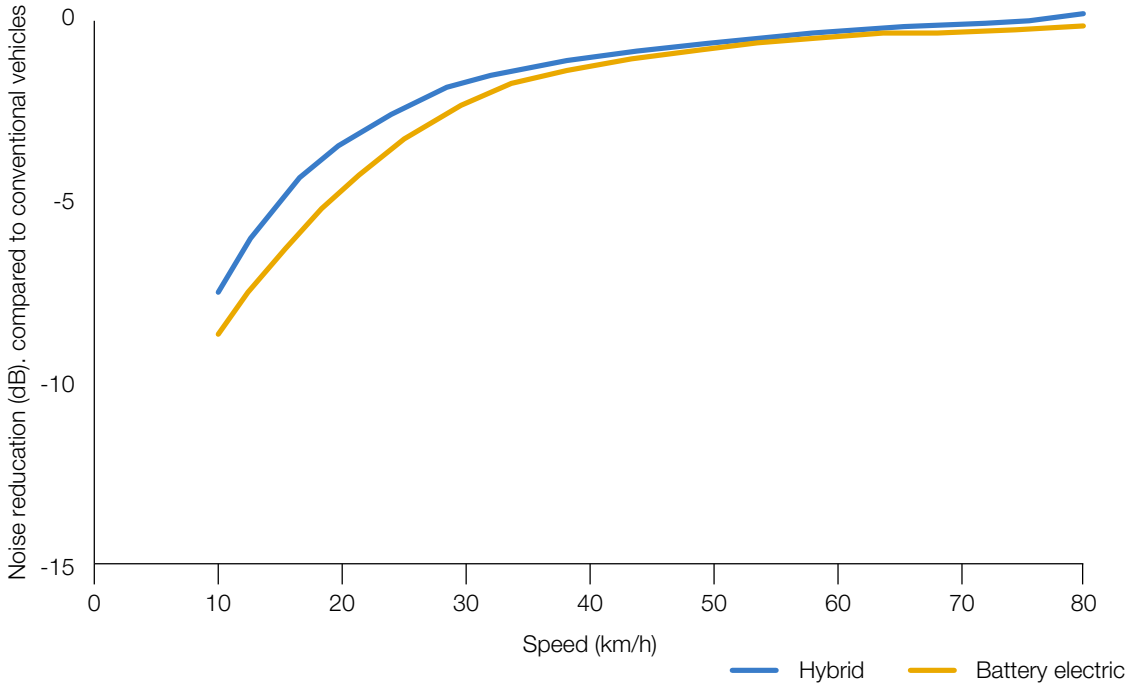
More efficient conventional vehicles on UK roads will mean lower overall fuel consumption for the economy. We have already reduced our reliance on oil imports by producing over £250 million worth of low carbon biodiesel in the UK each year, and the benefit is set to increase with the planned growth in biofuel use.

Cleaner, quieter cities

Noise from conventional vehicles affects human health and damages the environment. The World Health Organization (WHO) estimates that the noise impact of road traffic is second only to pollution as the biggest environmental impact of vehicles.[75] In England alone, the annual social cost of urban road noise is estimated to be £7–£10 billion.[76] Although the noise of vehicles travelling above 12 mph is principally due to tyres and road surface noise, at the lower speeds typically found in town and city centres engine noise is the main contributor. At low speeds, vehicles driven by electric motors are significantly quieter than those powered by conventional engines.[77]

The potential reduction in noise should be transformative for those living close to busy roads and city centres. A reduction of urban noise levels by 3dB can reduce annoyance effects by 30%.[78] At average central London speeds, the reduction in vehicle noise is approximately 8dB.[79]

Figure 1.6: Electric and hybrid vehicles are significantly quieter than internal combustion engine vehicles at low speed[80]



Source: Verheijen, E & Jabben, J (2010). Effect of electric cars on traffic noise and safety

Inclusive Travel

We want our transport systems to be developed in an inclusive way, with the needs of everyone considered. We are due to launch the Inclusive Transport Strategy shortly, which will provide further details on the steps we will take across the entire transport system to ensure this is the case. We will also launch a call for evidence on the Future of Mobility shortly. As part of this, we would welcome views and evidence on the right role for government in helping to ensure that future transport technologies and services are developed in an inclusive manner.

We want chargepoints to be easy to locate and access for all users. Existing legislation means that the provision of chargepoints is covered by the Equality Act 2010. This includes a reasonable adjustments duty that applies to, amongst others, a person or organisation providing services, goods or facilities to the public.

We also recognise the importance of vehicle noise to alert pedestrians and other road users to a vehicle's presence. The United Nations Economic Commission for Europe (UNECE) has adopted a technical standard for electric vehicle noise generators to improve pedestrian safety. Legislation will require fitment to electric vehicles entering the UK market from July 2019 and will improve safety for road users while still reducing noise pollution.[81]

Part 2

Vehicle Supply and Demand

Part 2: Vehicle Supply and Demand

Part 2a: Reducing emissions from vehicles already on our roads

In this section we consider the actions being taken to reduce emissions from the 38.9 million vehicles already on UK roads by:

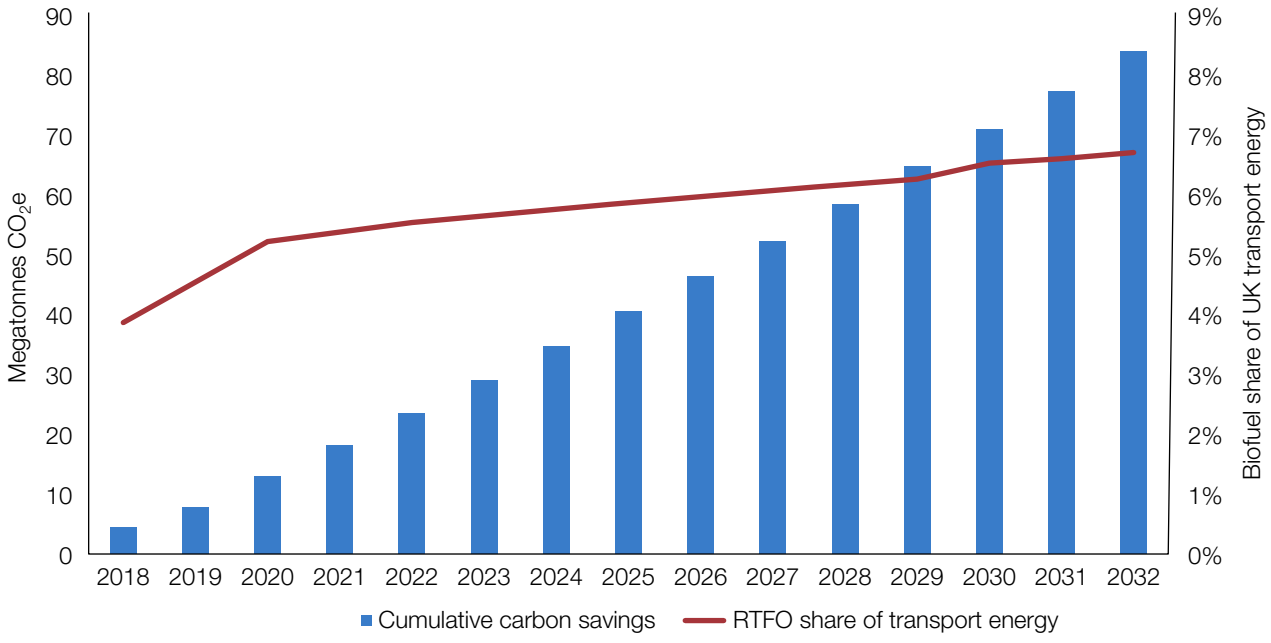
- increasing the use of low carbon fuels
- improving existing vehicles by retrofitting new technology
- influencing driver behaviour.

Increasing the use of low carbon fuels

Low carbon fuels have been one of the most significant contributors to reducing the greenhouse gas emissions of UK road transport over the last ten years. In 2008 the Renewable Transport Fuel Obligation (RTFO) was introduced, requiring fossil fuel suppliers to ensure a percentage of their fuels are renewable. As a result, sustainable, low carbon fuels are blended with the petrol and diesel used every day.

Over the next few decades demand for liquid fuels will remain high – as the majority of vehicles already on our roads and being sold today still use petrol and diesel. That means low carbon fuels will continue to play a vital role in reducing greenhouse gas

Figure 2a.1. The use of low carbon fuels in transport is increasing, delivering substantial greenhouse gas savings[82]



Source: Department for Transport (2017). The Renewable Transport Fuel Obligations Order - Government response to the consultation on amendments. Tables 13 & 28

emissions from the vehicle fleet as we move to zero emission road transport.

In September 2017 we announced a new strategy for low carbon transport fuels for the next 15 years, aligned with our Clean Growth Strategy commitments and designed to provide a firm platform for investment in sustainable advanced fuels for automotive, road freight and aviation use.[83] We committed to increasing the use of low carbon fuels in transport from its current level of around 2.63% in energy terms to around 5.26% by 2020, and 6.7% by 2032. These targets have been enshrined in legislation.[84] The amended RTFO is expected to save nearly 85 million tonnes of CO_2 over the 15-year period, and represents around a third of transport's projected contribution to UK carbon budget savings during the 2020s.

This growth is supported by the 'development fuels' sub-target within the RTFO, which further incentivises waste-based fuels made using new technologies by setting a target for specific fuels.[85] These advanced fuels deliver a range of benefits including very high greenhouse gas savings, reduced waste disposal and improvements in fuel quality, potentially with air quality benefits too. This is also designed to support investment in UK infrastructure for the types of low carbon fuel required to help reduce emissions from the most challenging transport sectors, including the heaviest HGVs, as well as aviation.

In addition to the sub-target we are providing funding to support the development of new technologies to produce advanced low carbon fuels that can lead to reduced greenhouse gas emissions in the real world. The Department for Transport's Future Fuels for Flight and Freight Competition (the F4C) makes £22m of funding available from the National Productivity Investment Fund to projects that will produce low carbon waste-based fuels to be used in aeroplanes and heavy goods vehicles.

The F4C is intended to help demonstrate the technical and commercial viability of high-potential technologies by removing fundamental barriers to scale up, enabling them to reach commercial-scale production. Government funding will be matched by the private sector, and is expected to support construction of up to five UK based, first of a kind plants by 2021.

In June 2018 we announced the seven applicants who were successful in bidding for Stage 1 funding. Each will receive a share of £2 million funding to develop their proposal for an advanced fuel production facility.

Case study: turning wastes into sustainable fuels – fatbergs

Fatbergs are the congealed lumps of waste oils and fats that block our sewers. Thanks to the incentives to utilise wastes set under the RTFO, suppliers are converting these into biodiesel to fuel our vehicles. Argent Energy recently invested £75 million in a new plant in Ellesmere Port which has the capacity to produce 85 million litres of biodiesel from these wastes. This underlines our commitment to further increasing the use of wastes to make biofuels in the UK.

We are mindful of the fact that some kinds of crop biofuels can indirectly lead to increased emissions.[86] To minimise this risk and support the move to advanced waste based fuels we will, over the 15-year period, reduce the maximum contribution that biofuels made from agricultural crops can make to our renewable transport fuel targets, sending a clear signal to industry to focus future investment in waste-derived fuels. The use of waste-derived fuels has increased from 12% of UK low carbon fuels in 2008/09 to 66% in 2016/17.[87]

Increasing the bioethanol in petrol – E10

There is also an opportunity to increase the amount of bioethanol in petrol, from up to 5% today to up to 10%. This is known as E10. E10 has been part of the industry standard for petrol since March 2013, and became the mandated reference fuel for official testing of fuel consumption and emissions for new models in March 2016. Bioethanol offers greenhouse gas savings compared to fossil fuels, even when taking other factors such as indirect land use change into account. A vehicle using E10 would emit around 2% less CO_2 than one using E5 (petrol with up to 5% bioethanol) for the same distance travelled.

Suppliers have the option of introducing E10 today, but there are some challenges to deployment, in particular incompatibility with some older (pre-2000) petrol vehicles. The Government is working with industry to facilitate any future introduction of E10 petrol to ensure that it is managed carefully, avoiding unreasonable cost rises for consumers, and ensuring ongoing availability of fuel suitable for older petrol vehicles.

Alternative uses of low carbon fuels

Low carbon fuels have potential use in other sectors beyond transport, specifically in the decarbonisation of heat. While incentivising their use, government will maintain an economy wide view of where these fuels can be used to deliver emission savings at least cost. Government will publish a new Bioeconomy Strategy soon that will set out a framework for growth in the sector to develop new low carbon bio-based products and processes.

New Fuels

We welcome innovation in technologies and fuels that can reduce poor air quality and greenhouse gas emissions in the real world. It is ultimately for industry to develop new fuels and provide evidence of their effectiveness to vehicle manufacturers, government and other interested parties. Any new product must also perform in terms of safety, performance, durability and economy; complying with appropriate performance standards.

However, where there is uncertainty over the environmental performance of a technology, or the need to independently verify the claims made by individual manufacturers, we will work with industry to do this. Clearing up this uncertainty is important not only in providing consumers and businesses with the right information to support their investment but also informing government policy around these technologies.

For example, we are conducting independent tests on paraffinic diesel, which industry claims has the potential to reduce NO_X emissions from diesel vehicles. The results will be used to assess the potential environmental benefits of using paraffinic diesel in road transport. Initial findings show considerable variability depending on the vehicle and how it is used.

Retrofitting engines

Retrofitting refers to all or part of an engine being modified with pollution-reducing and/or fuel saving technologies. Examples include: exhaust gas treatment technologies, such as selective catalytic reduction (SCR) technology; thermal management technology; fuel saving technologies such as hybridisation; and more extensive modification for fuel conversion to compressed natural gas, liquefied natural gas, electric, hydrogen or liquefied petroleum gas. These have the potential for significant reductions in emissions of air pollutants, greenhouse gases, or both. For example, accredited retrofit SCR after-treatment systems can deliver reductions in tailpipe NO_X emissions of over 80% and retrofitted battery electric engines deliver 100% reductions in tailpipe emissions.[88]

Retrofitting vehicles with pollution-reducing technology can offer a relatively low cost alternative to purchasing new low emission vehicles. It also reduces the incentive to relocate dirtier vehicles away from areas with the worst air quality problems and thus reduces overall emissions of NO_X. At present retrofitting is particularly relevant for heavy vehicles, taxis and vans operating in areas with poor air quality.

The Government believes that the continued development, promotion and implementation of innovative retrofit technology is important in reducing emissions, particularly of air pollutants, and cleaning up the existing fleet of vehicles.

Bus retrofitted with SCR technology
Source: Low CVP, Eminox

There is a small but successful retrofit industry in the UK which currently focuses mainly on buses. Several thousand vehicles have already been retrofitted in recent years under government grant programmes. Between 2013 and 2015, government awarded over £27m to retrofit almost 3,000 of the oldest vehicles (mainly buses) in England. In 2018 we launched the Clean Bus Technology Fund 2017-19, awarding nearly £40 million to twenty English local authorities to retrofit more than 2,700 buses.[89] These programmes aim to stimulate the retrofit market in the UK, supporting businesses to seize the economic opportunities of technological change and create new jobs in skilled sectors.

The Government has further supported this work by funding the Low Carbon Vehicle Partnership's Clean Vehicle Retrofit Accreditation Scheme for buses, coaches, HGVs, vans and black cabs. The scheme provides independent evidence that a vehicle retrofit technology will deliver the expected emissions reductions and air quality benefits. It enables drivers, technology manufacturers, businesses and local authorities to be confident that accredited technologies provide the appropriate emissions reductions for free entry to Clean Air Zones.

At Budget 2017, government announced a £220 million Clean Air Fund which English local authorities with the most challenging pollution problems will be able to bid into. The detail of this fund was clarified further in the recently published consultation response on Additional measures to support individuals and businesses affected by local NO_2 plans.[90] Retrofitting vehicles with accredited technology is one of the measures that is eligible for support from the fund. In London, air quality funding was explicitly addressed through the 2015 £5.7 billion Transport for London funding agreement.

Fuel-efficient motoring

Alongside physical improvements to the vehicle fleet, significant emissions reductions can be delivered relatively easily today by changing how vehicles are driven. Driving with good anticipation and smooth acceleration and braking saves fuel and cuts emissions. Correctly inflated tyres, avoiding carrying unnecessary weight and removing carriers and racks when not needed increases these benefits. The emphasis on greater anticipation brings safety benefits, and the resultant reduced tyre and brake wear delivers further cost savings and reduced pollution.

Evidence from 60,000 fleet drivers receiving training through the Energy Saving Trust (EST), a key partner supporting the efficient motoring agenda, gave an average 15% saving of fuel and CO_2. For electric vehicles range increased by 20%. Organisations that have incorporated a wider package of behavioural and procedural measures in managing their fleets (see the case study below) have delivered typical emission savings of between 10-30%.[91]

This is why we are supporting a range of complementary measures – driver training and standards, information and new technology to promote a step change in driver behaviours across company fleets and private car use.

Drive DeVilbiss Healthcare

In 2011 Drive DeVilbiss Healthcare formed a "Green Team" and engaged the Energy Saving Trust to help identify opportunities to reduce the carbon footprint and the costs of their vehicles, whilst also improving driver safety. Since then, as their fleet of vehicles has more than doubled (to 68 vans, 26 cars and 2 lorries in 2016), they have:

- installed advanced monitoring systems and speed limiting devices;
- trained over 100 company and private vehicle drivers as part of the Energy Saving Trust's Eco-driving scheme;
- introduced a driver handbook to help embed the practice amongst their drivers, which is regularly assessed and updated;
- introduced additional training for drivers with the lowest driving performance needing improvement;
- introduced better route planning to minimise mileage and relocated service centres accordingly; and
- replaced many older vehicles with Euro 6 compliant leased equivalents.

This delivered a reduction in fuel use per vehicle of around 20%. CO_2 emissions per vehicle reduced from 9.78 tonnes in 2014 to 8.40 tonnes in 2015. Moreover, the changes have resulted in significant improvements in safety, with instances of speeding dropping by over 25%.

Driving standards

There are close synergies between safe driving and fuel-efficient driving. The driving test establishes minimum standards for safe driving and the syllabus includes guidance on fuel-efficient techniques. Only a small proportion of newly-qualified drivers go on to take additional post-test training. Whilst those opting to attend the police's National Driving Offender Scheme (commonly known as speed awareness courses) will receive a reminder of fuel-efficient driving techniques, these courses cannot be mandated purely on this basis.

Going forward, we will therefore focus on novice and fleet drivers, and how recent changes to the driving test and the Driver and Vehicle Standards Agency's (DVSA) new five-year strategy can reinforce the benefits of efficient driving. This will include:

- working with the driver training industry and wider stakeholders to reiterate the benefits of driving in a more environmentally friendly fashion, particularly to learner and novice drivers;
- promoting efficient driving more prominently in DVSA publications – including those for training of instructors to highlight that it could be a theme in the assessment of instructional ability;

Source: Energy Saving Trust

- appropriate communications and messaging around fuel economy, reduced costs, journey time and wear and tear;
- encouraging fuel efficiency related initiatives as part of a new voluntary accreditation scheme aimed at increasing the number of DVSA recognised learning and training products available to drivers; and
- supporting the Driving for Better Business campaign (a Highways England initiative in partnership with Roadsafe) and collaborating with other organisations through promotion of DVSA's fleet register of trainers.

The EST and DVSA are committed to working together, and with the driver training industry, in particular on increasing the number of EST-approved driving instructors, with a greater awareness of efficient driving techniques.

Sharing best practice

There are potentially large benefits both for fleets and for the private motorist. We will work with the EST, the devolved administrations and industry groups such as the Federation of Small Businesses to seek ways to support businesses, particularly SMEs, to adopt fuel-efficient motoring and encourage uptake of efficient driving technology across the UK. We will work with motorist and consumer groups such as the AA, RAC, the Royal Society for the

Prevention of Accidents (RoSPA) and IAM Roadsmart to develop and ensure widespread use of tailored messages for targeted driver groups. Given the potential for fuel-efficient driving to support improved vehicle range this will also include messages to support wider uptake of ultra low emission vehicles.

Our new government buying standards and the government fleet commitment will mean that central government fleets will be some of the cleanest on the road. This includes embedding the use of telematics or similar technology to manage fuel use, and guidance will be published later this year. We will continue to support this work through the work of the EST, who will engage closely with the Crown Commercial Services and other key partners to enable and disseminate best practice.

New technology

The benefits of training and better information can decline over time. Previous examples have shown that after a year savings from a single efficient driving lesson fall from 15% to around 2% to 6%. Technology looks to be the best means for delivering substantial reductions in the long-term. Evidence suggests a low willingness to pay for technology if not embedded in the vehicle at the point of purchase. This is down to a lack of awareness of the fuel cost and emissions benefits, and because other than fuel savings, there are few incentives for owners and drivers to make use of the technology. Telematics technology is in use by some insurers to assess risk and set conditions around the premiums, particularly of young or novice drivers. It can be used to monitor fuel use and safe and fuel-efficient driving as well. We will:

- improve our understanding of the scope to use technology to embed best practice, examining driver trials, both for on-road safety and fuel efficiency, driver and owner attitudes to wider adoption and appropriate messaging looking to lessons learned from our fleet support programme; and
- set up a task force with the motoring and insurance industry to assess the extent to which vehicle technology is being actively used and the benefits that it brings, understand the challenges to greater use and work with that industry to develop and put in place interventions to address those challenges.

Part 2b: Driving uptake of the cleanest new cars and vans

This part sets out government support for ensuring *new* cars and vans are as clean as possible and accelerating the uptake of ultra low emission cars and vans.

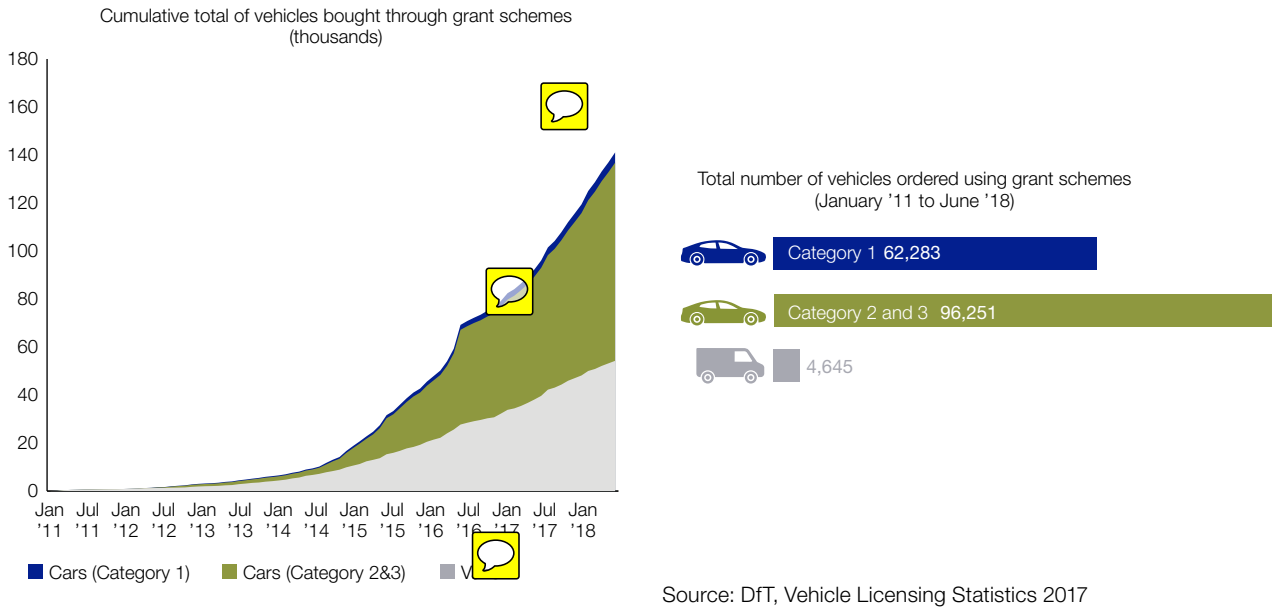
Since 2010, we have invested more than £500 million into one of the most comprehensive support packages in the world for ultra low emission vehicles. It is thanks to this stable and consistent package that the UK today has one of the largest ultra low emission vehicle markets in Europe.[92] In recent months, ultra low emission vehicles have accounted for as many as 2.7% of all cars sold.

But while we have made a strong start, we cannot be complacent. Consumer acceptance and adequate supply of ultra low emission cars and vans and consumer acceptance remain challenges. Part 3 outlines the steps we are taking to support the development of a fit for purpose infrastructure network.

We will respond to these challenges through:

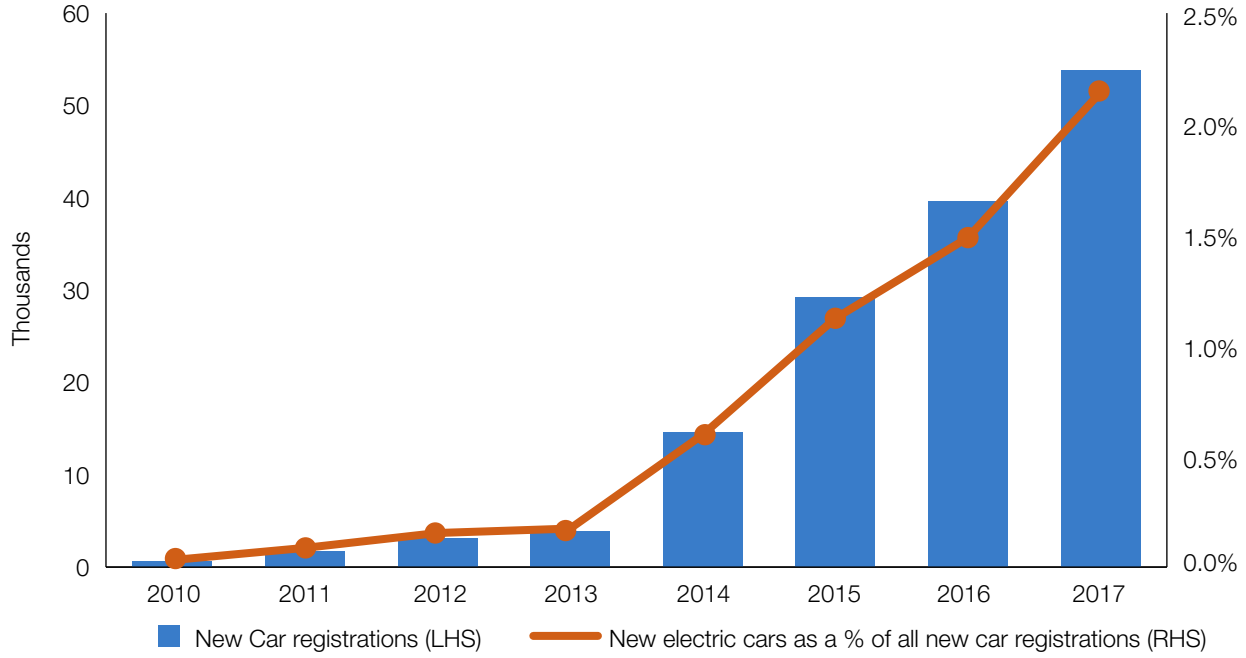
- **Regulation**: regulation is one of the most important levers to ensure manufacturers deliver cleaner and more fuel-efficient vehicles to the market and help provide a stable environment for industry investment. As we leave the EU, we will pursue a future approach to vehicle emissions regulation that is at least as ambitious as current arrangements.
- **Affordability**: ultra low emission vehicles in many cases are still more expensive to purchase than their conventional equivalents. We will continue to bring down the cost of purchasing and owning ultra low emission vehicles through grants and other incentives. Further innovation is

Figure 2b.1: The number of vehicles ordered under the plug-in grant schemes is increasing



Source: DfT, Vehicle Licensing Statistics 2017

Figure 2b.2: New electric car* registrations GB



*Includes plug-in hybrids, 100% electric, range extended electric and fuel cell electric cars

Source: DfT, Vehicle Licensing Statistics, 2018 - table VEH0253.

	CO_2 emissions (g/km)	**Zero emission range** (miles)	**Price Cap**
Category 1 (battery electric, hydrogen, and range-extended vehicles)	<50	70+	N/A
Category 2 (plug-in hybrid electric vehicles)	<50	10+	£60,000
Category 3 (plug-in hybrid electric vehicles)	50–74	20+	£60,000

a vital part of bringing the price down of ultra low emission vehicles in the long term. In Part 2d, we set out how we will continue to support the development of new ultra low emission vehicle technologies in the UK.

- **Consumer Information**: supporting consumers and businesses with the information they need to make informed decisions about the environmental impact of their vehicle choices. We will continue to work with industry to promote the benefits of switching to ultra low emission vehicles to consumers and fleets.
- **Leading the way**: we will use government's buying power to lead the way in the transition to ultra low emission vehicles.

Environmental performance of battery electric, fuel cell electric and hybrid vehicles

Battery electric vehicles (BEVs) are highly energy efficient and have zero tailpipe emissions. They also have substantially lower greenhouse gas emissions than conventional vehicles, even when taking into account the electricity source and the electricity used for battery production. Assuming the current UK energy mix, battery electric vehicles produce the lowest greenhouse gas emissions of all the energy sources and fuels assessed, irrespective of vehicle type and operation.[93] For example, a battery electric car is estimated to have greenhouse gas emissions around 66% lower than a petrol car and 60% lower than a diesel car. Between now and 2050, we project electricity grid emissions will fall by around 90%, with total greenhouse gas emissions from electric vehicles falling in parallel.[94]

These vehicles deliver both air pollutant and greenhouse gas emission reductions under all driving conditions.

The results are clear: battery electric vehicles have substantially lower greenhouse gas emissions than conventional vehicles, even when taking into account the electricity source and electricity used for battery production.

Hydrogen fuel cell electric vehicles (FCEVs) also have zero harmful tailpipe emissions. Like battery electric vehicles, greenhouse gas emissions from FCEVs depend on the method of energy production. Based on steam methane reformation (SMR), FCEVs deliver greenhouse gas emissions savings of between 10% (compared with a diesel HGV) and around 43% (compared with a petrol car).

A range of production pathways and technological improvements in hydrogen production are under development, with the potential to significantly reduce greenhouse gas emissions.

FCEVs have two advantages over early models of BEVs: fast refuelling with high-pressure hydrogen (typically 5 minutes) and longer range (typically over 300 miles). The development of longer range battery electric vehicles, greater deployment of higher speed recharging has started to erode some of these advantages, and the lower 'round-trip' efficiency of hydrogen as a fuel means that it remains more expensive than electricity for the consumer. In the long term, hydrogen vehicle technologies may be well suited to use in HGVs and by fleet operators.

At present, there are 12 hydrogen refuelling stations available for public use in the UK, and providers have announced plans for at least four more. There will be approximately 250 FCEVs on UK roads by the end of 2018. Part 3 sets out our strategy for hydrogen fuel cell electric vehicle infrastructure in the UK.

Although the environmental performance of **range extenders, plug-in, and non-plug-in hybrids** depends on their use and zero emission range, these vehicles are amongst the cleanest vehicles on the market. They are an important way of helping motorists make the switch to a different way of powering their vehicles. A full **petrol hybrid electric car** is estimated to deliver greenhouse gas emissions reductions of around 5% (compared with a diesel car) and 20% (compared with a petrol car). A **plug-in petrol hybrid electric car** is estimated to deliver greenhouse gas emissions reductions of around 33% (compared with a diesel car) and 43% (compared with a petrol car).

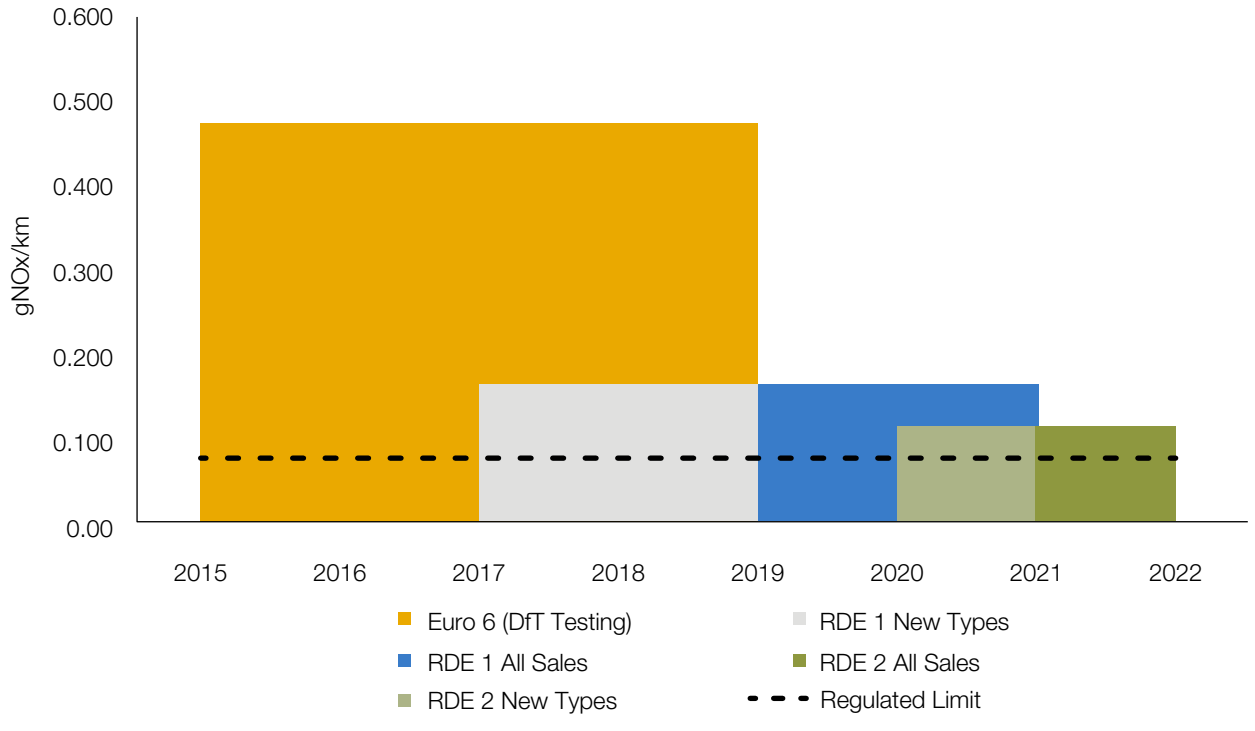
Regulation

EU emissions regulation currently cover:

- **Tailpipe pollutant emissions**: these regulations set the maximum levels of certain air pollutants that can be emitted by vehicles during a range of test. These are known as Euro standards and cover pollutants including hydrocarbons, carbon monoxide, nitrogen oxides and particulate matter.
- **Tailpipe CO_2 emissions**: these regulations place a requirement on vehicle manufacturers to ensure that the average CO_2 emissions from their sales of both new cars and new vans meet certain targets.

As we leave the EU, we will pursue a future approach that is at least as ambitious as current arrangements for vehicle emissions regulation. We want to see an approach that improves air quality and reduces

Figure 2b.3: New Real Driving Emission (RDE) regulations set limits for new diesel cars which are designed to decrease real world NO_x emissions. RDE limits include measurement uncertainty.



Source: DfT testing, EU RDE Acts

greenhouse gas emissions, and regulation will be critical in supporting our ultimate aim of delivering our 2040 mission.

Restricting tailpipe pollutant emissions: Euro standards

Since their inception in 1992, the Euro standard regulations have led to large improvements in emissions of air pollutants from new vehicles. However, these regulations have not achieved the reduction in emissions of NO_X from diesel cars and vans in real world use expected from the laboratory test results. The gap in some cases is large. We published the results of on-road emissions testing in April 2016 and on average the measured road test NO_X emissions from Euro 5 and 6 diesel cars were over six times higher than the official legislative laboratory test limit.[95]

While real world standards to address this were introduced for heavy duty vehicles (trucks and buses) in 2013, they have only recently been agreed for cars, vans and taxis. We led calls for action at a European level to ensure these standards became a reality.

The Real Driving Emissions (RDE) requirements that came into force in September 2017 require that manufacturers limit emissions of both NO_X and particulates across a wide range of normal driving conditions. These measurements are taken in the real world, which is a big step forward. We welcome the continued innovation and investment by vehicle manufacturers to

The role of diesel in the transition to zero emission vehicles

Cleaner **diesel cars and vans** can play an important part in reducing CO_2 emissions from road transport during the transition to zero emission vehicles whilst meeting ever more stringent air quality standards. For diesel vehicles to play their part fully, their air quality impact must continue to be reduced. We want new cars and vans to be as clean as possible as fast as possible. We welcome the continued innovation and investment by vehicle manufacturers to develop cleaner diesel vehicles that meet the more challenging Real Driving Emission (RDE) requirements, delivering critical improvements in NO_X emissions on the road.

Fleet turnover to the newest, cleanest cars and vans will play an important part in reducing emissions from the vehicle fleet. In air quality terms a new conventional vehicle will almost always be cleaner than an older one of the same type. But zero emission cars and vans are now available and are the best option environmentally.

If zero emission technologies are not currently practical, the most appropriate vehicle technology will depend on drivers' individual circumstances, including location and usage pattern. In most cases, for cars principally being used in urban areas where journeys tend to be shorter and at slower speeds, petrol hybrid, other alternatively fuelled or new conventional petrol cars are likely to be most suitable. Diesel is more suitable for vehicles, including cars, that regularly drive long distances or carry heavy loads.

develop cleaner diesel vehicles that meet these more challenging requirements, delivering critical improvements in NO_X emissions on the road.

Achieving these tougher standards for cars and vans will require wide scale adoption of the most effective emissions control technologies. Some of these technologies may cause emissions of other air pollutants or greenhouse gases. For instance selective catalytic reduction (SCR) technology, which helps remove NO_X from diesel tailpipe emissions, also emits small amounts of nitrous oxide (N_2O) which is a powerful greenhouse gas. We will seek to work closely with the industry to monitor this and consider options for tackling any issues where necessary.

Enforcing emissions limits

It is vital that we know that the technologies used to reduce emissions are working effectively and achieving the real world reduction we expect to see throughout a vehicle's lifetime. We are aware that, in some trucks, for instance, these technologies are being disabled. For HGVs the DVSA have begun conducting roadside checks to identify drivers and operators circumventing emissions controls and in targeted checks have found almost one in 12 trucks to have had their emissions control systems disabled.[96]

We are committed to working further with the DVSA, VCA and industry to ensure that our regulatory and enforcement regimes give us the levers we need to tackle this problem. It is already an offence to use a vehicle which has been modified in such a way that it no longer complies with the air pollutant emissions standards it was designed to meet. We will continue work to ensure the relevant regulations apply to emerging technologies and will commission research into the most effective methods of detecting attempts to tamper with emissions reduction systems. This will build on previous work conducted here and elsewhere in the EU. As set out in the Clean Air Strategy consultation, we intend to build on our existing regulations to make tampering with an emissions control strategy a legal offence.

In 2016, the Government established a new Market Surveillance Unit in DVSA to test vehicles and components on the UK market and ensure they meet the standards to which they are approved. DVSA works closely with the Department for Transport and VCA to deliver this programme which has initially focused on vehicle emissions testing. The Unit expects to continue expanding its testing to a wider range of vehicles and components in future years.[97]

While Euro standards have focused on tailpipe emissions, reducing particulate matter from other sources such as brakes and tyres is also important. As the existing regulatory regime has driven substantial reductions in tailpipe emissions, emissions from brakes, tyres, road wear and dust thrown up by vehicles now form around 60% of particulate matter attributed to road transport.[98]

The UK government is actively involved in the United Nations Economic Commission for Europe (UNECE) working group discussions and research to tackle this problem.[99] We will launch a call for evidence on non-exhaust emissions of particulates from tyre, brake and road wear to improve our understanding of these emissions and consider options for how they may be reduced.

Reducing CO_2 emissions

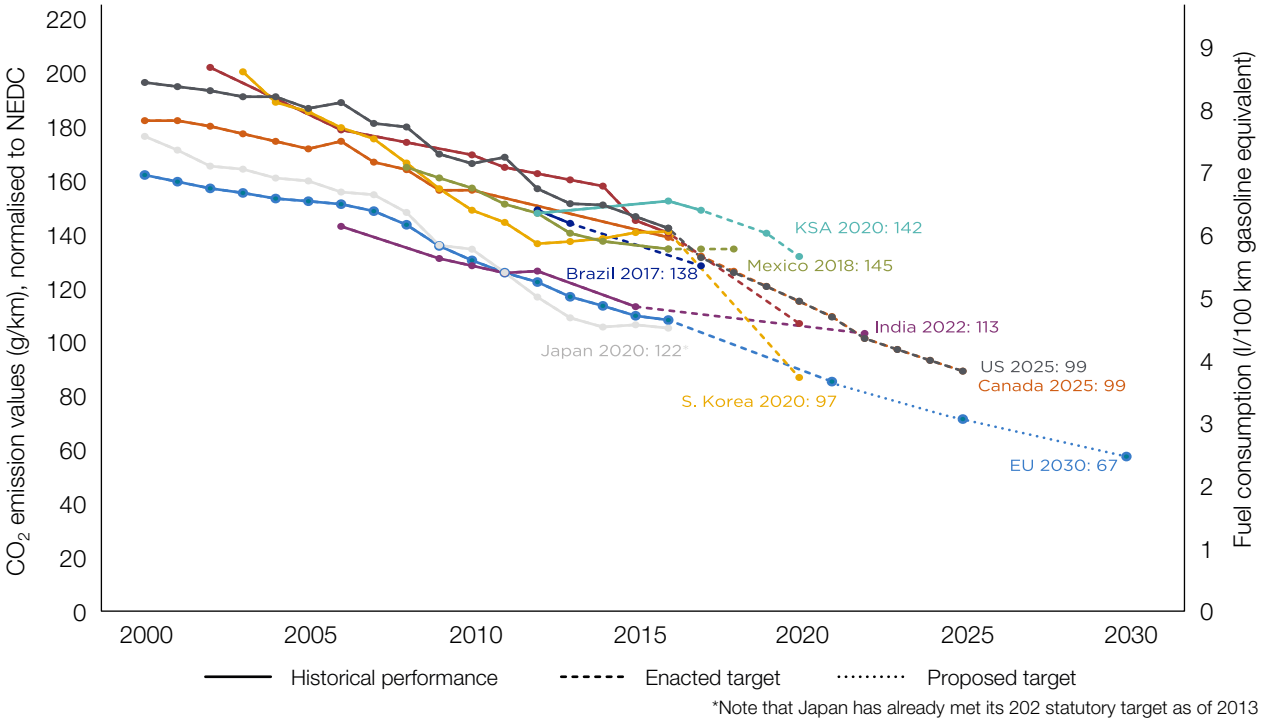
EU regulations on the CO_2 emissions from new cars and vans were introduced in 2009 and 2011 respectively and have driven industry investment in improving fuel efficiency. However, historically much of this investment has been primarily focused on incremental improvements to internal combustion engine vehicles rather than a shift to zero emission vehicles.

We continue to work at the European level to develop future CO_2 emission regulations for cars, vans and now heavy-duty vehicles (HDVs).[100] Recent draft proposals from the European Commission have adopted a familiar approach and do not mandate ultra low or zero emission technologies.

As with air pollutants, there has been a difference between laboratory and real-world driving CO_2 emissions. Studies have shown that while the CO_2 emissions of new vehicles in the laboratory have reduced significantly in recent years, this level of reduction has not been seen on the road. This poses a risk to emission reduction efforts and is why a new laboratory test cycle known as WLTP (Worldwide Harmonised Light Vehicle Test Procedure) was introduced in September 2017. This test is more stringent and we expect its introduction to significantly reduce this gap.

Relying on incremental improvements in internal combustion engine efficiency, reducing the gap between real world emissions and lab tests, and extending standards to heavier vehicles is not enough to meet our long-term ambitions. Our approach needs to drive towards delivering our 2040 mission. It is important that future emissions regulation enables Europe's automotive industry to transition and

Figure 2b.4: International targets for fleet CO_2 emissions are driving down average emissions[101]



*Note that Japan has already met its 202 statutory target as of 2013

Source: ICCT (2018). Overview of Global Fuel Economy Policies

The Worldwide Harmonised Light Vehicle Test Procedure (WLTP)[102]

In 2017 the WLTP was introduced to measure the official fuel consumption and CO_2 emissions of new cars and to check their compliance with air pollutant emissions limits. Manufacturers seeking type approval for new models are already required to use this test, and it will become mandatory for all new cars by September 2018.

The new testing regime aims to provide a closer representation of 'real-world' fuel consumption and CO_2 figures and provide model specific values at the point of sale that take into account the options specified. It differs from the outgoing NEDC process in a number of ways although all tests will continue to be conducted in a laboratory allowing meaningful comparisons between cars to be made. The WLTP driving cycle is divided into four parts with different average speeds: low, medium, high and extra high. The cycle contains a variety of driving phases, stops, acceleration and braking phases.

Source: HORIBA MIRA

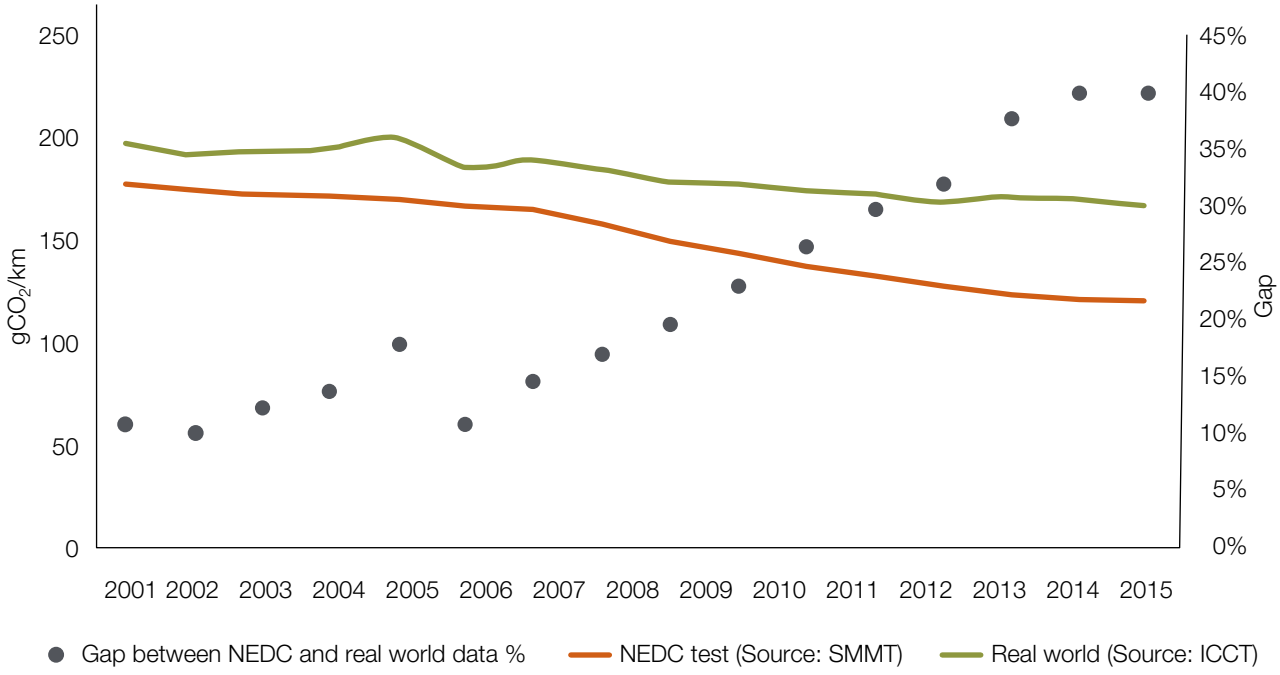
compete with the significant investments in zero emission vehicle technology taking place across China, wider Asia and North America.

The EU Commission has proposed a minimum regulatory expectation on manufacturers of 15% of new car sales to be 'zero or low emission vehicles' (defined as having tailpipe emissions of less than 50g CO_2 per km) by 2025 and 30% by 2030. This is below the UK's level of ambition.

Local action

National and international vehicle standards are not the only frameworks that will incentivise the move to a clean and ultimately zero emission fleet – ambitious local action has a major role to play too.

Figure 2b.5: The gap between real world and NEDC new car CO_2 emissions has increased



Following publication of the *NO_2 plan* in July 2017, Ministers directed 28 local authorities to develop local air quality plans to bring their areas into compliance with legal NO_2 limits in the shortest time possible. For some, this is likely to involve introducing a Clean Air Zone to restrict entry of the most polluting vehicles. The Clean Air Zone framework, published by government in May 2017, sets out the different classes of Clean Air Zone and the types of vehicles each applies to. Ministers also directed a further 33 English local authorities with shorter-term air quality problems to carry out targeted feasibility studies to recommend measures which would achieve compliance with NO_2 limits in the shortest possible time. Part 4 sets out the steps we will take to support local leadership to drive down road transport emissions.

Financial incentives: Cars, vans, HGVs and taxis

Government currently offers a range of incentives to support consumers to make the shift to ultra low emission vehicles, including the tax system, direct grants and other financial support. These remain important and consumer incentives in some form will continue to play a role beyond 2020.

Tax incentives[103]

For ultra low emission **cars**, the current UK incentive package includes lower rates for vehicle excise duty (VED) – with zero emission vehicles paying no VED and from 2020-21, longer zero emission ranges will be incentivised through the company car tax system. As no fuel is consumed by battery electric cars, no car fuel benefit charge is due either. The combined savings can add up to thousands of pounds.[104]

HMT announced in March 2018 that it will exempt almost all drivers of purpose built ultra low emission **taxis** bought from April 2018 from paying the VED supplement for vehicles over £40,000. This will save ultra low emission taxi drivers £1550 over 5 years. When coupled with considerable savings on fuel and the plug-in taxi grant of £7,500, the package is a significant incentive to switch to the new electric taxis.[105]

Zero emission **vans** only pay a small proportion of the van benefit charge (40% for 2018-19). Electric vans are not subject to van fuel benefit charge. To promote continued uptake of ultra low emission vans, we are consulting on a new van Vehicle Excise Duty regime linked to vehicle emissions.

The Government continues to charge a reduced rate of VAT, currently 5%, on electricity used to recharge a plug-in vehicle at home, lower than for other road fuels charged at the standard rate, currently 20%.

For businesses:

- since April 2018, there has been no benefit in kind (BIK) liability for electricity provided to charge employees' own electric vehicles;
- an enhanced capital allowance (ECA) is currently available for businesses investing in new electric vehicle charging or gas refuelling infrastructure, allowing them to deduct the full cost from their profits before tax. An ECA is also available for purchasing zero emission goods vehicles.[106]

To help local authorities in England implement their plans to reach legal NO_2 compliance, government has introduced a £255 million implementation Fund. The additional £220 million Clean Air Fund will allow them to help individuals and businesses adapt to these plans.[107] The Government published its response to a consultation on the potential options local authorities might consider in doing this, including provision of financial incentives to encourage use of lower emission or ultra low emission vehicles.

The Clean Air Fund and the Implementation Fund are paid for by:

- a VED supplement applied to new diesel cars first registered from 1 April 2018, so that their first year rate is calculated as if they are in the VED band above;
- a rise in the existing company car tax diesel supplement from 3% to 4%, with effect from 6 April 2018.

Those purchasing diesel cars meeting the Real Driving Emissions step 2 standards, also known as Euro 6D-Final (see Figure 2b.2) do not pay either of these supplements. These changes aim to encourage manufacturers to bring forward next-generation, cleaner diesels as quickly as possible.

The Chancellor also announced that the Government will end the fuel duty escalator for LPG, which will help to unlock investment in this niche market, supporting uptake of lower emission LPG vans and taxis in the transition to zero emission vehicles.

Direct grant support

Today, the upfront cost of ultra low emission vehicles is still higher than for conventional equivalents. Costs are coming down. For example, battery prices (a large part of the current total cost of electric vehicles) have fallen almost 80% since 2010.[108] However, falling battery costs have largely been offset by an increase in the battery size used in vehicles, increasing the vehicle range. Vehicle manufacturers also need time to ramp up the production of ultra low emission vehicles as demand grows.

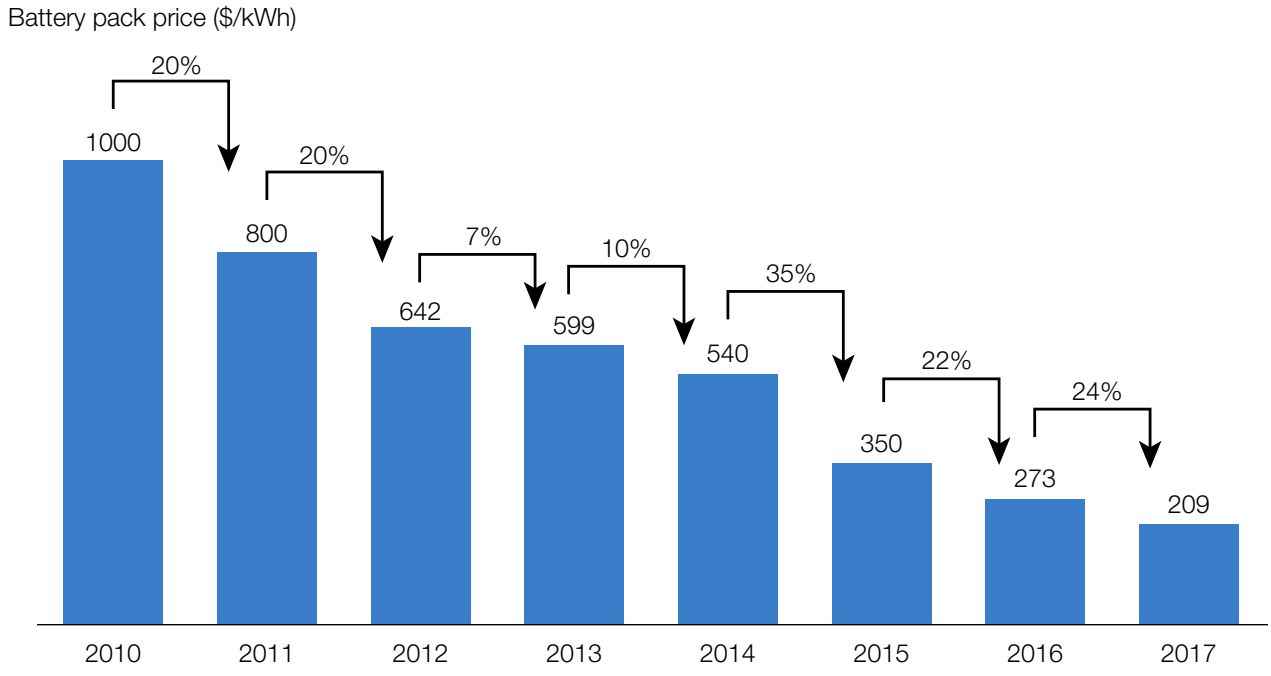
We expect prices to continue to fall and for vehicle manufacturers to bring increasing numbers of affordable models to the market.

Cars

The plug-in car grant was introduced over 7 years ago as an introductory measure to help offset the higher upfront purchase price of ultra low emission cars. We will continue the plug-in car grant until at least 2020 and will continue current plug-in car grant rates until at least October 2018. By 2020, we will have supported this market for almost a decade. We have already supported the purchase of more than 150,000 vehicles. In the coming years, we expect sales will increasingly be driven by tougher global emission regulations, and accelerating consumer demand thanks to longer vehicle ranges and greater vehicle choice.

With rising sales, the long-term continuation of the plug-in car grant will become unviable in terms of cost to the taxpayer. We therefore expect to deliver a managed exit from the grant in due course and to continue to support the uptake of ultra low emission cars through other measures.

Figure 2b.6: Electric vehicle battery pack prices have fallen almost 80% between 2010 and 2017



Source: Bloomberg New Energy Finance

Vans

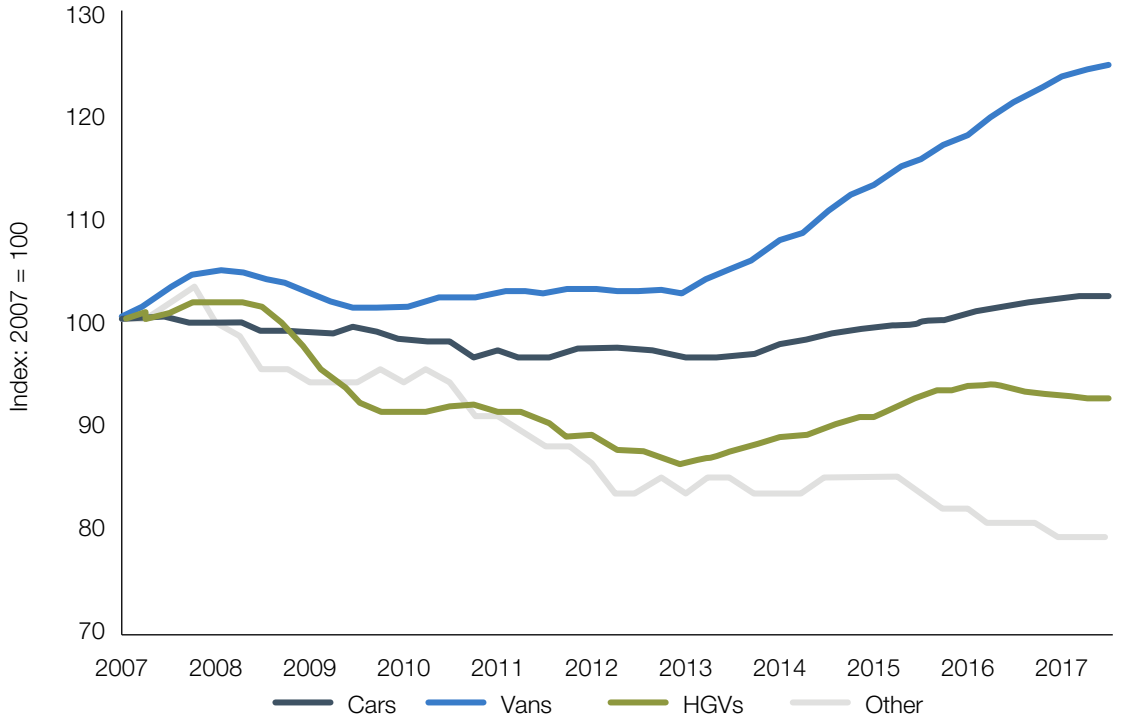
Our 2016 greenhouse gas emissions statistics show that emission reductions from cars have been partially offset by increases in emissions of CO_2 from light duty vans.[109] A variety of factors including the growth in popularity of internet shopping has led to an increase in the van miles travelled in urban areas.[110] Around 96% of the vans on the road in the UK in 2016 were diesel, compared to 60% in 1996.[111] In 2016, 33% of the NO_X emissions from road transport were from vans.[112]

The market for vans is smaller than cars; by way of comparison, in 2017 there were 2.5 million new car registrations versus around 360,000 new light goods vehicle registrations.[113] Since 2012 fewer than 5,000 vans have received the plug-in van grant. Demand has been constrained by the limited availability of models – the majority of which are battery electric vehicles.

Other factors have also affected the growth of the market, such as the reduced payload compared with a diesel vehicle. To help compensate for lost payload capacity due to the added weight and size of some current alternative fuel technologies, we are legislating to allow category B (car) licence holders to drive certain alternatively fuelled vehicles up to a maximum weight of 4.25 tonnes (rather than 3.5 tonnes).

Faster progress is needed. There are positive signs, with improvements to battery range in existing models as well as new larger electric and range extended models due to be released in the coming months and years. Some of the biggest van manufacturers such as Ford, Mercedes, Volkswagen and Renault are trialling vans.

Figure 2b.7: Van mileage has increased in recent years relative to other vehicle types



Source: Department for Transport – Road Traffic (vehicle miles) by vehicle type in Great Britain

Vans

There are more than 4 million vans in use across the UK and they are key part of the UK economy. Vans do much higher mileage than cars and are largely for business use so cost (in particular cost of ownership), utility, and reliability are key factors in purchasing decisions. There has been a trend towards larger vans in recent years, giving drivers more flexibility in terms of their use.[114]

Diesel vans offer good driveability and reliability when pulling heavy loads and good fuel economy for high mileage vehicles. This has led to manufacturers offering predominantly diesel vans in Europe, in response to consumer demand. However, current diesel vans emit high levels of nitrogen oxides (NO_X), contributing to air pollution problems in our towns and cities. In 2016, 33% of road transport nitrogen oxides emissions were from vans.[115]

We want vans to be as clean as possible, as fast as possible. We want up to 40% of new van sales to be ultra low emission by 2030 and all new vans to be effectively zero emission by 2040. Ultra low emission vans provide substantial reductions in both NO_X and greenhouse gas emissions but they currently make up only 0.3% of new sales and these are principally small electric vans.[116] We will continue to incentivise their purchase and we want to see manufacturers bring forward more options.

Where ultra low emission vans are not currently practical, the purchase of (or repowering to) methane or liquid petroleum gas vans can substantially reduce NO_X emissions compared to most current diesel equivalents without increasing greenhouse gas emissions. However unfamiliarity and a lack of vehicles and refuelling infrastructure has limited uptake of gas vans.

Petrol vans have lower NO_X emissions than current equivalent diesel vans but are less fuel efficient leading to higher greenhouse gas emissions. Nevertheless, they could be a better option for those operating in urban areas and with lower mileage.

We welcome the investment and innovation that diesel van manufacturers are making to meet the new RDE standard and deliver critical improvements in NO_X emissions on the road. These cleaner (RDE compliant) diesel vans are expected to have significantly lower NO_X emissions than those currently available and will play a key role in improving air quality during the transition to zero emission vans.

Examples of fleets leading the way

Royal Mail

The Royal Mail fleet now has more than 49,000 vehicles in operation. Last year the company made two ultra low emission vehicle announcements. The first was a trial of large electric delivery vehicles (up to 7.5 tonnes), supplied by Oxfordshire-based manufacturer Arrival. These vehicles will deliver mail from central London to sites around the south east of England. The second was the purchase of 100 Peugeot Partner electric vans, which are already in active duty around the UK.

Source: Royal Mail

A number of companies are developing and building ultra low emission vans in the UK, supporting UK jobs and growth and new export opportunities.

These include:

- battery assembly for Nissan's eNV200 in Sunderland;
- Arrival is to build vans (from 4 tonnes) and heavier vehicles at their Banbury site; and
- the London Electric Vehicle Company is building a range-extended electric van at their Coventry site.

Like cars, ultra low emission vans and trucks are more still expensive than their conventional equivalents. We will continue the plug in van grant in some form until at least 2020. We will continue current rates of the plug in van grant until at least October 2018 with a review around this time.

Examples of fleets leading the way

UPS

UPS has one of London's largest fleets of electric vehicles. They currently operate 62 electric vehicles out of their Kentish town depot, but have plans to electrify 100% of their central London fleet.

With the help of OLEV funding, a UPS-led consortium recently deployed new charging technology that allows it to recharge an entire fleet of electric vehicles (EVs) without the need for an upgrade to the power supply grid. This will allow UPS to replace all of the 170 trucks currently operating from its central London site with EVs.

The innovative charging solution combines smart-grid and energy storage technologies. It is believed to be the first time these systems have been deployed at this scale anywhere in the world. UPS believes the day is rapidly drawing closer when the cost of an urban distribution electric vehicle, including the necessary power supply investments, will be lower than that of its diesel counterpart.

Source: UPS

Motorcycles

The market for zero emission motorcycles is at an earlier stage than either cars or vans. Zero emission motorcycles can help reduce congestion, improve urban air quality and reduce noise. While cars outnumber motorcycles by more than 24 to one on UK roads, motorcycles are a sizeable vehicle population, with almost 1.3 million currently licensed.[117] Since the launch of the plug-in motorcycle grant in 2016, nine manufacturers have had bikes approved to the scheme with more than 20 models currently available at a range of prices and specifications.

In 2017, around 100 zero emission motorcycles were ordered via the plug-in motorcycle grant in the UK.[118] To continue to support the development of the market and bridge the cost gap that remains between

Last mile deliveries

We are considering further options for reducing emissions for last mile deliveries, particularly in urban areas. We will shortly launch a call for evidence on this subject, including exploring for the first time providing grants and/or other financial incentives to support the use of e-cargo bikes.

zero emission and petrol motorcycles, we will continue the plug-in motorcycle grant until at least 2020. We have also supported research and development into zero emission motorcycle technology through the Niche Vehicle Network. Other, future R&D opportunities for zero emission motorcycles include OLEV's Integrated Delivery Programme and Innovate UK's Open competitions for SMEs.

Other vehicles

We cover buses and purpose built taxis in Part 4 and HGVs in Part 2c. We are confident the investment we are making across vehicle types will provide spill-over benefits and improvements to a wider range of vehicles, for instance refuse vehicles, coaches and minibuses. We welcome more ultra low emission versions of these vehicles being introduced and used.

Residual values and resale of ultra low emission vehicles

Residual values (i.e. the price a vehicle can be sold for second hand) play an important role in determining the first hand purchase and lease costs of vehicles for consumers. The second hand market makes ultra low emission vehicles an option for consumers and businesses unable to afford new cars or vans and needs to be ready for an increasing number of these vehicles.

There are reports of a lack of dealer and auction house understanding and a lack of consumer confidence in the longevity of vehicle batteries dampening the re-sale value of these vehicles. We have already supported Energy Saving Trust to deliver dealer training sessions. We will:

- work with the National Association of Motor Auctions (NAMA) to publish electric vehicle guidance for sellers, dealers and auction houses;
- explore changes to the V5 documentation that is handed to new owners when a vehicle is sold, to include the specifications of ultra low emission vehicles e.g. battery size and electric energy consumption;
- continue to fund training sessions for new and used car and van retailers and to the motor auction community; and
- establish a regular forum with dealers, auction houses, price guides and BVRLA to improve uptake of second hand electric cars.

Providing information to consumers and businesses so they can make confident decisions about what's right for them

We want to provide clear information to consumers about the environmental performance of different fuel and vehicle choices. This is a shared challenge with industry, dealerships and consumer groups.

The Department for Transport will therefore, in partnership with a number of key motoring organisations, set up a Road Transport Emissions Advice Group. This Group will bring together industry stakeholders with consumer groups and communications experts to work together to address the challenges of clear and consistent consumer messaging and advice on fuel and technology choices across the UK. Some immediate challenges that the Group will

Go Ultra Low

A press advert from the 2017/18 Go Ultra Low campaign. Source: Go Ultra Low

Go Ultra Low (GUL) is a joint government-industry marketing campaign which aims to increase the uptake of ultra low emission vehicles in the UK. Launched in 2014, GUL has had considerable success and has grown since its inception.

In 2017/18, the Go Ultra Low campaign set out to demonstrate how electric cars can fit into people's lives and fulfil their driving needs by addressing a range of common concerns including cost, driving range and charging.

The campaign told the story of ultra low emission vehicle owners from across the UK and created a series of videos and content through radio, video on demand, online, press and the GUL website. GUL also developed four tools which allow consumers to calculate for themselves the benefit of owning an electric vehicle in terms of journey cost, car tax, journey range and home charging. This included a journey cost saving calculator, a car tax calculator, a journey range calculator, and a home charging calculator.

More than 600,000 people have visited the newly launched GUL website since October 2017 with over 115,000 landing on the tools. Videos which tell the stories of real owners have been viewed more than 19 million times.

96% of a sample group surveyed said the adverts made them feel more positive about electric vehicles. Attitudinal tracking carried out before and after the campaign showed a 13% increase in consumers who stated electric vehicles are a credible alternative to petrol and diesel cars. Intention to purchase an electric vehicle also increased by 19% after the campaign.

Moving to ultra low emission options: fleets

To provide fleets with the support they need to make the switch to ultra low emission vehicles we will fund fleet reviews through the Energy Saving Trust. The Energy Saving Trust programme will continue to focus on SMEs who often lack the organisational capacity to take advantage of efficient fleet operations. With the potential implementation of Clean Air Zones there is a growing need to 'future proof' smaller fleets and support local authorities in implementing measures that will facilitate achieving compliance within Clean Air Zone cities.

GUL Companies celebrates the public and private sector organisations that have made a commitment to an ultra low emission future. The scheme is open to businesses that have at least one plug-in vehicle on their fleet now, and commit to have them make up at least 5% of their total vehicle fleet by 2020.

To date, more than 140 private and public sector organisations have joined the scheme. Members range from small and medium-sized enterprises with a handful of plug-in vehicles on their fleet, through to household names such as Microsoft and Europcar that have over 100.

consider include how to provide clear guidance to consumers on:

- the change in car and van CO_2 emissions test methodology, which will result in more representative fuel economy figures than the current methodology used;[119]
- new fuel labels to be introduced, which will highlight to motorists the existing biofuel content of conventional petrol and diesel fuels;
- the potential introduction, by fuel retailers, of a new fuel grade (known as E10) in order to help meet UK requirements for the supply of biofuel; and
- the potential introduction of Clean Air Zones, or other types of emissions standard-based charging zones, by local authorities in areas where this is necessary to meet legal requirements in the shortest possible time.

We know confusion persists about the ultra low emission options now available. Surveys indicate uncertainty about the technology, price, infrastructure and range continue to be barriers to further uptake. We want these vehicles to be a well-understood option for consumers and to promote the benefits of making the switch.

We will continue working with industry on consumer communications about ultra low emission vehicles until at least 2020 and launch a 2018/19 Go Ultra Low campaign to promote the benefits of ultra low emission vehicles to consumers and businesses.

Defra and Environment Agency fleet

In 2016 Defra announced plans to bring together partners who have fleet operations under a single service provided by the Environment Agency team. Following the formation of Defra Group Fleet Service in 2016, the service delivered an annual saving of £500k through the merging of policies and processes and by combining procurement needs into a single aggregated tender.

In late 2017 they set out a strategy to be the leaders in government by committing to purchase only petrol plug-in hybrid or battery electric cars by 2025. They anticipate this will reduce CO_2 and NO_X significantly, and in the first year alone has seen new cars CO_2 fall by 10% and NO_X fall by 88%. Their aim is to have 100% of the car fleet ultra low emission by 2025, alongside a high proportion of their commercial vehicles.

Government leading the way

We want central government to lead the way on ultra low emission vehicles. In December 2017 new government buying standards for transport committed to new government vehicle purchases being ultra low emission by default, with alternatives considered only in exceptional circumstances. A requirement within these standards is to electrify 25% of the central government car fleet, meaning that one in every four cars will be ultra low emission by 2022.

It will be for individual government departments to determine how they work towards this target. However, OLEV is providing guidance to fleet managers with more detail on how the target will be met. We expect these steps to encourage both public and private fleets across the country to adopt ambitious targets. We are committed to 100% of the central government car fleet being ultra low emission by 2030.

Part 2c: Setting a clear pathway to reducing emissions from HGVs and progress to zero emission solutions

Heavy goods vehicles (HGVs) are the lifeblood of the UK economy transporting goods to consumers and businesses.[120] However, HGVs are a major source of pollution – accounting for 18% of greenhouse gas emissions and 13% of nitrogen oxide (NO_X) emissions for road transport in 2016.[121,122]

Government's long-term goal is the development and deployment of zero emission HGVs. While the pathway to achieving this is not as clear as for cars and vans, technologies are starting to emerge even for the largest vehicles – Cummins, Mercedes and Tesla have now produced large electric battery trucks.

But industry needs high confidence in the operational performance of these technologies in order to invest further, before they will become a commercial reality.

Government can play a key role in supporting R&D, real-world trials and demonstrations and we remain committed to supporting our industry to capture the economic benefits of developing and deploying these exciting new technologies.

As solutions emerge it remains essential to scale up and expand the behavioural and efficiency measures that can reduce emissions from existing HGVs.

Reducing emissions in the near term

HGV operators are increasingly adopting measures that help deliver marginal improvements in fuel efficiency and environmental performance. This includes driver training, telematics, aerodynamic equipment and more efficient tyres.

R&D for low and zero emission HGVs

Low Emissions Freight and Logistics Trial (LEFT). In 2017, OLEV and Innovate UK awarded £20 million of grant funding to 20 projects, leveraging £12m in private investment. The aim is to support industry-led trials of alternative propulsion technologies for commercial fleets in the UK, including electricity, hydrogen and gas. This will include emissions testing of a number of the latest gas HGVs. The results of this testing will be used to inform decisions on future government policy and support for natural gas as a potential near term, lower emission fuel for HGVs.

Integrated Delivery Programme (IDP) 14. We recently announced this co-funded programme for accelerating the transition to zero emission vehicles. A total of £18.1m will be awarded to projects focusing on innovative low emission HGV technologies.

Zero emission research project and dynamic charging. We are taking forward a research project to explore different zero emission HGV technologies, including dynamic charging which involves vehicles receiving electricity as they travel.[123]

This activity has been supported by multiple initiatives which have made a significant impact. For example:

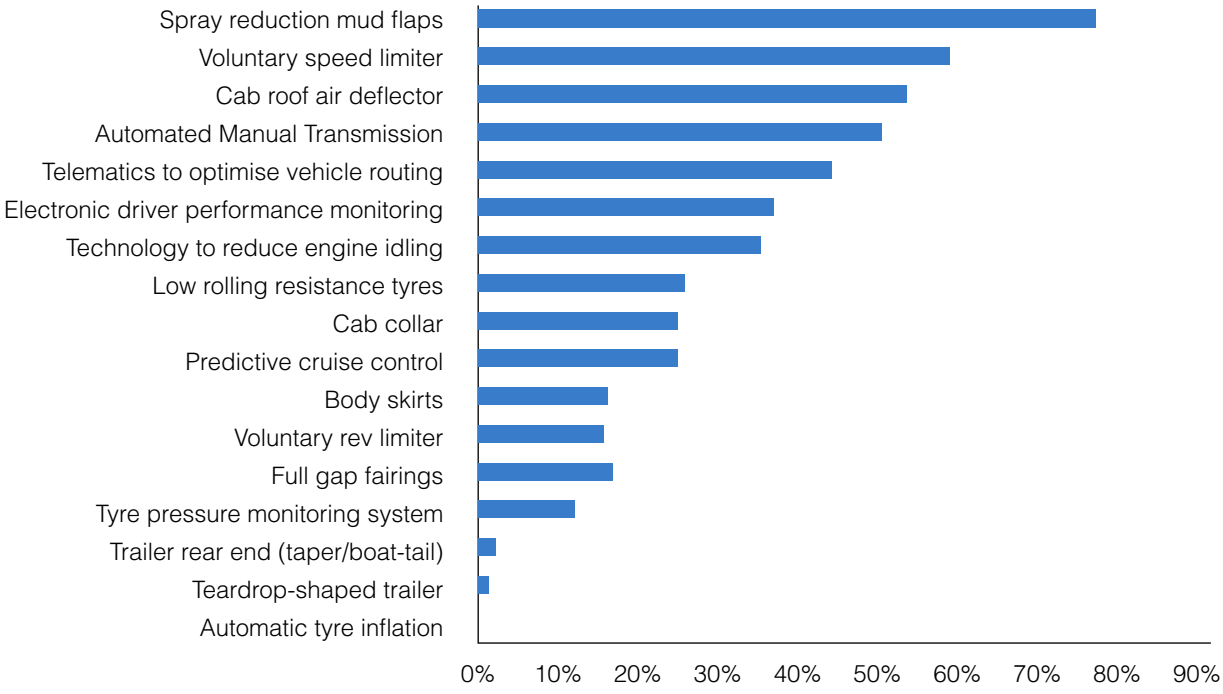
- the Freight Transport Association's Logistics Carbon Reduction Scheme (LCRS) set HGV operators a target to reduce their 2015 carbon emissions by 8% compared to 2010 levels.[124] LCRS members who consistently provided data from 2010 and 2015 achieved a 7% reduction in CO_2e emissions per vehicle kilometre within this period compared to industry as a whole; and
- the ECOStars scheme, a Barnsley Metropolitan Borough Council owned initiative, is delivered by Transport Research Laboratories and provides operators with bespoke advice and guidance about how best to reduce emissions and run their fleets efficiently.

This is a strong start, but there is still potential for the HGV sector to deliver significantly more emissions reductions.

We have agreed a new industry-wide voluntary target for reducing HGV greenhouse gas emissions by 15% by 2025, from 2015 levels. This is supported by industry. This commitment promises to help the industry achieve significant emissions reductions while realising concrete commercial benefits through improved fuel and logistical efficiency.

This is the first time that the industry has come together to agree such a target: both the major trade bodies – the Freight Transport Association (FTA) and Road Haulage Association (RHA) – support it. Other industry organisations also support the initiative. This backing from industry will be very important for successfully engaging

Figure 2c.1: Uptake of technologies by operators – Many operators are already taking action but there is potential for greater take up of relevant technologies[125]



Source: DfT (2017), Freight Carbon Review, Appendix B – HGV technology survey 2015

road haulage companies, and particularly smaller operators.

As part of the industry support for the voluntary target, the FTA has re-launched their Logistics Carbon Reduction Scheme as the Logistics Emissions Reduction Scheme (LERS). The new scheme (which the FTA provides free to all haulage operators) will adopt the 15% target and help individual companies both to meet it and to track their performance against it. LERS also has a separate shorter-term target of a 5% greenhouse gas emissions reduction target for 2020. This will provide a valuable step towards the industry-wide 15% commitment. The RHA has committed to supporting DfT and the Energy Saving Trust (EST) with the development and promotion of good practice advice for HGV operators.

The Government recognises that the target of reducing greenhouse gas emissions by 15% by 2025 is challenging, and we will support the industry in fulfilling this commitment. In particular:

- We recognise the need to ensure that independent and robust information is available to HGV operators to enable them to identify relevant measures and technologies for improving their fuel efficiency and reducing emissions. We have funded the EST to develop a freight portal with advice for HGV operators, particularly smaller hauliers, on improving fuel and operational efficiency. This will provide the sector with a valuable source of advice in considering the measures they need to adopt to meet the target. We will work with the FTA, RHA and other key industry bodies to provide advice and help for operators in this area.
- We will also support the freight portal and the industry's efforts to reduce its emissions by investigating the practical obstacles preventing many hauliers from adopting measures to reduce emissions and how such barriers can be overcome.
- Reducing congestion for HGVs is a crucial way for reducing their emissions and achieving the 15% target will be all the more challenging if congestion increases. We, and Highways England, will continue to work with the HGV sector to understand and respond to the freight industry's needs with respect to reducing congestion and ensuring freight can travel efficiently. The second Road Investment Strategy will guarantee funding for further Strategic Road Network improvements and will consider options to reduce congestion. The Government has also recently consulted on creating a Major Road Network (MRN) to improve the middle tier of our busiest and most economically important local authority 'A' roads, including by reducing congestion.
- The Rail Freight Strategy highlighted potential for growing rail freight and we will continue to support shifting freight from road to rail. For example, Innovate UK are funding a project to develop adaptable passenger train carriages with seats that fold away to create space for light freight.
- We are continually assessing the future role of longer semi-trailers that began trialling in January 2012. The initial allocation of 1,800 vehicles was increased by an additional 1,000 when the trial was extended for a further five years to run until 2027. As stated in the trial's 2016 Annual Report, it is estimated to have

reduced carbon emissions through approximately 150,000 journeys saved.

- DfT will work over the course of this year with industry to develop an Ultra-Low Emission Truck (ULET) standard to provide clarity on expected emission standards and therefore promote increased research, development and testing of suitable technologies. Establishing a ULET standard also has the potential to facilitate possible future incentives for the use of, or infrastructure for, cleaner, alternatively fuelled HGVs.
- We will continue to pursue regulatory opportunities to support the road freight sector in switching to lower emission commercial vehicles. We have allowed up to an extra tonne for certain vehicle categories using certain alternative fuels. We are legislating to allow British car licence holders to operate certain alternatively fuelled vans up to 4.25 tonnes (rather than 3.5 tonnes), thereby addressing payload penalty issues associated with alternative powertrains.

We have recently announced changes to the HGV levy aimed at improving air quality.[126] From February 2019, lorries that pay the levy and meet the latest Euro VI emissions standards will be eligible for a 10% reduction. The levy will increase by 20% for those that do not meet this standard. We are also considering longer-term options for reforming the levy to incentivise greater efficiency and further improve environmental performance and we will continue to engage industry on this.[127]

In 2017 the Government published a national framework to provide a consistent approach to the implementation of Clean Air Zones. The framework includes suggestions on how local authorities might reduce emissions from HGVs in Clean Air Zones. For example, local authorities could consider giving exemptions to vehicles with zero tailpipe emissions in Clean Air Zones, such as allowing night-time deliveries or delivery access to pedestrian areas.

We are also considering the impact of emissions from Transport Refrigeration Units (TRUs). Conventional TRUs are powered either directly by the vehicle engine (vans and trucks) or by secondary (diesel) engines. The Clean Air Zone Framework for England encourages local authorities to consider incentives to encourage the upgrade of TRUs to the least polluting and zero emission TRUs. There is potentially scope for including emissions from TRUs in the development of ULET standards.

We also want to understand whether the lower taxation of red diesel (which is used in TRUs) is preventing uptake of lower emission TRU technologies.[128] In 2017, the Government carried out a call for evidence on the use of red diesel, including in non-road mobile machinery (NRMM, which includes TRUs). We are following this up with a more detailed call for evidence to understand the impact of NRMM and its use of red diesel in urban areas. “Red diesel” is the term used for gas oil which benefits from preferential duty rates for uses other than in road transport.

The potential for alternative fuels

Using higher blends of low carbon fuels

While we work to develop lower and zero emission options for HGVs, diesel will continue to dominate the market. Low carbon fuels, which can be used in existing diesel HGVs, have the potential to reduce greenhouse gas emissions from the current HGV fleet.

The vast majority of today's low carbon liquid fuels are delivered in low blends with ordinary petrol and diesel, but higher blends can be used too (for instance 20% or greater biodiesel in HGVs) – with potentially substantial greenhouse gas savings. There remain barriers to their widespread use, for example, issues such as vehicle warranties can reduce adoption of these fuels by operators. We will work with industry to better understand these issues and identify potential solutions.

The government has asked the National Infrastructure Commission (NIC) to undertake a study to look at the future of freight. This will outline how the UK can deliver efficient and productive freight whilst reducing its impact on congestion and carbon. It includes looking at the opportunities that new technologies and alternative fuels may deliver, as well the infrastructure improvements that may be needed to ensure an effective freight system out to 2050.

Natural gas

There is growing interest in the use of natural gas in HGVs because of its potential to reduce both greenhouse gas and air pollutant emissions compared to diesel HGVs. Natural gas vehicles can also provide other benefits, such as quieter operation, that may make them more suitable for certain tasks such as night operation.

Government is working with industry, through OLEV's Low Emissions Freight and Logistics Trial (LEFT), to test the latest gas trucks to assess their emissions compared to diesel alternatives. Where data is available in time, it will also inform the government's review of duty rates for alternative fuels, ahead of Budget 2018.

The long term: zero emission solutions for HGVs

Zero emission technologies are at different stages of development for different segments of the HGV sector, with solutions more advanced for zero emission smaller, shorter-haul HGVs than for larger, long-haul HGVs. But zero emission technologies exist and are technically proven for all types of HGVs and operations. For example, electrification of large and long-haul HGVs is possible. Manufacturers have produced large electric HGVs and there has been several successful trials of dynamic charging technologies for HGVs internationally. Hydrogen is also a feasible zero emission solution for large, long-haul HGVs.

Government will play an active role in stimulating research and development of emerging technologies while ensuring the relevant infrastructure is available for operators (e.g. charging stations for electric HGVs). The regulatory regime will need to facilitate the uptake of zero emission solutions by operators. Government and industry will also need to collaborate internationally to align the implementation of zero emission technologies given how freight companies operate across borders.

In October 2016, we extended the plug-in van grant to cover all HGVs weighing more than 3.5 tonnes – we will provide up to £20,000 for the first 200 such vehicles (the grant offers up to £8,000 for vans up to 3.5 tonnes).[129] No vehicles over 3.5 tonnes have yet applied for the grant. However, we expect a number to do so in the near future and we will consider ways that we can best reward ambition in the future.

Large long-haul HGVs are the most challenging segment of the HGV sector for developing zero emission options. That is why DfT and Highways England are taking forward this year in-depth research and analysis to identify and jointly assess the full range of zero emission technologies with potential for application to HGV traffic on the UK road network, with a focus on large, long-haul HGVs operating on the SRN.

This research will evaluate the potential costs, benefits and opportunities associated with the various technologies as well as their suitability for different types of HGVs and duty cycles across different parts of the network. This research will be conducted with a view to ultimately performing full-scale demonstrator trials on the UK road network if appropriate technologies are identified. The research will be valuable in identifying the most promising solutions for the UK network and how best to develop them.

We will also seek to use the outputs of this study to work with industry to accelerate research, development and adoption of zero emission HGV technologies as part of the Industrial Strategy Future of Mobility Grand Challenge.

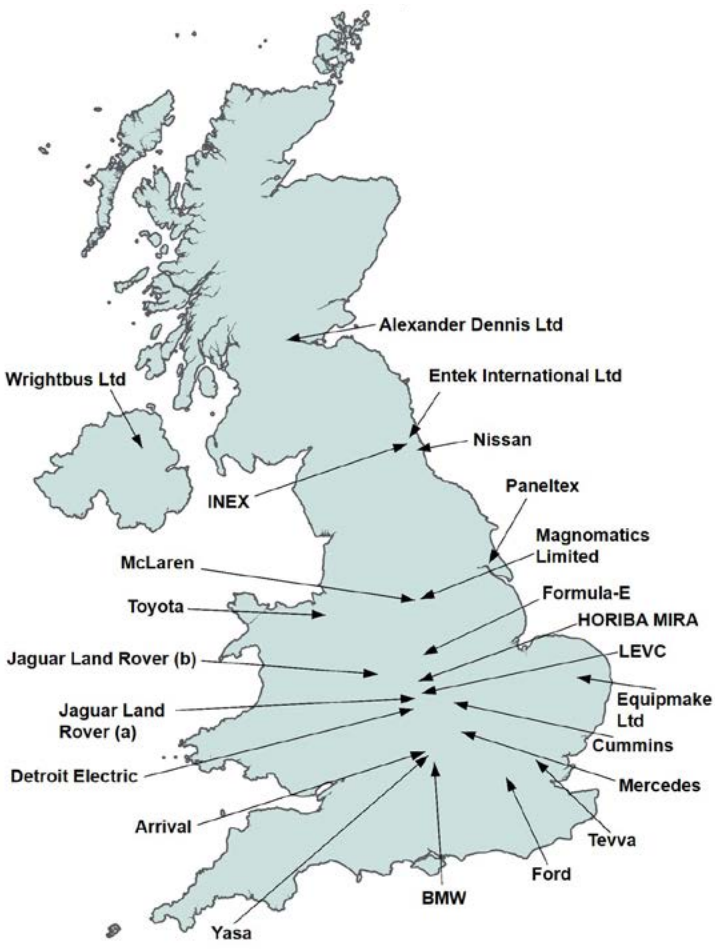
Part 2d: Putting the UK at the forefront of the design and manufacturing of zero emission vehicles

The UK automotive industry has been a great success story in recent years. We are one of the leading car manufacturers in Europe, manufacturing 1.67 million cars in 2017 and exporting 14.6% of the UK's total export goods worth £44 billion.[130,131]

In the next 10 years, the sector will see more change than in the previous hundred. Technology is changing what the industry looks like and providing new business opportunities as demand shifts to ultra low emission vehicles.

New conditions require new thinking and we want to work in partnership with the sector to provide this. We have set out our ambition in the Automotive Sector Deal. This builds on the longstanding partnership between the Government and industry, brought to life by the Automotive Council, to work together on shifting the industry to zero emission vehicles. It will also create a world-leading test environment for connected and autonomous vehicles and raise the competitiveness of UK suppliers to match the best in Europe.

Figure 2d.1: There are companies across the UK developing ultra low emission technologies. A selection are shown in this figure



Company	Investment	Location (City, County)
Alexander Dennis Ltd	Alexander Dennis has developed a range of low and zero emission buses for the global market. In addition to their own investment of more than £30m, Scottish Enterprise awarded the company a £7.3 million R&D grant to design and manufacture low carbon vehicles, creating 100 new jobs.	Larbert, Stirlingshire
Entek International Ltd	Have announced a £10 million investment in a new generation of battery separator for the automotive industry. It is the only manufacturer of its kind in the UK and currently employs 130 staff at its Camperdown Industrial Estate base and another 305 staff worldwide.	Newcastle Upon Tyne, Tyne and Wear
Nissan	Nissan have invested in production of the next generation of the Nissan LEAF at Sunderland, which also makes EV batteries for the LEAF and eNV200 electric van.	Sunderland, Tyne and Wear
Paneltex	Manufacturer a 3.5 tonne to 11 tonne truck, including refrigerated and temperature-controlled vehicles, which offer a zero-emission range of up to 150 miles.	Hull, North Humberside
Magnomatics Limited	Magnetic gear manufacturer part of a consortium with Romax Technology and Changan UK to produce the next-generation in efficient hybrid powertrains, with £38 million of funding from OLEV and Innovate UK.	Sheffield, South Yorkshire
Formula-E	Formula-E has operational headquarters at Donington Park – housing teams, manufacturers and suppliers competing in the ABB FIA Formula E Championship.	Donington Park, Leicestershire
HORIBA MIRA	Located at the MIRA Technology Park, a globally-recognised transport R&D facility – it is Europe's largest transport technology park.	Nuneaton, Warwickshire
London Electric Vehicle Company (LEVC)	LEVC have invested £325 million in a dedicated electric vehicle manufacturing facility in Coventry, which will create 1,000 new jobs. The company's first product, a range-extended electric taxi, is currently on sale and LEVC will be bringing an electric van to market next year that uses the same range-extended EV technology.	Coventry, West Midlands

Company	Investment	Location (City, County)
Equipmake Ltd	Equipmake Ltd supplies electric drive technology to British sports car company Ariel who are producing the Hipercar. They are also developing a low cost electric bus drivetrain to enable more widespread adoption of electric buses.	Hethel, Norfolk
Mercedes-Benz	Mercedes will enter Formula-E in 2019 and will produce an electric drivetrain for new electric motorsport cars at their base in Brixworth near Northampton.	Northampton, Northamptonshire
Cummins	Cummins have committed to launch a leading all-electric powertrain to market by end of 2019 for buses and delivery vehicles incorporating a Cummins-developed battery pack. This is part of an overall £380m global investment by Cummins to be a leader in electrified power for commercial markets.	Milton Keynes
Tevva	Chelmsford based company producing range-extender electric 7.5-14 tonne trucks to delivery companies, such as UPS, Kuehne+Nagel and others.	Chelmsford, Essex
Ford	The Ford Dunton Technical Centre is a global centre of excellence for the development of both Commercial Vehicles and Powertrains. Electrified powertrains are playing an increasing role in CO_2 and air quality improvement, as demonstrated by the plug-in hybrid Transit Van fleet Ford is trialling in London.	Queen Elizabeth Olympic Park, London
BMW	Electric MINI to be produced in Cowley, near Oxford from 2019, where currently 4,500 staff are employed at this site.	Cowley, Oxfordshire
Yasa	Growing Oxford-based electric motor manufacturer.	Kidlington, Oxfordshire
Arrival	In August 2017, the Royal Mail announced an agreement with Arrival to trial nine electric vehicles in the ranges of 3.5, 6 and 7 tonnes GVW. The manufacturing facility will be based in Banbury and will represent the first electric-only truck manufacturing facility in the UK.	Kidlington, Oxfordshire
Detroit Electric	To invest £304 million in Leamington Spa facilities to build electric sports cars and SUVs, creating 120 new engineering jobs and 100 new manufacturing jobs.	Royal Leamington Spa, Warwickshire

Company	Investment	Location (City, County)
Jaguar Land Rover (a)	Jaguar Land Rover's £150 million investment established the National Automotive Innovation Centre (NAIC) at the University of Warwick. The centre houses approximately 1,000 scientists, engineers, academics, technicians and support staff working on future automotive technology, including electric vehicles; carbon reduction; and smart and connected vehicles.	Coventry, West Midlands
Jaguar Land Rover (b)	Manufacturing Centre in Wolverhampton for research into reducing emissions and weight, employing 1,400 people.	Cannock, Staffordshire
Toyota	In February 2016, Toyota invested £5.8 million in hybrid electric powertrain manufacture in Deeside, helping to secure 400 jobs.	Deeside, Clwyd
INEX	Established in 2002, INEX produces innovative micro/nano technology and semiconductor based systems.	Newcastle Upon Tyne, Tyne and Wear
McLaren	McLaren Automotive is building a £50m centre of excellence for innovating and manufacturing lightweight materials, creating around 200 direct jobs focusing on the development of advanced composites technologies.	Sheffield, South Yorkshire
Wrightbus Ltd	Northern Ireland based company designing and manufacturing battery electric and fuel cell electric buses.	Ballymena, County Antrim

Government is committed to putting the UK at the forefront of the design and manufacturing of zero emission vehicles. We want to have one of the best packages of support in the world, including:

- funding for innovation and R&D;
- promoting the growth of the UK supply chain in the UK and internationally;
- ensuring we have the right skills;
- creating a competitive business environment.

Innovation and R&D

We are a global leader in research and development: we come top in a number of measures of research excellence and are home to four of the top ten universities of the world. In the Industrial Strategy, we announced the biggest increase in public investment in R&D in our history (towards a target for total R&D investment of 2.4% of GDP by 2027) and an increase in the rate of R&D tax credit to 12%.[132]

UKRI, the Advanced Propulsion Centre (APC) and the Faraday Battery Challenge are working to accelerate innovation in ultra low emission technologies from fundamental research through to commercialisation.

Early stage research and development

OLEV has awarded over £300 million in grants via Innovate UK (now UKRI) into ultra low emission technologies. This has supported a range of high quality, industry-led R&D projects that have driven forward advanced technologies and strengthened UK industrial and supply chain capability. Since inception:

- OLEV has supported 14 calls for projects, generating a total investment of £550 million, of which £200 million of has been secured from partner co-investment.
- Funded 297 feasibility and R&D projects, involving 40 universities, 419 industry participants and more than 900 partners, all with a UK footprint.

The projects have been projected to provide a return on investment of £8-14 by 2025 and £20-34 by 2030 for every £1 spent, securing total annual sales of £2.9bn and securing nearly 12,000 jobs by 2030.[133]

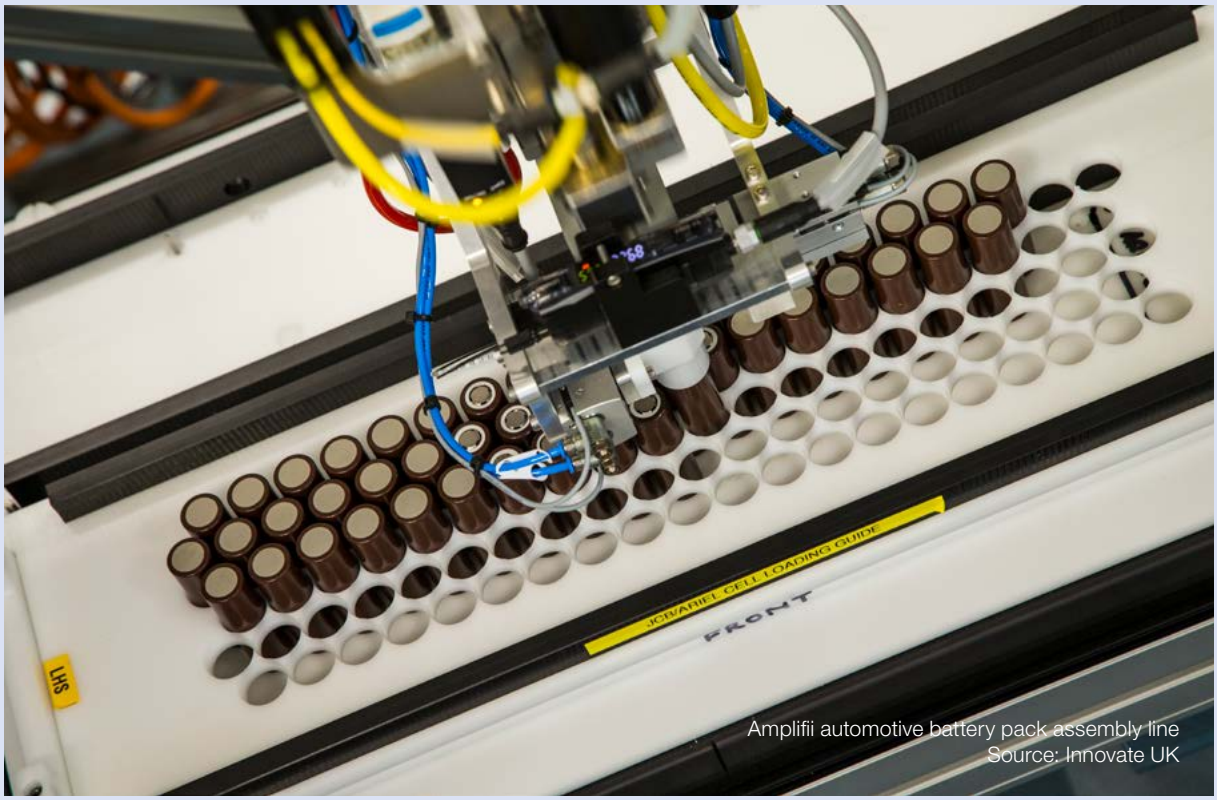
The commercial pipeline

The Advanced Propulsion Centre (APC) was launched in 2013 through the Automotive Council to position the UK as a global centre of excellence for low carbon powertrain development and production. With a £1 billion budget over 10 years, 50:50 match funded between government and Industry, the APC supports projects at the later stages of technology development, realising the commercial potential of innovative automotive technologies with carbon reduction impacts. To date, the APC has:

- funded 36 collaborative R&D projects;
- a total portfolio value of £589 million with grant funding of £289 million;
- created or safeguarded more than 20,400 jobs; and
- saved an estimated 34m tonnes of CO_2 equivalent to taking 1.7 million cars off the road.

AMPLiFII

The AMPLiFII (Automated Module-to-pack Pilot Line for Industrial Innovation) project was awarded £10 million in 2015 to create a new automotive battery pack manufacturing research centre. Led by Warwick Manufacturing Group, the project brings together vehicle manufacturers, supply chain organisations and research organisations, with the aim of developing a pilot line to test and demonstrate manufacturing processes at automotive production rates and quality. The technology developed to date provides a modular battery solution that can be easily tailored to individual project requirements.



Amplifii automotive battery pack assembly line
Source: Innovate UK

Phillips 66 Limited's Humber Refinery: A refinery for the future

Phillips 66 Limited's Humber Refinery in North Lincolnshire is the only refinery in Europe to produce high-grade graphite coke (alongside other petroleum products). Staff at the Humber Refinery and Phillips 66's US R&D group based in Oklahoma have worked with battery anode makers in China to develop unique, new coke formulations suitable for use as anodes in electric vehicle (EV) batteries.

Phillips 66 has grown its EV battery coke business from zero in 2014 to quantities in 2018 sufficient to put around 500,000 new EVs onto roads each year. Working with government, Innovate UK, and other battery supply chain businesses, Phillips 66 Limited is keen to promote a UK-based supply chain for EVs.

Delta Motorsport – MiTRE

Based next to the home of British motor racing at Silverstone, Delta Motorsport have developed a low-cost micro-turbine technology specifically designed as a range extender for electric vehicles to match petrol or diesel-powered equivalents.

The result of a £3.1 million collaborative R&D project, co-funded by the OLEV and Innovate UK, its MiTRE (Micro Turbine Range Extender) features small, lightweight turbo-machinery attached to an electric generator. This maintains the battery state of charge or (at higher speeds) reduces the rate of discharge. The device has attracted significant interest from across the industry and as far afield as China.[134]

We want to build on the success of this approach and continue to directly support match-funded innovation into ultra low emission vehicles with a focus on real world applications.

We will leverage advances from the Faraday Battery Challenge to cement and extend the UK's position as a world leader in energy storage and battery technologies.

New battery technologies are key to improving the range of electric vehicles and represent the majority of the value of the vehicle. The production of batteries is critical for anchoring future zero emission vehicle production in the UK. To help attract the first UK largescale battery production facility in the UK, we will deliver the £246 million Faraday Battery Challenge.[135]

The first phase of the Faraday Battery Challenge involves the establishment of a Faraday Institution to coordinate battery research across the UK. The winning consortium was announced in October 2017 and comprised of seven partner universities working in collaboration with industry. This has been broadened out to research groups across a number of other universities. Priorities for batteries include:

- *Technology pipeline* – it can take over a decade for new chemistries at proof of concept to emerge as market products. We must ensure that innovative products and services we have supported can progress to commercialisation, avoiding the 'valley of death' – the point at which many new innovative ideas often fail.
- *UK Battery Industrialisation Centre (UK BIC)* – We have announced £80 million of funding for the UK's first ever battery development facility. This will be based in Coventry and Warwickshire and will deliver state-of-the-art innovation to support automotive battery industrialisation.[136]
- *Production at scale* – beyond the Nissan facility in Sunderland, investment in new UK automotive battery capability has been small-scale. Given shipping constraints, electric vehicle manufacturing will require a supply of battery packs close to vehicle assembly plants. This provides opportunities for developing a UK based battery cell and module supply chain.

Batteries

The production of lithium-ion batteries, currently the most common type used for electric vehicles (EVs), necessitates the use of lithium. A substantial increase in lithium production will be required to meet the needs of a growing battery market. However, based on current rates of production, geological availability is not considered to be an issue and so supply constraints are unlikely to be long term.[137,138]

Similarly, studies have indicated that current reserves of rare earth metals are sufficient so that increased production of electric vehicles will not be affected.[139] Despite their name, 'rare' earth metals are often not in fact very scarce; rather, they occur in low and dispersed concentrations.

The government is aware of social, environmental and supply concerns surrounding the mining of rare earth metals. We will work with industry and international partners on how best to address these concerns. Replacement or reduction may help avoid such issues. This is also a priority for vehicle manufacturers. AC induction motors, for instance, are constructed without rare earth metals and have been successfully implemented in electric vehicles by some manufacturers. Another example is the steps BMW are taking to increase the transparency of its cobalt supply chain, as well as exploring how to improve the social and ecological impact of mining.[140]

Source: Nissan

We also expect a recycling market for critical materials to emerge once electric vehicles become more widespread, further easing issues around supply. Luton-based company Cawleys has developed a solution to recover lithium content of batteries, offering the UK a sustainable solution to meet increased demand for electric vehicles.[141] New batteries consisting of different materials have the potential to increase range and enable shorter charging times. Innovation in materials may also provide a mechanism to reduce levels of rare earth metals used currently.

We will make sustainable supply chains a key theme to the Zero Emission Vehicle Summit in September 2018 to help drive up standards globally.

Emerging battery types: new batteries consisting of different materials have the potential to increase range and enable shorter charging times. The Government is keen to ensure the UK remains a world leader in battery research and development.

Source: Nissan

Solid-state batteries: Solid-state batteries replace liquid electrolyte solution, which carries the charge in lithium-ion batteries, with solid components. It is envisaged this technology would enable batteries to be smaller, cheaper, charge faster and last longer. Manufacturers such as Dyson and Toyota are actively researching this technology and hope to bring solid-state electric vehicles to market by 2020.[142]

Lithium-air: The combination of lithium and air can theoretically provide an extremely high energy density, almost to the same level as petroleum engines. A pivotal breakthrough was made by the University of Cambridge and Johnson Matthey PLC, who produced a lithium-air demonstrator with a long shelf-life and high efficiency, marking an important step towards commercialisation for lithium-air batteries.[143]

Lithium-sulphur: Lithium-sulphur batteries utilise a lithium anode and a sulphur-carbon cathode and offer more than five-times the energy density of lithium-ion batteries. During discharge (when the battery is being used to fuel the vehicle), lithium is lost from the anode to the sulphur cathode. Oxfordshire-based company, OXIS energy, has established a lithium-sulphur battery system testing centre in Abingdon.[144] The

Government has provided funding to OXIS Energy through Innovate UK allowing them to conduct cutting-edge research aimed at advancing lithium-sulphur battery uptake.

Sodium-ion: A sodium-based battery may not may not match the performance of lithium-ion batteries yet, but would have a number of advantages as sodium is more readily available and cheaper than lithium. It will also be able to fully discharge without undergoing the same level of strain as lithium-ion batteries. As part of a project co-funded with Innovate UK, Faradion and Williams Advanced Engineering, produced the world's first sodium-powered vehicle, designed and developed in the UK.[145]

- *Battery recycling* – At present options for battery recycling are limited, and we need to establish protocols. The full lifecycle of vehicle batteries must be considered now to save costs and limit environmental impacts in the long term. We need to ensure that all parts of the recycling industry understand both the opportunities and the broader health and safety challenges that come with these technologies.
- *Vehicle-to-grid technologies* – We are currently supporting innovation in vehicle-to-grid technologies, where electric vehicles are used to supply electricity to the grid at times of high energy demand, and expect companies in the UK to be major global leaders. There are opportunities to licence and export this technology around the world. We have awarded £30 million to fund innovative projects for new business models, consumer awareness and technologies that support interaction between electric vehicles and the grid.[146]

We will also drive a new focus on UK technological and industrial capability in the development and manufacture of electric motors and power electronics. Part 3 sets out our innovation support for infrastructure.

Building the UK business supply chain: domestically and overseas

In order to continue attracting international investments and anchor high value manufacturing to the UK, we must increase the productivity and competitiveness of the UK ultra low emission supply chain. There are still significant gaps in the UK supply chain forcing many car manufacturers to import components that they would prefer to buy in the UK.[147] Better data is key – we need to understand our strengths and where we could compete globally.

The Automotive Sector Deal announced a commitment for industry to increase the percentage of UK content in the supply chain to 50% by 2022.[148] Our ambition is to work with industry to set a target that is at least as ambitious for UK content in the ultra low emission vehicle supply chain as we look to secure battery manufacturing investment in the UK.

McLaren Automotive carbon fibre innovation and manufacturing centre

McLaren Automotive, the pioneering British creator of luxury sportscars and supercars, is investing in developing the UK's ability to lead and deliver technology and innovation, which, in turn, will contribute to increasing the capacity of the UK supply chain.

In close collaboration with the University of Sheffield's Advanced Manufacturing Research Centre (AMRC), McLaren Automotive is building the McLaren Composites Technology Centre (MCTC) which will be a centre of excellence in lightweight materials. It will be responsible for the development and production of the carbon fibre chassis for future McLaren cars and be fully operational from 2020. The MCTC will deliver £100 million of GVA benefit to the local economy and increase the British content of McLaren's cars to up to 58%.[149]

Source: McLaren Automotive

To support this:

- we have committed £16m, subject to business case, to an industry-led supplier competitiveness and productivity improvement programme. This will support a sustainable and internationally competitive UK supply chain for future volume vehicle production. This programme will be match funded by at least £16m from supply chain companies.
- we will support the work of the APC in collaboration with the British Software Company, Value chain, and Cloud2, to develop an Electric Vehicle Supply Chain Portal. The Portal will promote effective collaboration between automotive manufacturers to develop new products, technologies and manufacturing processes.

Toyota UK manufacturing

Toyota have built more than four million vehicles and around five million engines and engine sets in the UK since production began in 1992. Altogether, Toyota have invested more than £2.75 billion in their two UK plants and currently employ more than 3,000 people.

Toyota's UK manufacturing plants were the first in Europe to build their full hybrid electric vehicles and engines, and in total they have produced over 650,000 hybrid electric engines and over 465,000 hybrid electric vehicles in the UK. Toyota is to produce its third generation Auris hybrid electric vehicle in the UK at its Burnaston plant.

To support production of the Auris, Toyota have invested £240 million to upgrade the factory with new equipment, technologies and systems. Defra is replacing more than 400 vehicles from its car fleet with these British-built hybrid vehicles. This changeover is already under way and will continue throughout 2018.

The new Toyota Auris which will be built in Burnaston
Source: Toyota

- we will launch a new supply chain competitiveness and productivity improvement programme targeting areas where key businesses need to improve to match the best in Europe. The programme will provide bespoke training and streamlined business processes to help build the integrated supply chain we need in the UK to manufacture the future generation of vehicles at volume.
- work with the ONS to extend their data collection to focus on jobs and exports attributable to both low and ultra low emission vehicle technologies.

Export potential

The focus on the developments of traction motor and power electronics technologies and capabilities could deliver significant export potential. Through the Advanced Propulsion centre as of February 2018, we are investing £79 million into circa £161 million of consortia projects led by businesses including Jaguar Land Rover, Ford, Mclaren, GKN, hofer powertrain and Ashwoods Electric Motors, to establish supply chains for the manufacture of electric machines and systems, with the aim of establishing both high and niche volume production facilities for electric vehicles in the UK.

Ensuring we have the right skills

Many of the skills utilised in internal combustion engine manufacturing such as stamping, machining and casting are required in the manufacture of electric motors. Investing in these workers represents a good opportunity to quickly deliver some of the skills required for manufacturing ultra low emission vehicles.

However, our automotive industry will require new technical skills to meet the specific challenges of new technologies. Our Industrial Strategy sets out plans to tackle our shortage of Science, Technology, Engineering and Maths (STEM) skills, and the growing need for digital skills, through a major programme of reform. This will help ensure that our technical education system can stand alongside our world-class higher education system, and rival the best in the world, with new T levels backed by over £500 million annually by the time the programme is rolled out fully.

Ultimately, though, a coordinated, industry-led approach at both national and local levels is required to provide employees with the appropriate skills to develop and manufacture the next generation of vehicles.

The industry led Automotive Industrial Partnership (AIP) has identified strategic skills priorities for the automotive sector, informing new Apprenticeship Trailblazer standards and new industry wide qualifications. However, many of these qualifications will not provide the specific skills required for ultra low emission technology. There must be more focus on the skills required to establish the UK as a world-leader in the manufacture and engineering of ultra low emission vehicles. Employers must embrace the opportunity that new technology will bring and play an active role in producing the highly skilled workforce required.

We are reviewing whether current regulations are sufficient to protect mechanics working on electric and hybrid vehicles. We are working with the Institute of the Motor Industry (IMI) to ensure the UK's workforce of mechanics are well trained and have the skills they need to repair these vehicles safely.

UK Business Environment

Our flexible labour market, competitive environment, and growing domestic demand for ULEVs – with stable and supportive policy, fiscal and legal frameworks – make us a great place to do business. However, our Industrial Strategy recognises there are areas where we need to improve to make Britain the best place to start and grow a business, and a global draw for the most innovative companies:

- *Green finance* – The Government established a Green Finance Taskforce in September 2017 to help deliver the investment needed meet the commitments within the UK's Industrial Strategy and Clean Growth Strategy.
- *Equity fund for green technology* – The Industrial Strategy announced the Government will strengthen support for the commercialisation of new clean technologies through investments in patient capital, starting with a new equity fund of £20 million.[150]
- *Support UK-based digital design and manufacturing* – The Automotive Sector Deal sets out opportunities for the UK in the digital design and testing of new vehicles.

Supporting new industries

There are a number of new entrants to the automotive market. Dyson, for instance, has recently entered the global market by announcing a new electric vehicle by 2020.[151] We want to build on the example of Dyson and other companies in complementary, adjacent sectors, such as the aerospace industry, to adapt their technology and help the UK drive the transition to ultra low emission vehicles globally. The increasing domestic demand for ultra low emission vehicles also provides potential for new industries in charging technologies, for instance.

Part 3

Infrastructure

Part 3: Infrastructure

We remain technology neutral, but recognise that the vast majority of vehicle manufacturer plans include plug-in battery electric powertrains. This section sets out government's role in the build-up of the supporting these electric vehicles' (EV) charging infrastructure for passenger cars and small vans and how we will manage the wider impacts to our power system.

Hydrogen fuel cell electric vehicles are at an earlier stage of market development. This section also covers government's role in supporting development of its hydrogen-refuelling network.

We will monitor the market for new ultra low emission technologies and consider whether there are steps we can take to support the deployment of any associated infrastructure.

Part 3a: Developing one of the best electric vehicle infrastructure networks in the world

Our vision is to have one of the best EV infrastructure networks in the world. This means current and prospective EV drivers being able to easily locate and access EV charging infrastructure that is affordable, efficient and reliable. The development of this infrastructure opens up a new market for chargepoint infrastructure providers in the UK and across the world.

Government funding and leadership, alongside private sector investment and local authority engagement has supported the installation of around 14,000 public chargepoints all across the UK. As we look out to 2040, it is clear that:

- many more public chargepoints will be needed; and
- the consumer experience of public EV charging needs to be improved.

This will be a key part of supporting progress in meeting our vehicle uptake ambitions. Whilst a world-class network of public chargepoints is important, we anticipate that the vast majority of drivers will choose to charge at home where this is possible. EVs offer consumers a more convenient and cost-effective way to refuel, with domestic charging playing a crucial role (some studies indicate this accounts for the vast majority of EV charging).[152] We expect that as EVs go mainstream, charging at home overnight, or at workplaces, will continue to be the most attractive options.

Clean electricity will power EVs just as it is now powering our economy. There are already many more distributed and localised resources on our power system and new smart technologies are emerging. There is huge opportunity for EVs to play a dynamic and complementary role in the move to smarter and more flexible electricity system by effectively adding millions of mobile storage batteries to our network by 2050.

The move to EVs will increase demand for electricity. Additional generation capacity will

be needed to meet overall and peak demand. Local network infrastructure will in some areas need to be reinforced to transmit power to where it is needed. But these changes will occur over a long period alongside wider changes to our electricity system and, with the appropriate electricity system planning and investment already underway, our electricity system can readily meet the additional demand and benefit from the uptake of EVs.

Enabling EV charging at home

Recharging an EV is fundamentally different to refuelling a petrol or diesel car. A key attraction of an EV is that they can be charged wherever they are parked if there is an electrical outlet. Charging cars at home overnight using a dedicated chargepoint is generally safer, faster and more convenient for consumers and will ensure EVs are able to play their full part in our future smart and flexible energy system. Access to overnight charging also encourages both plug-in hybrids and battery electric vehicles to be used to their full potential.

To support and encourage this, we will:

- ensure the houses we are building over the coming years are EV ready. It is our intention that all new homes should have a chargepoint available. We plan to consult as soon as possible on introducing a requirement for chargepoint infrastructure for new dwellings in England where appropriate and will look at how to achieve this in the most cost effective way, mindful of the Government's Housing supply objectives.

Source: Go Ultra Low

- continue the Electric Vehicle Homecharge Scheme (EVHS) to provide grant support for EV drivers installing a dedicated domestic EV chargepoint;
- maintain the EVHS grant at £500 (capped at 75% of costs) until March 2019, or until 30,000 installations in 2018/19 have been supported, whichever is sooner;
- review grant levels on at least an annual basis, with a view to removing grant support as uptake increases and the market becomes self-sustaining;
- work with industry to set requirements for smart chargepoints, so the impact of EV charging on the electricity system can be managed; and
- consider how to best ensure all types of residential property owners, including leaseholders or legal occupants with private off-street car parking are able to access a chargepoint for their plug-in electric vehicle and are not disadvantaged merely on the basis of having communal parking facilities or not owning their own home. We will review the provision of chargepoint infrastructure as part of the Law Commission's work to review and reinvigorate the commonhold tenure in England and Wales.

Enabling EV charging on residential streets

We want to ensure that everyone can easily realise the benefits of charging an EV at home. More than a third of households in England do not have access to off-street parking, and this proportion increases in urban areas where air quality concerns are most acute.[153] Not everyone without off-street parking has a vehicle, but there are indications that around 25% of all cars are parked on streets overnight.[154] There remain barriers for owners living in households without access to off-street parking.

Trialing new approaches to on-street charging in Oxford

Oxford City Council are testing six different charging technologies at 30 different locations to find the best options for residents parking on Oxford's narrow streets.[155] Funded through OLEV's Go Ultra Low City Scheme, they include:

- domestic chargers using pavement cable channel to enable residents to use their own electricity for charging without running cables across pavements;
- fitting three lamppost chargers per vehicle to avoid the need for dedicated parking bays;
- discreet, slim-line standing chargepoints which can provide a higher rate of charge and better manage residents' concerns over street clutter.

Data on reliability, usage and cost effectiveness of each solution, as well as on user experience and learning will be analysed by the University of Oxford Transport Studies Unit to understand how each technology has worked and report on users experiences. This will inform future decisions on roll-out across Oxford and the UK.

The on-street charging challenge is faced by towns and cities worldwide.

To encourage development and deployment of on-street infrastructure, we will:

- make £4.5 million grant funding available to 2020 for the On-street Residential Chargepoint Scheme (ORCS) for local authorities who remain best placed to support infrastructure roll-out on publically owned residential streets;
- future-proof our streets: we want all new street lighting columns to include charging points, where appropriately located, in residential areas without off-street parking provision. To help local authorities deliver this, we will update the Well Managed Highway Infrastructure Code of Practice and the Network Management of Traffic Equipment Code of Practice – that highway authorities refer to as part of the management and maintenance of their assets – to include a section on the benefits of introducing EV lamppost charge points. We will also work with local authorities and the local government Association to raise awareness of the updated codes and encourage best practice;
- fund the Energy Saving Trust to assist more local authorities, share more knowledge and expertise and directly support the development of more EV infrastructure delivery plans and applications to the on-street scheme;
- launch the process for a R&D programme of up to £40 million by summer 2018 to develop and trial innovative, low cost wireless charging and public on-street charging solutions that can be deployed across entire residential streets; and

Source: Go Ultra Low

- make available a minimum of £6m of funding to support more local areas to install dedicated on-street infrastructure to support ultra low emission taxis.

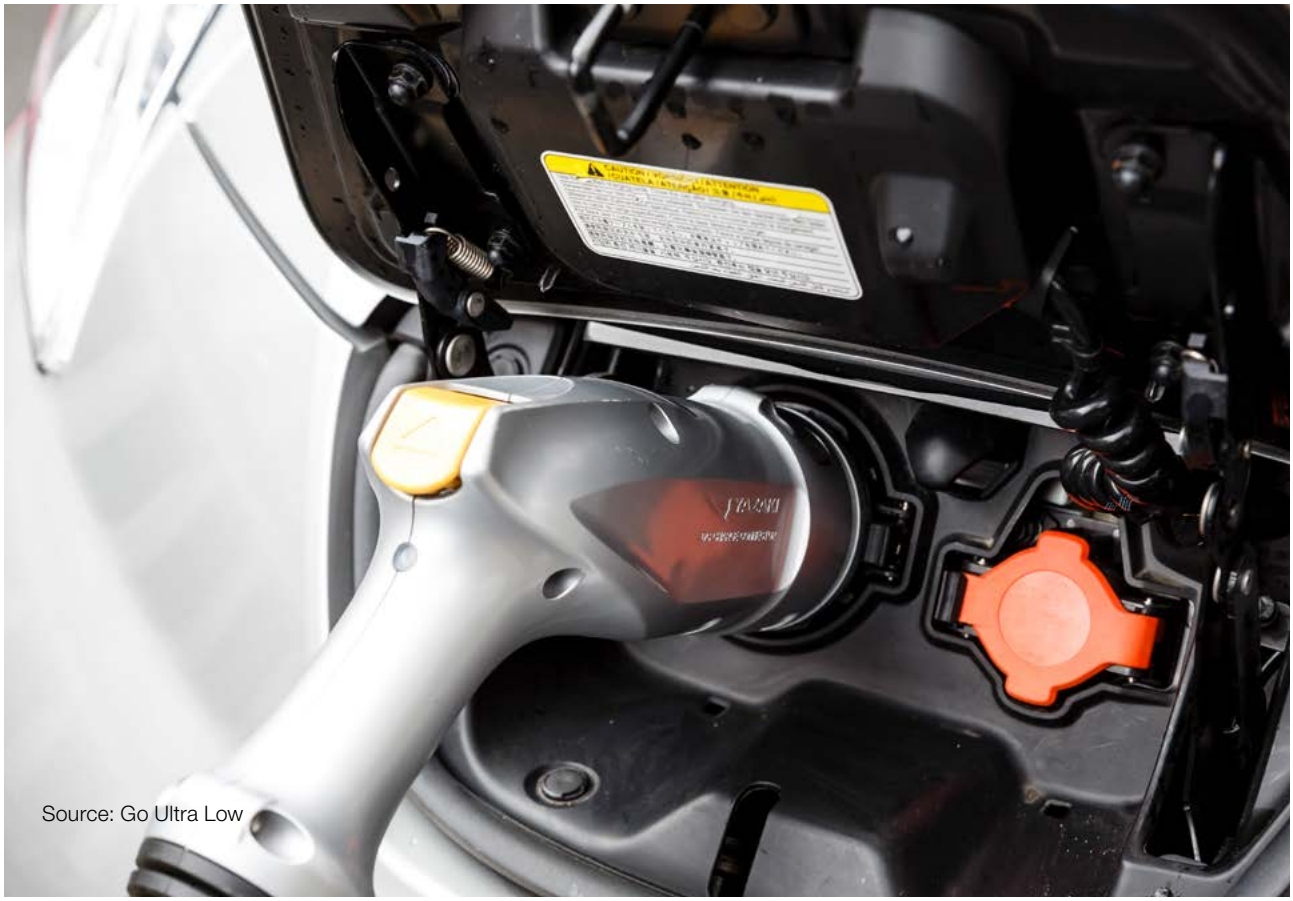
Enabling electric vehicle charging at workplaces

As well as cleaning up their own vehicle fleets, employers have an important role in enabling their employees and visitors to charge up while at workplaces. Workplace charging can be the sole alternative for drivers without off-street parking at home, and can enable plug-in hybrid and range extender drivers to ensure they can benefit from the full zero emission capability of their vehicles.

Government has made available funding for private businesses and public bodies through the Workplace Charging Scheme, a grant scheme to support charging infrastructure at workplaces, as well as publishing supporting guidance for businesses who are considering installing chargepoints, through the EST. Hundreds of companies across the UK have used the scheme to install EV chargepoints for their employees and fleets.

To support and encourage workplace charging, we will:

- increase the levels of the Workplace Charging Scheme (WCS) to provide up to £500 off the installation costs of charging sockets deployed at workplaces for consumers and fleets. A further £4.2m commitment could see over 8000 sockets installed before the end of March 2019.



Source: Go Ultra Low

Leeds leads the way in electric fleets and infrastructure for their employees

Leeds City council has been at the forefront of switching to an EV fleet for their employees. The Workplace Charging Scheme has helped them deploy 16 chargepoints across four of their depots and sites to facilitate their transition towards an EV future. They currently have 44 EVs in their fleet, with an order for another 51 in progress and completed a home charge pilot for staff with EV vans.

- legislate so that no benefit in kind liability arises for employees who charge their own electric and plug-in hybrid vehicles at work. Although the legislation will not be introduced until Finance Bill 2018-19, the policy has been in effect since 6 April 2018, to provide certainty for employees and remove a barrier for employers who are currently considering the installation of chargepoints.[156]

Smart charging and the role of EVs in a smart energy system

Historically, the GB electricity system has been powered by a small number of large fossil fuel power stations, with the power then being transmitted to people's homes and business. This is changing. There are now increasing levels of low carbon and renewable generation, often connected at the local distribution network and behind the meter. To enable these changes in generation and minimise the need for conventional network reinforcement, the system is adapting to become more flexible and smarter in order to better manage the new flows in power. It is estimated that there are benefits of up to £40bn to 2050 in the move to a smart power system.[157]

The Government is already acting and in July 2017 published Upgrading Our Energy System: A Smart Systems & Flexibility Plan, setting out 29 actions that government and Ofgem are taking, alongside industry, to deliver a smarter, more flexible energy system.[158] These actions are focused on:

- removing barriers to smart technologies including storage
- enabling smart homes and businesses; and
- making energy markets work for flexibility

EVs offer new opportunities for consumers and the power system as part of a smarter and more flexible system. Smart charging, during off-peak periods and when demand and network congestion is otherwise low, means consumers can potentially benefit from cheaper pricing when charging, avoid triggering future network reinforcement, use their EVs to power their homes or businesses, or sell back to the grid.

To encourage this, by 2019 all government supported chargepoint installations will have to have smart functionality. The Automated and Electric Vehicles Bill, currently in Parliament, will give government the powers to ensure that all chargepoints sold or installed in the UK will have smart functionality, that is requiring all new chargepoints to be able to receive, interpret and respond to signals from a third party,

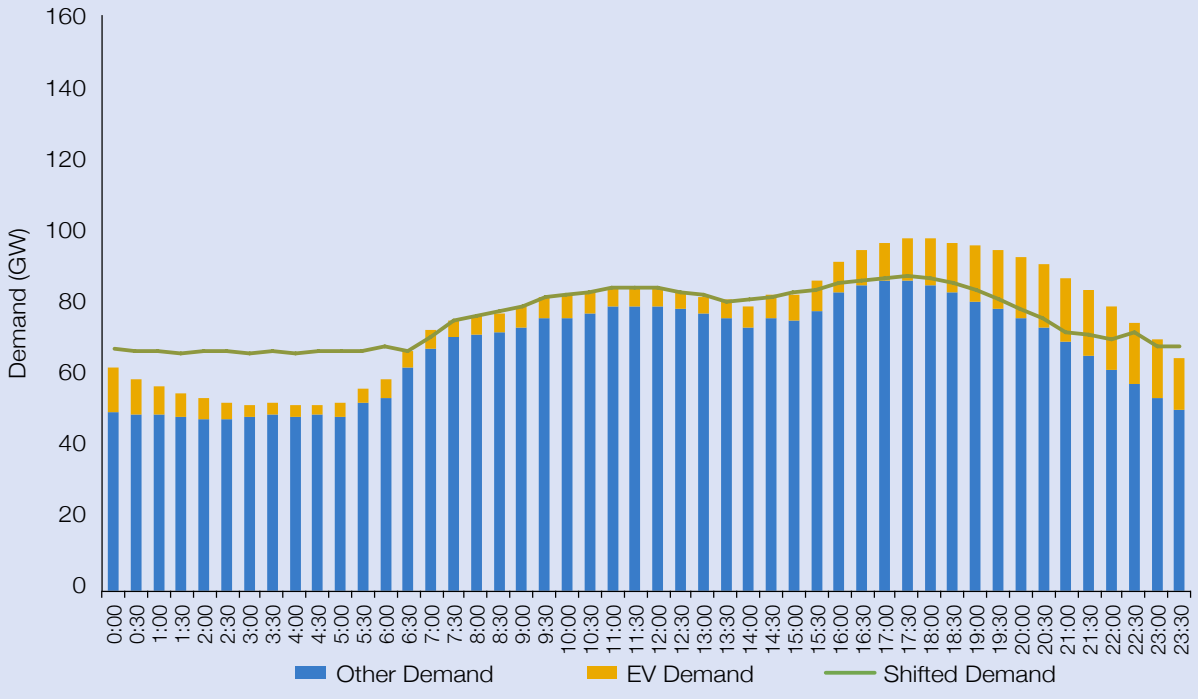
extending the benefits of smart to all new chargepoint installations. We will consult before using these powers to help determine the best approach to ensuring cyber security, interoperability, and data privacy.

This will help balance the electricity system by allowing EVs to charge at times when demand is lower. Smart meters rollout is continuing, with over 7 million units already rolled out, and every GB household will be offered a smart meter by the end of 2020. Smart meters will have a key role to play in providing a clear price signal to the end consumer providing an incentive for them on charging at times of lower demand, when the price is likely to be cheaper.

Smart Charging

A key feature of a smarter energy system is the ability to minimise peak demand and network congestion, allowing the use of cheaper, low carbon generation to be maximised. The current electricity system has been designed to meet a peak in demand between 17:00 and 20:30. For the rest of the day there can be large amounts of underused generation and network capacity. Generation during these off-peak periods is usually cleaner and cheaper. EVs can support the transition to a smarter energy system by, for example, charging overnight (during the off-peak) reducing the need for investment in infrastructure, but also provide power back to the grid. This makes it cheaper for people to charge and integrates EVs into the electricity system in an affordable way.

Figure 3.3: How EV charging load could be shifted to the off-peak



Source: BEIS Modelling

Vehicle-to-Grid

Vehicle-to-grid technologies support interaction between EVs and the grid. OLEV and BEIS are funding an Innovate UK competition for collaborative R&D in vehicle-to-grid technologies to explore how the UK can become a world leader in these technologies and open up new opportunities for consumers.

We recently announced the winners of this competition. We look forward to working with the winners to develop the consumer case for vehicle-to-grid. From feasibility studies to real-world demonstrators for transport hubs, commercial and personal vehicles, there were 21 winners, collectively receiving nearly £30 million. As well as trialling around 2700 vehicle-to-grid chargepoints, the projects will demonstrate the power of collaboration. The consortiums brought together key partners from across the energy, automotive and other sectors to find solutions that work for everyone. Partners included National Grid, distribution network operators, leading energy companies, vehicle manufacturers, universities, local authorities and many others.

A smart home chargepoint
Source: OVO and Nissan

OVO Energy is working with Nissan to deliver what could be the UK's first large scale domestic vehicle-to-grid demonstrator. The 2-year project involves 1000 households using OVO's grid balancing platform 'vNet' to optimise charging/ discharging according to the status of supply and demand on the national grid.

Successful demonstration will quantify the potential for intelligent software platforms such as 'vNet' to optimise charging of the UK's EV fleet to unlock valuable flexibility at times of peak consumption without unnecessary costs on consumers.

Keeping energy bills down

Currently businesses seeking new or upgraded connections to the electricity distribution networks face an upfront charge if there is a need to upgrade the network to accommodate them. For existing domestic premises installing an EV chargepoint, if the total demand of the house is less than the house's fuse cut out, then any additional network reinforcement costs are borne by consumers more generally. The way that charges are distributed in the energy system is principally a matter for Ofgem, but government is keen to see that the needs of EV owners is fairly balanced with those of electricity bill payers as a whole, and that bills are kept as low as possible.

Ofgem are due to launch a consultation on network access and forward-looking charging arrangements shortly.

Supporting growth of the UK's public chargepoint network

A widespread public chargepoint network is important for drivers who do high mileage, travel long distances and/or have no access to chargepoints at home or work.

The UK is home to around 14,000 public chargepoints and has one of the largest, and most comprehensive rapid networks in Europe.[159] But more will be needed to deliver one of the best EV charging networks in the world to meet the demands and realise the benefits of the increasing numbers of electric vehicles. We want to address range anxiety, ensure that battery electric vehicles can be used on longer journeys and that plug-in hybrid vehicles can be used to their full potential.

We want to encourage and leverage private sector investment to build and operate a thriving, self-sustaining public network. We will use our experiences and lessons learned as an early facilitator in infrastructure to put in place the right framework of support. With the right policy framework for investors and consumers, as EV uptake increases and utilisation rates improve, we expect the market to be able to deliver the public infrastructure needed in the long term. It is essential that viable commercial models are in place to ensure continued maintenance and improvements to the network.

To ensure sufficient coverage, we will continue to monitor whether any significant gaps – in uptake or infrastructure provision – emerge in the medium term. In the future, we will consider whether there is a case for direct central government support in areas where there is a market failure which may include rural areas.

Figure 3.4: There is a wide network of public chargepoints across the UK[160]

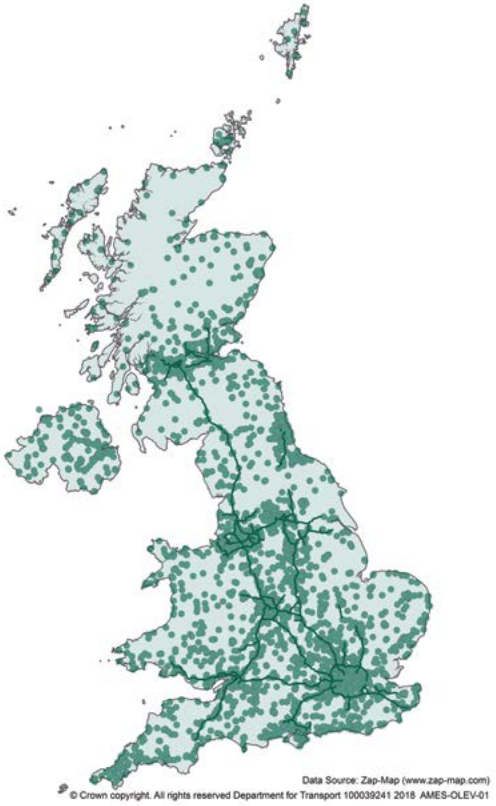
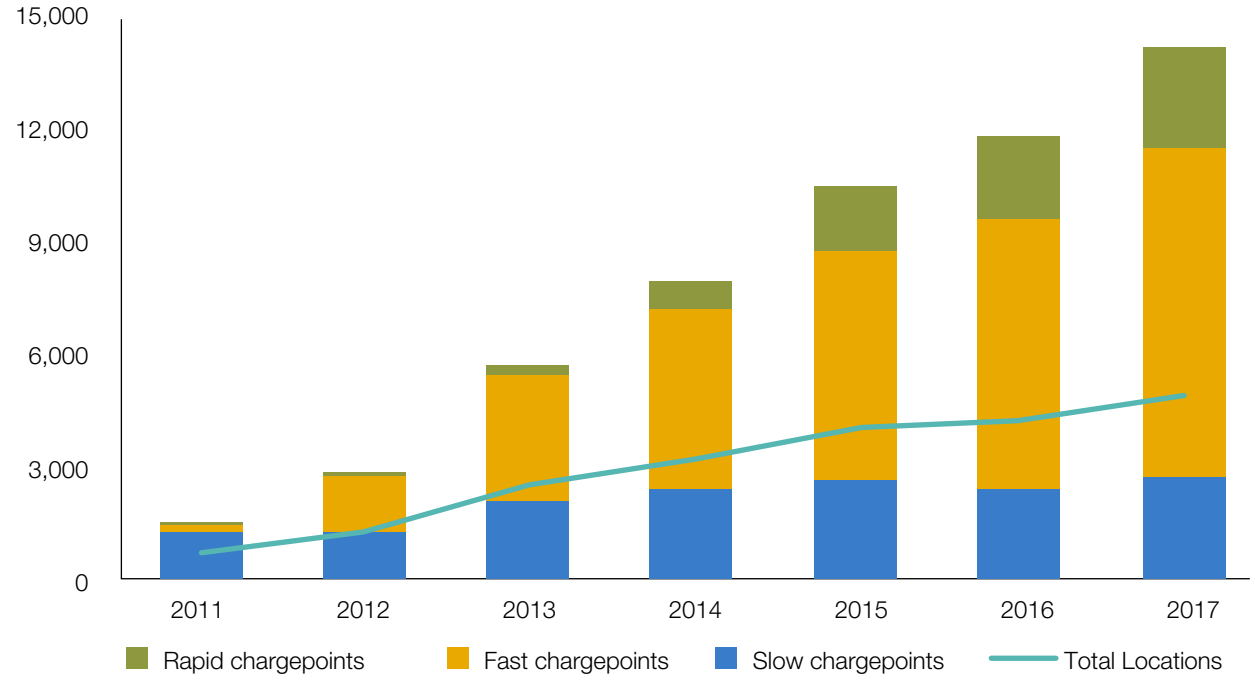


Figure 3.5: The number of public chargepoint connectors and locations in the UK is increasing[161]



Source: Zap Map

Key facts on existing EV chargepoint types

Public chargepoints are primarily one of three main types, based on the power output:

- **Slow**: up to 3kW AC – between 6-12 hours to charge a battery electric vehicle throughout, less for a plug-in hybrid
- **Fast:** 7 to 22kW AC power outputs, and typically charge a battery electric vehicle throughout in 3-4 hours
- **Rapid:** Typically, rapid AC chargers are rated at 43kW, while rapid DC are typically 50kW. Will typically charge a BEV to 80% in around 30 minutes.

Superchargers and high-powered charging are becoming increasingly relevant for battery electric vehicle throughout drivers, though current EVs are limited in the charging power they can accept.

Technological change

As technology develops at pace, we must be able to adjust to evolving user needs over time. Our considerations include: how longer vehicle range will influence the infrastructure needed and its use, changing driver behaviours as we move to mass market, and the different infrastructure needs for plug-in hybrid and battery electric vehicle drivers, as well as recognition that drivers' needs may differ by locations.

The Committee on Climate Change recently published analysis on the potential future demands of the UK infrastructure network, under their central scenario, which anticipates that 60% of new car and van sales will be plug-in hybrid or battery electric by 2030. Their key findings for the public network include that:

- to meet long distance en route rapid charging requirements, and maximise carbon emission reductions, the number of rapid chargers located near the major roads network needs to expand to 1,170 by 2030 (from 460 in 2016). The number needed may not need to increase in line with the rate of EV uptake given longer battery ranges, new charging technologies and a greater proportion of EVs able to use faster rapid charging technologies; and
- the number of public chargers required to meet the 2016 level of demand for 'top-up' charging while parking around towns and local areas is estimated to rise from 2,700 in 2016 to over 27,000 by 2030.[162]

Emerging charging technologies

The predominant method of charging electric vehicles has been through plug-in (conductive charging) technology. As the number of EVs increases, more dynamic, convenient and faster charging technologies will enter the market. We welcome the development of new charging technologies. But it is essential to continue support for the installation of the existing technologies now to grow the early market. Over the next decade, we expect to see co-habitation of different charging methods, with different technologies meeting the different and evolving needs of vehicles and drivers.

High power charging

Higher powered charging (up to 350kW) has been developed in response to increased sizes of batteries, with cars featuring these bigger batteries expected to be available from 2018. This could have an important role to play for longer journeys and in densely populated urban areas. Alongside other potential investors, Ionity, set up by BMW group, Daimler, Ford and Volkswagen Group with Audi and Porsche, has partnered with organisations such as Shell and announced plans to bring high power chargepoints to UK forecourts.[163] This will allow for convenient and quick charging when travelling long distances for compatible vehicles. Supported by government Go Ultra Low funding, City of York council are building five 'Hyper Hubs' which will include 150kw DC chargers and accommodate up to 200 vehicles charging per day.

Wireless power transfer

The wireless charging of EVs is becoming a commercial reality, with some premium manufacturers offering static wireless charging products at home this year. The development of wireless charging is an exciting prospect and one the Government is planning to support through our new R&D programme. Dynamic wireless charging – enabling vehicles to be charged whilst on the move – is being actively explored by a number of companies in the UK. Specially designed wireless transmitters could be embedded into the road network and be used to power vehicles and top up the battery as they drive. Upgrading motorways with this technology could allow vehicles to be driven long distances without affecting battery life and pave the way for commercial vehicles, buses and taxis to charge in use.

Infrastructure in Scotland

Drivers of EVs in Scotland can benefit from a comprehensive network of chargepoints through ChargePlace Scotland. Initially created as a result of combined UK government and Scottish government funding through the Plugged in Places project, ChargePlace Scotland is a network of electric vehicle charge points developed in partnership with all 32 Scottish local authorities, and through the Energy Saving Trust, with local businesses.

There are currently more than 800 publicly available charge points on the network, including over 175 rapid charge points. With just one access card needed for all journeys across Scotland, in August 2017, Electric Vehicle drivers using the ChargePlace Scotland network broke a network record by taking enough charge to travel over 1 million EV miles, which is the equivalent of travelling around Scotland's trunk roads 459 times without releasing any CO_2 emissions into the atmosphere.

Destination EV charging

Fast charging at "destination" locations which cars drive to and tend to stay for an hour or more is a convenient way for people to charge their vehicles. Surveys show that the presence of EV charging facilities can be a key factor for EV drivers looking for a parking location.[164] There is already a lot of activity as destinations such as car parks, supermarkets and hotels begin to meet growing demand for chargepoints. These locations can also play an important role in meeting the needs of people who do not have off-street parking, by offering overnight services to meet local residential demand.

As private investment increases, we do not see a need for direct government grant support in this area, but recognise the important role that fiscal levers, policy and planning can play as an enabler to support provision to maximise uptake:

- **Taxation**: In November 2016 the Government announced it would offer first year allowances (FYA) to businesses installing EV infrastructure, until the end of March 2019. This allows businesses to set 100% of the cost of the assets against taxable profits in a single tax year, meaning a company will be able to write off the cost of the chargepoint against the business's taxable profits in the financial year the purchase was made;
- **Planning**: The Government's National Planning Policy Framework provides direction to ensure local authorities fully consider the inclusion of chargepoint infrastructure in new developments;
- **Permitted Development Rights:** We commit to consult during the summer on a proposal to increase the height limit for the Permitted Development Right in England for the installation of electric vehicle chargepoints in designated off-street parking spaces. This will reflect the advances in technology; and

Supporting chargepoint installation through building regulations improvements

In addition to new domestic buildings, we are also planning to support charging facilities in new non-residential buildings and we will consult on amending Building Regulations to introduce relevant requirements for new non-residential buildings with appropriate associated car parking, to future proof them for chargepoint provision.

- **Transport hubs** are cornerstones of the UK's transport system. In particular, train station carparks are places where large numbers of vehicles are left for several hours and so hold an opportunity for more destination chargepoints. We have committed to providing a greater emphasis on the delivery of chargepoints as part of the rail franchising process in England to incentivise more ambitious chargepoint roll-out by Train Operating Companies.

Connecting chargepoints to the network

Smaller capacity (e.g. home chargers) grid connections will usually be able to be accommodated within an existing network connection. Installers can fit chargepoints and then notify the distribution network operator. Where larger capacity or multiple chargepoints are being installed, a new connection to the network will be needed or an existing connection will need to be expanded.

Source: BEIS

Since 2010, 1.4 million new customers were linked to the distribution network, including around 16GW of new distributed generation (e.g. wind turbines, solar photovoltaic).[165,166] The UK's process of connecting up new customers to the electricity network has been recognised as one of the best of the world; the 2018 World Bank Ease of Doing Business Survey ranked the UK in the top 10 countries worldwide for obtaining a connection.[167]

In November 2017, Ofgem launched its Electricity Network Access project to review how parties get access to the electricity network, the nature of access arrangements and what users pay.[168] New access arrangements could offer more choice for how consumers gain access to the system, leading to more efficient use of the network. More defined flexible access arrangements could incentivise EV users to allow network operators to constrain access to the network, subject to certain considerations, in return for a reduced connection charge. Changes to network charges could give better signals to users about the cost of using the network at different times and locations and, as a result, support more efficient use of the network. Ofgem is working with industry on options and will consult on their Initial Proposals for Reform in summer 2018.[169]

In recent years, industry and the regulator, Ofgem, has been working together to strengthen the regime further with the introduction of a range of new incentives and customer engagement mechanisms. Building on the learning from a range of innovation trials, industry has begun introducing 'smart' connection offers where the higher cost of investing in conventional infrastructure is avoided by incorporating other technologies such as storage or through actively managed connections. Government has also legislated to help ensure a fairer sharing of costs, help ensure independent connection provides can compete on a level playing-field and streamline the connection quotes service through revisions to the 'Second Comer' regime and the introduction of Assessment and Design Fees.[170,171]

Second life uses of batteries

Electric vehicle batteries have performance guarantees of around 8 years of service or 100,000 miles, depending on manufacturer.

There are various second life opportunities for batteries – including in-home storage. One second life application being developed is for batteries to act as home energy storage systems. Nissan are collaborating on a scheme called xStorage with power management company Eaton. The objective of this partnership is to develop energy storage solutions for houses, buildings and commercial facilities that have the capacity to store energy, saving money to the customer and supporting the entire energy system. Users can contribute to the de-carbonisation of the energy supply by storing, consuming or feeding renewable energy back to the grid. The systems also support sustainability by providing a second life for Nissan's electric vehicle batteries.

As part of the forthcoming call for evidence on last mile deliveries, we will gather further evidence of any potential key network connection infrastructure barriers, which may prevent further uptake of ultra low emission vehicles, specifically for fleet operators.

Rapid EV charging – enabling longer journeys

Despite only making up 2% of roads in England, the Strategic Road Network (SRN) takes a third of all traffic.[172] Highways England (HE) has a key role supporting the Government's air quality and decarbonisation commitments, working with its partners to support a future zero emission road network. As part of the first Road Investment Strategy (2015-2020), HE committed £15 million to ensure that its users are always within 20 miles of a rapid chargepoint along 95% of the SRN in England and are delivering a programme that will install at least 65 chargepoints in 2018/19 to meet the commitment. As a result, drivers can be confident that they will have access to rapid charging capability on long journeys undertaken on the SRN.

HE intend to fund the installation of rapid chargepoints that are no more than 2.5 miles or 5 minutes' drive from the SRN and are undertaking two parallel procurement approaches to installation: i) providing grants to local authorities installing chargepoints at between 15 and 20 locations; and ii) running a competitive procurement exercise that will install chargepoints at the remaining locations required to meet the target.

It is vital that our motorways and strategic roads are appropriately equipped for mass EV uptake. Our road network must meet the needs of drivers for use when they are undertaking longer journeys, and to ensure drivers do not become stranded. We expect the market will deliver a large proportion of this, as EV uptake increases, but if regulatory intervention is deemed necessary, the Automated and Electric Vehicles Bill, currently in Parliament, will play an important role in ensuring provision of chargepoints in key locations. This would provide government the powers to ensure sufficient, accessible and appropriate types of chargepoints are available in MSAs and at large fuel retailers.

By their nature MSA tend to be in rural areas with a requirement for rapid charging which means that it can be expensive to provide the additional electrical capacity required to meet future demand. To continue the work of future proofing the Strategic Road Network, we will run a pilot working closely with Highways England to increase electrical capacity at a MSA in the RIS 1 period.

Highways England – progress to date

Highways England (HE) have completed a gap analysis to identify locations required to fulfil their target. Under the grants process, HE have already issued grants to two local authorities, Mid Suffolk and Shropshire (A49) with a further four applications received: South Somerset (A303); Ryedale District Council (A64 York – Scarborough); Herefordshire (A49); Chichester (A27). Chargepoints will be installed this year.

Market delivery in action

There have been hundreds of millions of pounds of investment into the UK charging infrastructure sector in the last year alone.

Some examples include the recent high profile acquisitions of charging networks by Shell and BP, with commitments made to further deployment of public infrastructure as a result. A partnership agreement between ChargePoint Services and Motor Fuel group (MFG) is seeing an extensive roll-out of forecourt electric vehicle rapid charging across the UK. This partnership will host the 50kW plus rapid chargers at their sites nationwide which operate under the BP, Shell, Texaco, JET and Murco fuel brands.

The pilot will determine what combination of increased network connection, technologies and storage could be pursued for the increased number of rapid chargepoints, including the higher-powered rapid chargepoints that will be needed to meet demand in the future.

Rapid charging in urban areas

Rapid hubs or chargepoint "filling stations" in key strategic, community, or urban locations, also have an important role to play in the future. In particular, for commercial fleets and individuals without off-street parking, they could enable a more "internal combustion engine-like refuelling experience" and greater confidence to users that there is potential for multiple chargepoints to be available for use.

The Go Ultra Low Cities scheme will result in the provision of hundreds of additional chargepoints in participating cities including 17 rapid charging hubs sited at high-profile locations in city centres and outer ring roads. Some hubs will host up to 20 rapid chargers coupled with solar canopies and energy storage facilities. We will support sharing the lessons learned from these initiatives across the UK.

Charging Infrastructure Investment Fund: Public Private Financing to support roll-out

Considerable private sector investment will be required over the coming years to achieve the build-out of UK EV charging infrastructure. To catalyse the private investment required, we have announced a new £400 million EV Charging Infrastructure Investment Fund (CIIF). Government will set up the CIIF that will be managed and invested in on a commercial basis by a private sector fund manager, and plans to invest £200 million into the fund, to be matched by private investors. This model – of government setting up a fund for private investment and acting as a cornerstone investor – has also been successfully adopted to support the roll out of full fibre broadband through the Digital Infrastructure Investment Fund.

This investment in charging infrastructure reflects government's confidence in the growth potential of the sector. It will accelerate the roll-out of charging infrastructure by providing access to finance to companies that deliver chargepoints and encouraging growth of a more diverse range

of actors supporting the private market – growing competition and delivering the best outcome for the consumer.

The work to establish the CIIF is being led by the Infrastructure and Projects Authority (IPA), part of HM Treasury and Cabinet Office, who have engaged with a wide range of investors, representatives from the chargepoint and related industries, and other stakeholders on how to focus, structure and run the fund. This work will inform a tender process in the form of a Request For Proposal (RFP) to appoint a fund manager, who will make independent, commercial decisions on how to invest, within parameters set by Government. Government will be a Limited Partner in the fund and the fund manager will be tasked with raising at least another £200 million of commitments from the private sector to match the Government's investment.

To date, the IPA have carried out detailed market engagement to work out the best way and timetable for establishing and structuring the fund. This has included over 75 stakeholder meetings with the industry and finance community. The market engagement process is important to ensure the fund is set up correctly. The IPA will launch the RFP to procure the private sector fund manager in the summer. Once a preferred fund manager is nominated and the legal documents agreed, the fund will be formally launched and start investing.

At this stage the investment parameters that IPA has in mind are wide, including equity, mezzanine and possibly senior debt investments. Investments may be corporate in nature or directly into project-focused Special Purpose Vehicles. All elements of charging infrastructure are currently considered, including the physical chargepoints, the software required to run them and to make them smart, communicative and interoperable, connections to the national and local electricity distribution networks and related grid reinforcement, costs associated with site leasing and development, as well as battery storage solutions that may be related to the chargepoints. Equally, existing or novel business models may be considered.

Initial market feedback suggests opportunities for commercial investment are likely to require scale/high utilisation or some form of underwritten revenues. Opportunities appear greatest in the rapid charger and destination charging market. Potential solutions could include petrol station or hub-type sites in busy urban and suburban locations, charging "depots" coupled with some form of "minimum usage guarantee" from vehicle fleets, or, in the destination market, contractual arrangements where there are, for example, underwritten secondary revenue streams.

Local levers for incentivising EV charging infrastructure provision

We recognise that cities, regions and counties have a key role in facilitating the growth of EV charging networks. Legislation in the Automated Electric Vehicles Bill would give them a lever to help them deliver this locally. The Bill will enable elected mayors (the Mayor of London and Mayors of Combined Authorities) to designate locations – at large fuel retailers – to identify and require the installation of charging infrastructure within their areas by the Secretary of State for Transport, taking into

consideration their local knowledge. Mayors will be required to consult on these plans.

Local authorities have an intimate knowledge of local needs and responsibility for local planning policies. Planning policy is an important tool in leveraging residential and non-residential chargepoint infrastructure. Local planning policies in England are guided by the National Planning Policy Framework which plays an important role in future proofing new developments. Whilst government is considering its response to the consultation on revising National Planning Policy Framework the draft revisions make clear that that developments should be designed to enable charging of plug-in vehicles, and encourages residential and non-residential developments to ensure adequate provision of spaces for charging plug-in vehicles through setting local parking standards. Building on this framework, we will create accompanying guidance on infrastructure provision, so that local planning authorities can best ensure the delivery of charging networks.

Local authorities also have an important role in future proofing roads for on-street charging when streetworks are underway. Government is committing to provide guidance to local Highway Authorities in England on how they can consider the installation of infrastructure when roadworks are taking place, working with utility companies and chargepoint operators. Encouraging this will in the long run make the installation of chargepoints on streets easier and reduce the disruption to road users.

We recognise that local authorities may need support in getting the right solutions for their local area. We are therefore committing to produce guidance for local authorities to inform them about EV infrastructure and encourage best practice on levers that they have at their disposal to incentivise infrastructure, including planning, parking and streetworks.

The consumer experience of EV charging infrastructure

At the centre of our vision for infrastructure is the consumer experience of charging. Charging must be straightforward and hassle free. The public charging network must therefore reliable, widespread, accessible, convenient and affordable.

The Alternative Fuels Infrastructure Regulations 2017 will improve the experience of using chargepoints. They ensure that users have ad-hoc access to every publicly available chargepoint, allowing recharging without a pre-existing contract; compel infrastructure operators to make the

The London Plan

The National Planning Policy Framework has encouraged some local authorities to take an ambitious approach to their local planning policies. For example, in 'The London Plan', the Greater London Authority mandate that "developments in all parts of London must: ensure that 1 in 5 spaces (both active and passive) provide an electrical charging point to encourage the uptake of electric vehicles". This is currently under public consultation.

geographic location of their chargepoints publicly available; and mandate minimum technical specifications for chargepoint connectors, ensuring greater interoperability.

The Automated and Electric Vehicles Bill will provide powers to greatly improve the charging experience for current and future EV drivers by ensuring improved accessibility and interoperability for users of the chargepoints. The Bill will enable government to mandate a common minimum method of accessing public charge points, enabling interoperability between different types of EVs and charge points. It will also enable government to set reliability and maintenance standards to ensure chargepoints are accessible.

In addition, EV drivers need to know where chargepoints are located, whether they are available for use and whether they are in working order. The powers in the Bill will enable us to ensure this data is made freely available in an open source format, building on the Government's National Chargepoint Registry. In addition, these powers could require chargepoint operators to make reliability information available, which could be used to improve the consumer experience.

We believe that pricing models are ultimately commercial matters for chargepoint network operators or host sites and appreciate that charging to access chargepoints is important for the creation of a commercially sustainable network in the longer term. Neither the Alternative Fuels Regulations nor the Automated and Electric Vehicle Bill will prevent operators from continuing to offer attractive membership deals. However we are clear that we do not want to see prohibitive pricing of public chargepoints become a barrier to the greater take up of electric vehicles, and we will continue to monitor market developments closely and work with industry to ensure pricing for EV charging is proportionate at this early stage in the market, and meets the needs of drivers.

Additionally, following consultation, we have proposed to use existing legislation to standardise pricing information for electric vehicle recharging and refuelling under existing regulatory powers. This could make public charging easier for electric vehicle drivers and encourage a more competitive market.

Chargepoints are new entrants to the streetscape and we want these to be aesthetically pleasing. We will therefore be launching a chargepoint design competition.

Delivering EVs and upgrading our energy infrastructure

The electricity market is already set up to bring forward investment in generation capacity to meet demand. The Contracts for Difference scheme supports investment in low carbon generation and importantly, the Capacity Market, which is specifically designed to ensure there is generation capacity to meet peak demand.[173,174] Capacity Market auctions procure the capacity that is needed four years ahead, and one year ahead, meaning the regime is designed to bring forward generation in a timely way even if EV take-up is faster than anticipated.

We will bring together government and the energy and automotive industries in an EV Energy Taskforce. It will focus on smart charging and how to plan for future EV

uptake and ensure the energy system can meet future demand in an efficient and sustainable way. It will launch in the summer and report back to government with proposals for government and industry over the following year.

In terms of transporting the power, Ofgem's RIIO price control process helps ensure timely investment in network infrastructure.[175] National Grid, as the System Operator, and the network companies are responsible for forecasting and monitoring new demand on the network, in order to shape their investment plans for reinforcing the local network, deploying smart grid technologies or procuring smart, flexible services from third parties. This ensures the network infrastructure can transport the power to where it is needed.

In line with the joint Ofgem and BEIS Smart Systems and Flexibility Plan, Distribution Network Operators are transitioning to a distribution system operator role. The transition is being coordinated by the Energy Networks Association through the Open Networks Project.[176] This involves actively managing networks to enable more competition for network services, including considering smart solutions (potentially using flexibility services provided by EVs) rather than solely network build.

As EVs are rolled out, they may be taken up in some areas more quickly than others, an effect known as 'clustering'. Smart solutions will help and industry is consulting on the best way to manage any effects from clustering.[177] The government looks forward to understanding stakeholder views and the best way of managing this issue in the best interest of consumers.

Electric Nation – smart charging to support mass roll-out of electric vehicles

Electric Nation has recruited 700 electric vehicle (EV) drivers, across 40 different EV makes and models, to test the latest smart charging technology and is developing their understanding of customer acceptance of domestic managed charging. Electric Nation is a Western Power Distribution (WPD) and Network Innovation Allowance funded project. WPD's collaboration partners in the project are EA Technology, DriveElectric, Lucy Electric, GridKey and TRL.

Early findings show that charging behaviour does create flexibility for smart charging at the key time of day for distribution networks, which has the potential to delay or reduce the need for costly and disruptive reinforcement work. The trial is due to complete in December 2018.

Part 3b: Hydrogen

The development and deployment of hydrogen fuel cell electric vehicles (FCEVs) is at an earlier stage than for plug-in hybrid or battery electric vehicles. Our approach in considering the appropriate government support to the development of hydrogen as a transport fuel in the UK has been based on moving in step with international progress on standards and technology, ensuring that the UK retains its position in the forefront of the adoption of zero emission vehicle technologies whilst retaining flexibility and managing risk in order to secure the opportunities at this early stage of the market.

A lack of refuelling infrastructure remains a key barrier to the future roll out of FCEVs. Since 2014, government has sought to help address this market barrier by providing £4.8m and a co-ordinating function turning the refuelling facilities from various demonstrator projects into an initial network of 15 hydrogen refuelling stations (HRS) – these are operational and publically accessible.[178]

The early nature of the market means vehicle costs are still high. £2m has been provided to directly support public and private sector fleets to become early adopters of FCEVs. There are limited volumes and models of FCEV's currently being produced globally. Despite this, the UK has been successful in securing allocations of these first and second generation models, facing strong competition from other lead markets. Major vehicle manufacturers are publicising their plans to increase production and bring new models to market over the next few years.

The funding will deliver a fourfold increase in the number of FCEVs on UK roads firmly placing the UK at the forefront of early adoption, alongside California, Japan, and Germany. This is important because fuel cell technology could offer a longer-term solution in the freight and bus sectors. In the long term, hydrogen may be more suited for use in HGVs and by fleets where range and fast fuelling are key concerns.

The UK is well placed to be a global leader in hydrogen and fuel cell powered transportation. We have high quality and growing engineering and manufacturing capability in relevant supply chains.

Hydrogen for Transport Programme

In March 2017, the Government announced £23m of additional funding to increase the uptake of FCEVs and grow the number of HRS. The Hydrogen for Transport Programme (HTP) is providing support out until 2020. The funding competition for the first phase of the programme offered £9m capital budget to provide match funding for eligible projects. The successful bidders were announced on 26 March 2018. The project is being delivered by a consortium which includes Shell, ITM Power, Toyota, Hyundai and Honda as well as fleets users such as the Metropolitan Police and Green Tomato taxis. It will see four new HRS being built, upgrades to five existing stations and the deployment of 193 FCEVs.

Our approach has been to align deployment of FCEVs with the appropriate infrastructure investments to ensure significant levels of station utilisation. 'Healthy' station utilisation should create levels of revenue for refuelling station operators that will encourage further private sector investment in expanding the network and support the case for investing in regular maintenance. Maintenance is important as it ensures high levels of availability, which in turn creates a positive consumer experience. Our ambition is that with these strategic interventions the market for hydrogen refuelling and vehicles moves to a genuinely sustainable footing as quickly as possible with growing industry involvement and investment.

An increasing number of studies and reports are presenting a range of visions for both global and UK hydrogen economies.

Globally, a number of countries are taking steps to reap the benefits of integrating hydrogen vehicles into the wider energy system. Japan, for example, is seeking to build a 'hydrogen society', with hydrogen delivering energy across the economy, as well as in transportation.

There is more to do to understand how far the UK hydrogen economy could expand, decarbonise and apply to other sectors. Government is supporting a range of innovation activity looking at the potential role of hydrogen in heat and industry as well as transport.

Source: ITM Power

Part 4

Leadership at all levels

Part 4: Leadership at all levels

The UK's devolved administrations in Scotland, Wales and Northern Ireland possess, through their devolved powers, levers not available to central government to encourage motorists to make the switch to ultra low emission vehicles. This includes local incentives and/or regulations, and leading by example by making bold changes to public sector fleets, buses and taxis.

We recognise and welcome the progress made in Scotland, Wales and Northern Ireland have already made to reduce emissions from road transport, and promote the uptake of ultra low emission vehicles.

Each of the devolved administrations already has its own programme of measures in place.

The ambitions we have set out in this strategy are for the whole UK, and it is vital that no area is left behind. Central government will continue to work closely with the devolved administrations to reduce emissions from road transport. The grants for plug-in cars, taxis, vans and motorcycles are available UK-wide, as well as the grants for domestic, workplace and on-street chargepoints.

Support for ultra low emission vehicles in the devolved administrations

Scotland

- The Scottish government has said it will phase out the need for petrol and diesel vehicles by 2032.[179]
- In June 2017, Transport Scotland published 'Switched on Scotland Phase Two: An Action Plan For Growth'. This document establishes a 10-point plan to define the actions that Transport Scotland and its partners will take between 2017 and 2020 to accelerate the uptake of electric vehicles and overcome barriers to adoption.[180]
- Scotland has announced that it will accelerate the procurement of ultra low emission vehicles in the public and private sector car and van fleets by the mid-2020s and into the commercial bus fleet by the early 2030s.
- The plan includes an expansion of electric charging infrastructure, including charging hubs. The Scottish government has announced a plan to create an 'electric highway' on the A9, including charging points along the route.
- Through the Energy Saving Trust Scotland, Transport Scotland funds an interest-free loan for electric vehicles of up to £35,000 to cover the cost of purchasing a new ultra low emission vehicle, or up to £10,000 to cover the cost of a new electric motorcycle or scooter.[181]

Wales

- The Welsh government wants Wales to have a leading role in the development of the ultra low emission vehicle industry and has set out its aims in the Wales Economic Action Plan.[182] The Wales Transport Strategy, in development, will set out how the transport sector can be decarbonised and maximise its contribution towards these aims.
- Welsh government has the ambition for the public sector in Wales to be carbon neutral by 2030, and expects ultra low emission vehicles to have a key role in achieving this.[183] EV charging points have been installed at Welsh government offices, and are being planned for the wider Welsh government estate, education establishments and hospitals.
- An Automotive Technology Park will be developed at Blaenau Gwent with a wider remit for the Valleys area to become a leading location for the development of emerging technologies by 2027.[184] Projects will include research into battery and powertrain technology, 5G testing, and the infrastructure needed for automated and ultra low emission vehicles. A Welsh National Battery Development Centre is also planned, based around the University of South Wales' industry-renowned Centre for Automotive Power Systems Engineering (CAPSE).[185]
- The Welsh government will be investing £2m in electric vehicle charging points over the next two years to improve publicly accessible provision throughout Wales.[186]
- A Clean Air Zone framework is being developed for Wales which will encourage the uptake of ultra low emission vehicles.[187]

Northern Ireland

- The Northern Ireland Department for Infrastructure led a consortium which installed a network of over 336 fast and rapid chargepoints at 176 locations in Northern Ireland.[188] These chargepoints are fully interoperable with the network in the Republic of Ireland providing a cross-border, all-island solution for users. These are owned and operated commercially by the Electricity Supply Board.[189]
- The Department for Infrastructure's Ecar team provides support to consumers and the private and public sectors to promote ultra low emission vehicle growth.[190] They have facilitated the installation of a further 54 chargepoints in the Public Sector Estate.

Local areas

Local areas can play a key role in encouraging the transition to zero emission vehicles. For instance, London alone has accounted for 1% of global sales of ultra low emission vehicles to date.[191] We welcome this leadership. It is these numerous, diverse centres of innovation that will underpin the transition to zero emission vehicles. We want all areas of the UK to consider the role they can play in tackling local air quality problems.

In July 2017, we required 29 local areas to bring forward plans for Clean Air Zones, to reduce levels of roadside NO_2 as soon as possible.[192] We encourage those local authorities developing plans to deliver compliance with legal NO_2 limits to consider how their plans can support and enable the transition to zero emission vehicles in the long term. Local authorities identified in the NO_2 Plan to take action are able to submit proposals to support such measures from the £255 million Implementation Fund and the £220 million Clean Air Fund, provided these deliver the objectives of these funds and can demonstrate they are in addition and complementary to existing government funding to support the associated infrastructure and uptake.[193,194]

£24.5 million from the Implementation Fund was made available to local authorities in March 2018 to support a range of measures to take immediate action locally. This included support for installing electric charge point hubs in car parks, bus priority measures, building cycle routes, and incentivising ultra low emission taxis through licensing schemes and leasing electric vehicles.[195]

We will continue to work across the UK to champion best practice and ensure that the benefits of the transition to zero emission vehicles are felt across the country.

Clean Air Zones

A Clean Air Zone (CAZ) defines a geographical area where targeted action is taken to improve air quality, shaping the urban environment in a way that delivers improved health benefits and supports economic growth.

CAZs aim to address all sources of air pollution, including NO_x and PM, and reduce public exposure to them using a range of specially tailored local measures. These measures can include charges for vehicles which do not meet defined minimum emission standards ('Euro VI/6' for diesel and 'Euro IV/4' for petrol).

The Government is currently working with 62 cities and local authorities where air pollution is above legal limits to develop local Air Quality Plans, which should consider a wide range of innovative options to improve air quality. Where these measures are not sufficient, a local authority may choose to implement a CAZ – although this is unlikely to be appropriate in all cases.

To help people understand what this means for them, the Government has taken steps to improve the information available to consumers and businesses.

Since April 2018, point of sale data for new cars has included the Euro standard (all new cars are Euro 6), a brief explanation of when the Vehicle Excise Duty supplement for diesel cars applies and confirmation that Euro 6 cars meet current minimum standards for CAZs. As some used cars will not meet the standard for CAZs, the used car label, voluntarily adopted by most dealers, will be amended in 2018.

This section sets out some of the levers available to devolved administrations and local authorities across the UK to drive progress and the steps we are taking to support them to do so. Support for local authorities considering the provision of infrastructure is outlined in Part 3 above.

Post-purchase incentives for ultra low emission vehicles

A number of studies indicate that post-purchase indirect incentives are effective at driving people to make the switch to ultra low emission vehicles, with higher numbers of supportive policies correlated with higher

Electric Vehicle Experience Centre: Milton Keynes

To encourage the uptake of EVs, Milton Keynes Council has provided an innovative approach through its launch of the Electric Vehicle Experience Centre in July 2017. Supported by OLEV's Go Ultra Low City Scheme, this is the UK's first brand-neutral Centre for EVs. Its aim is to attract would-be owners of EVs and provide them with sufficient information, experience and support to inform their decision to purchase or lease.

The Centre gives people the opportunity to talk to highly trained EV experts ('EV Gurus'), and is open 7 days a week. The Gurus talk through the benefits of electric vehicle ownership, the available vehicle choices on the market, how to charge an EV, the savings in running costs and then offer a brief test drive from one of the ten car brands in the EV Experience Fleet, which are parked a few steps away from the Centre. It also has a loan fleet of over 50 vehicles enabling a short-term or longer-term "try before you buy" experience.

Milton Keynes Council has been collecting data to establish the number of short-term and long-term test drives, number of leads generated and total footfall. In its first 6 months it had a total footfall of over 7,000 people per month, with almost 1,860 sales leads generated. It is clear that it is already having an impact in improving understanding of electric vehicles.

Source: EV Experience Centre

uptake.[196] Globally, the cities with the highest uptake of EVs each employ various direct and indirect incentives to encourage sales.[197]

In 2016, we funded eight exemplar cities to accelerate the roll-out of ultra low emission vehicles through a £40 million Go Ultra Low Cities scheme.[198]

In addition to providing valuable learning points and examples of best practice for all local authorities, the GUL City Scheme will deliver around 1600 new chargepoints including up to 1000 on-street chargepoints.

These projects also support the uptake of ultra low emission vehicles in adjacent rural areas. For example, infrastructure planned under the Bristol and West of England project includes installations in surrounding district council areas. Dundee and York are installing chargepoint hubs to link up wider local areas, enabling commuters and others to benefit.

Other local measures include:

- Free or subsidised parking for ultra low emission vehicles – as in Milton Keynes and Dundee;
- Support for local businesses transitioning their fleets to ultra low emission vehicles – as in Nottingham and Bristol; and
- Incentives through preferable access to low emission and clean air zones (London provides free access for ultra low emission vehicles to its Congestion Charge Zone).

These are already proving to be successful. To continue to support local authorities to introduce post-purchase incentives for ultra low emission vehicles, we will:

- Disseminate best practice and learning points from the eight GUL cities to enable other authorities to promote ultra low emission vehicles and support the installation of chargepoint infrastructure. We will run a series of regional events across the UK during 2018.
- Launch a new service on the Go Ultra Low website that captures in one place all the local incentives that exist across the UK to help promote them to motorists.

In order to promote ultra low emission vehicles, local areas may need to define which vehicles are ultra low or zero emission. There is a case for a national standard to give clarity and consistency to consumers and businesses. But local areas will also need flexibility to reflect local circumstances. We will aim to set out guideline definitions in early 2019 which local areas may wish to adopt in setting their own definitions.

Taxis

The move to zero emission taxis will deliver significant local benefits because taxis are typically used more intensively than private cars and often in urban centres where congestion and poor air quality are issues.[199] There are around 250,000 taxis operating across the UK: 75,000 hackney carriages and 175,000 private hire vehicles. The transition of this fleet to ultra low emission vehicles is a priority to help prevent the most polluting vehicles from entering areas with air quality issues.

There is now a new market in purpose built zero emission black cabs. The Coventry based London Electric Vehicle Company's new zero emission taxi is on the road in a

A zero emission black cab
Source: LEVC

number of cities around the country and we expect ADV Dynamo to launch its new taxi in the near future. We have supported this early market through a new plug-in taxi grant of up to £7,500 to help reduce the upfront price premium for a purpose built taxi.[200] The plug-in car grant supports other ultra low emission vehicles that are used as taxis.

To support this new taxi market it is important that suitable chargepoint infrastructure is in place. We are therefore providing ten local authorities across the country with £14m up to 2020 (which also will enable match funding) to install chargepoint infrastructure. Several of these ten local authorities service wider rural areas.[201]

To support this funding, these authorities are using their taxi licensing regime and other local levers to drive the uptake of these new taxis. For example, London introduced new requirements so that from January 2018 all newly licensed taxis must be capable of zero emission journeys.

The combination of national and local measures means we expect taxi fleets will be capable of zero emission journeys faster than the wider private fleet. We recognise that there may need to be interim steps for some operators, particularly where air quality is an immediate issue. For example, in the short term this may mean choosing a Euro VI petrol vehicle or considering alternatives such as converting existing vehicles to run on LPG.

There is still much more to do across the country to complete the taxi fleet's transition to zero emission vehicles. That's why:

- we have established a £50 million plug-in taxi grant, providing up to £7,500 off the price of a purpose-built taxi.
- we have established and will continue to support a best practice network for the 10 local authorities where we have invested £14 million for taxi chargepoint infrastructure.
- we will provide a minimum of £6m further funding to help more local areas install infrastructure.
- we are working to revise best practice guidance to local taxi and private hire vehicle licensing authorities in England. As part of this work we are exploring whether to mandate that all taxi fleets in urban areas should be capable of zero emission journeys by 2032.
- the Low Carbon Vehicle Partnership is developing guidance on ultra low emission taxis for local authorities to be published in early summer 2018.

Buses

Buses are a vital part of the public transport system and critical to the government's objectives to encourage modal shift to more sustainable modes of travel. One full double decker bus can take up to 75 cars off the road.[202] That means that buses take millions of car journeys off UK roads every year, reducing greenhouse gases and congestion. Buses also play an important role in providing more accessible transport for those who cannot drive.

Overall, buses emit less air pollution than the equivalent number of car journeys they replace. However, on urban routes – where the majority of buses operate – the slower speeds, stop-start conditions and presence of multiple bus routes mean that older diesel buses can be responsible for significant local emissions. We are therefore taking urgent action to clean up the bus fleet.

As things stand the majority of buses on the road in the UK use diesel engines – but ultimately, as for all vehicle types, we want a transition to zero emission vehicles. The bus industry has seen a significant increase in the number and range of market-ready zero emission technologies in recent years, as well as widespread action to retrofit emission-reduction technology to the existing bus fleet.

Zero emission buses have significantly lower greenhouse gas and air quality pollutant emissions compared to those powered by other liquid or gaseous fuels. Battery electric buses provide greenhouse gas savings of around 80%, whilst hybrid electric buses provide greenhouse gas savings of about 40%, compared to a standard diesel bus.[203] Electric operation can be particularly beneficial in low speed, stop-start conditions where traditional combustion engines powered by diesel or gas are least efficient.

There are already more than 2,500 low emission buses on UK roads, out of the 40,300 across Great Britain. However, we want to see these more across the country as soon as possible, especially in the areas with the most pressing air quality issues. We have already invested £130 million to support the purchase of over 1,700 low emission buses and supporting

Liverpool City Buses

With nearly £5 million support from the Low Emission Bus Scheme in late 2017, Liverpool City Region in partnership with Arriva Merseyside delivered 72 low emission buses, including 12 single decker electric buses on routes from the city centre to Everton Valley, Anfield and Kensington. The buses can operate for 130 miles on a single charge. The Liverpool City Region Alliance has launched the 'Better by Bus' campaign communicating the advantages of travelling by bus and the experience passengers can expect on the new fleets. Passengers can enjoy exclusive ticket offers, smarter mobile ticketing apps and on-board technology solutions such as free Wi-Fi and USB charging points.

Source: Arriva Bus

infrastructure through the Green Bus Fund and the Low Emission Bus Scheme.

Since 2013, we have also awarded £67m to retrofit 5,700 buses through the Clean Bus Technology Fund with technology to reduce tailpipe NO_2 emissions, as set out in Part 2a. There will be a further opportunity for local authorities developing local air quality plans to bid for funding for bus retrofit through the Clean Air Fund. All of this is supported by the Clean Vehicle Retrofit Accreditation Scheme.[204]

To provide further support for the transition to zero emission buses, we have launched a new ultra low emission buses scheme. £48m will be provided to accelerate the uptake of ultra low emission buses and related infrastructure in England and Wales.[205]

The Bus Services Act 2017 includes a range of measures to improve bus services through franchising and better partnership working. Local authorities and bus operators will be encouraged to agree a package of improvements to introduce bus priority

measures to reduce idling and journey times, or to introduce ultra low emission options along key routes.

Leading by example: public sector procurement and fleets

25% of the central government fleet will be ultra low emission by 2022 and we want 100% of the central government car fleet to be ultra low emission by 2030. We want to see similar ambition from local government and other public sector fleets. We will provide fleet transition advice through the local roadshows we are planning to run across the country.

Annex A

Summary of the environmental performance of fuels and powertrains

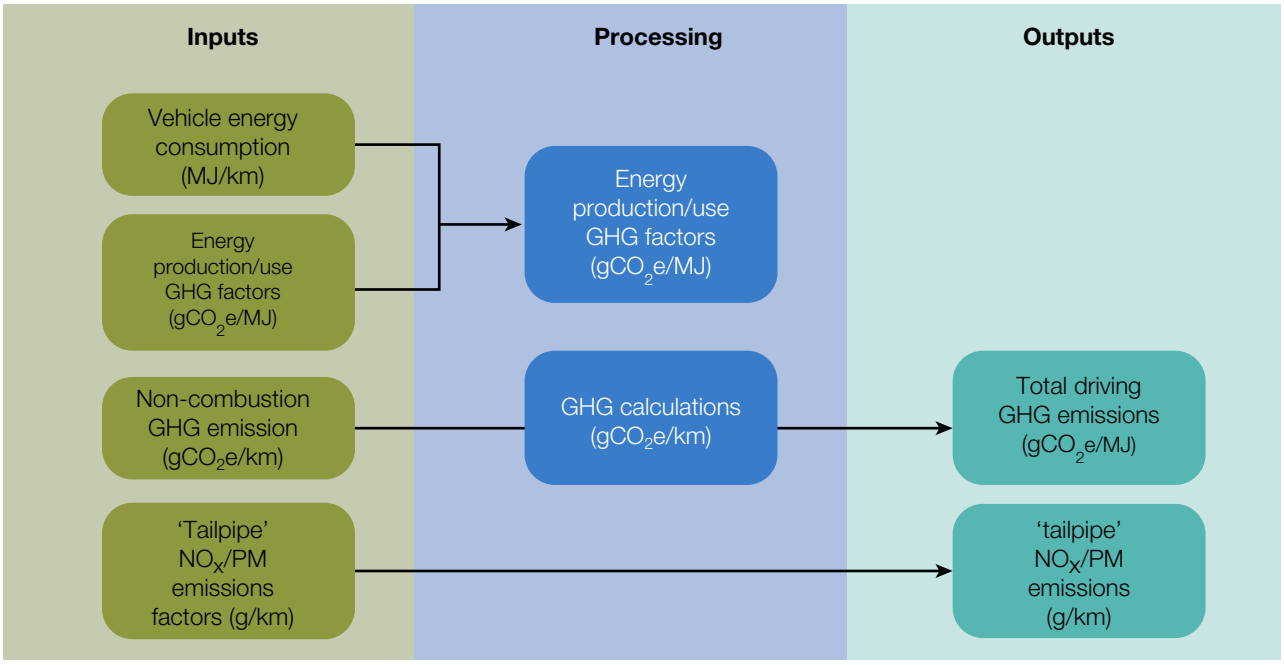
Annex A: Transport Energy Model – summary of the environmental performance of fuel and powertrains

This Annex appraises the relative environmental performance (in terms of air pollutant and greenhouse gas emissions) of different fuel and powertrain options available to consumers based on the outputs of the Transport Energy Model. The diesel emissions scandal and the ongoing gap between laboratory and real world emissions performance of new cars has undermined public confidence and has made it difficult for consumers to determine the environmental impact of their vehicle choices. Vehicle manufacturers must do better to deliver the environmental performance the UK public expect.

Uncertainty over real-world environmental performance is having an impact on individual purchasing decisions and industry investment. Consumer groups and stakeholders from across the automotive, fuels and environmental sectors have called for a transparent assessment of the environmental impact of different road vehicle fuels and technologies, and for clear signalling from government to help focus investment and purchasing decisions.

To respond to these calls, the Department for Transport has developed the Transport Energy Model (the TEM; see figure A1). The model allows us to estimate the tailpipe

Figure A1: Transport Energy Model methodology



Key: MJ = mega joules, GHG = greenhouse gas, gCO_2e = grams of CO_2 equivalent, NO_x = nitrous oxide, PM = particulate matter

emissions of air pollutants, the greenhouse gas emissions and the energy consumption of a range of fuel and powertrain options for cars, vans, buses and heavy goods vehicles (HGVs) over the period to 2050.

The Government has worked extensively with vehicle, fuel and other stakeholders to develop the model and it has been subject to an external quality assurance review. The detailed methodology and outputs of the Transport Energy Model are set out in the Transport Energy Model Report, published alongside this strategy.

The outputs of our modelling have been used to consider the current and likely future environmental impact of the range of energy sources and technologies that are currently used in road transport.

Figures A2–A7 (see pages 118–123) illustrate the greenhouse gas emissions and tailpipe emissions of oxides of nitrogen (NO_X) from a medium car, a panel van, a bus and an HGV running on a range of energy sources. For fossil fuels the greenhouse gas impact includes current average biofuel blend levels. For electricity the greenhouse gas impact is based on UK marginal grid electricity. Charts illustrating emissions of particulate matter can be found in the Transport Energy Model Report.[206]

Diesel

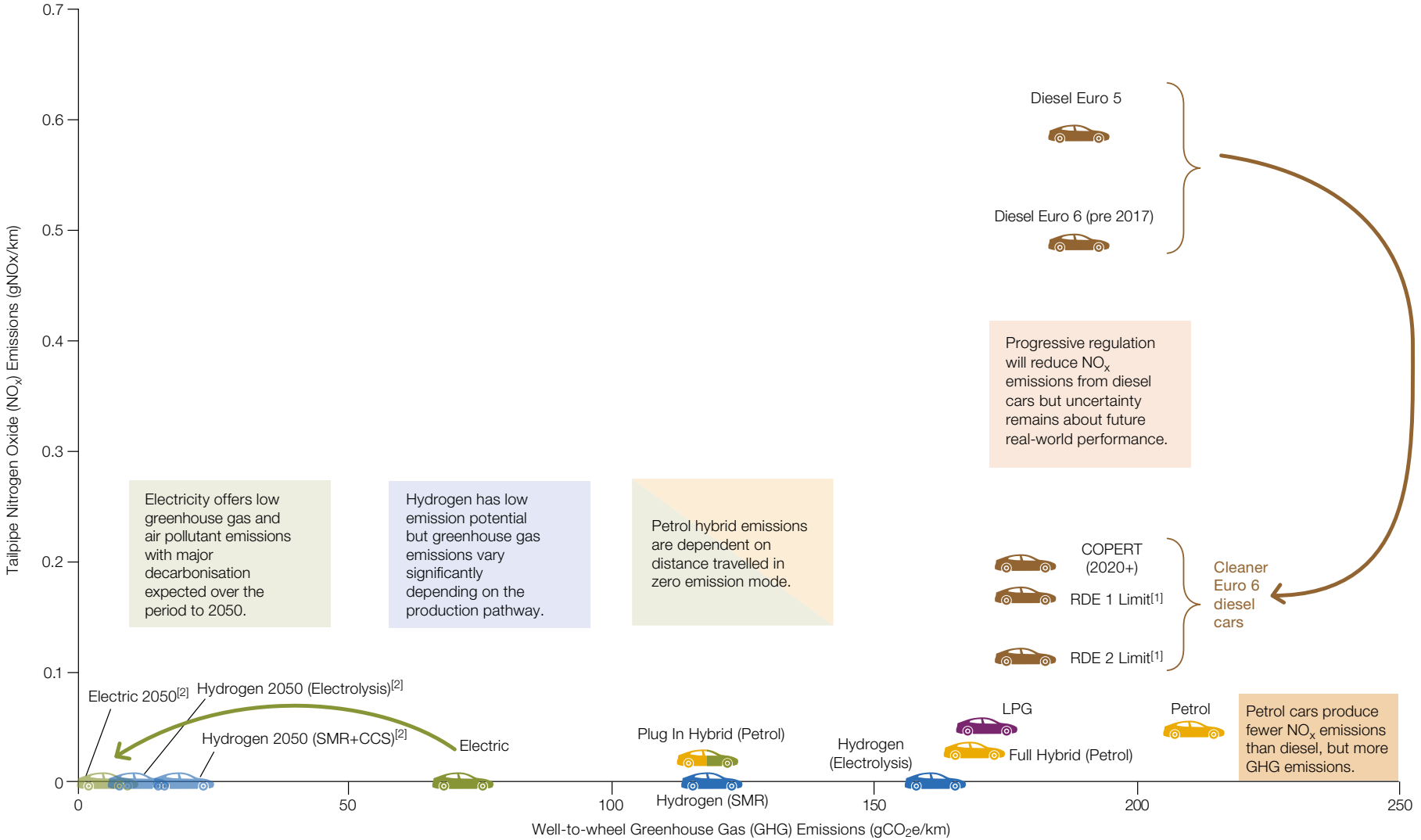
The use of diesel is widespread in cars and dominates in vans and heavier vehicles (buses and HGVs) in the UK. For diesel cars and vans the relatively better efficiency of diesel engines compared with petrol engines results in improved fuel economy and lower greenhouse gas emissions per kilometre than from petrol equivalents.

Real world emissions of NO_X from diesel cars and vans that do not meet the new Real Driving Emissions (RDE) standards are typically much higher than petrol equivalents. Particulate matter emissions have reduced substantially with the use of diesel particulate filters, and NO_X emissions from these vehicles are expected to decrease considerably with the introduction of more stringent real-world emissions testing in coming years. However, current best estimates suggest that future NO_X emissions from diesel cars and vans will remain higher on average than petrol equivalents.

For heavier vehicles, particularly HGVs, the fuel efficiency and high torque (pulling power) of diesel engines make diesel a popular and practical option, especially for those doing high mileage. In addition, real world NO_X emissions from heavy diesel vehicles (buses and HGVs) have reduced significantly as a result of tougher regulatory standards from Europe – by an estimated 97% for a 44 tonne HGV (long haul duty cycle) going from Euro IV to Euro VI. The UK played an active role in supporting and developing these standards.

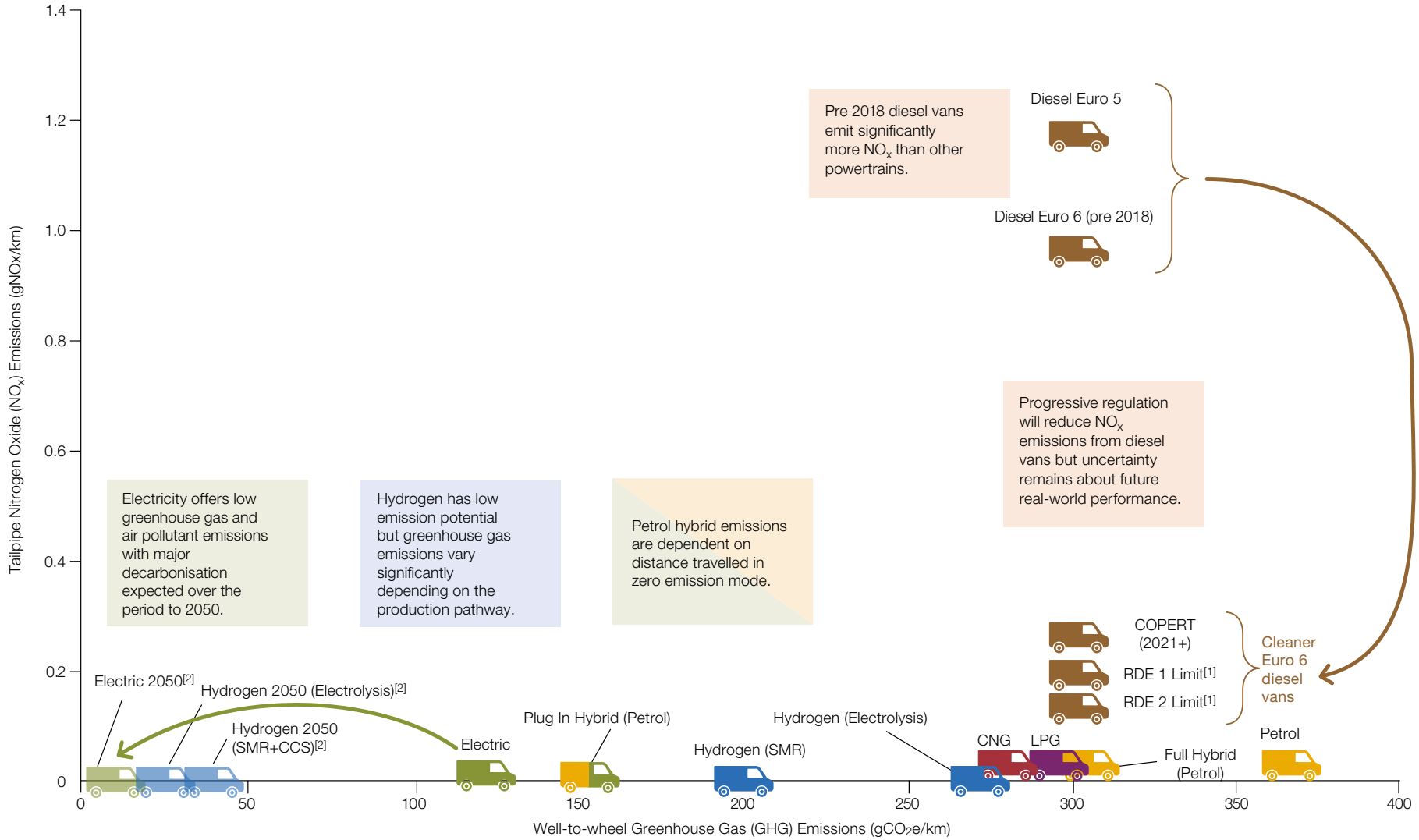
It is important to note that our modelling work takes into account the potential impact of selective catalytic reduction (SCR) technology on greenhouse gas emissions. This technology is increasingly being installed to help remove NO_X from diesel tailpipe emissions. It emits small amounts of nitrous oxide (N_2O) which is a powerful greenhouse gas.[207]

Figure A2: Estimated greenhouse gas (GHG) and nitrogen oxides (NO_x) emissions for a typical medium car on a mixed urban/extra-urban duty cycle (average speed 34km/h)



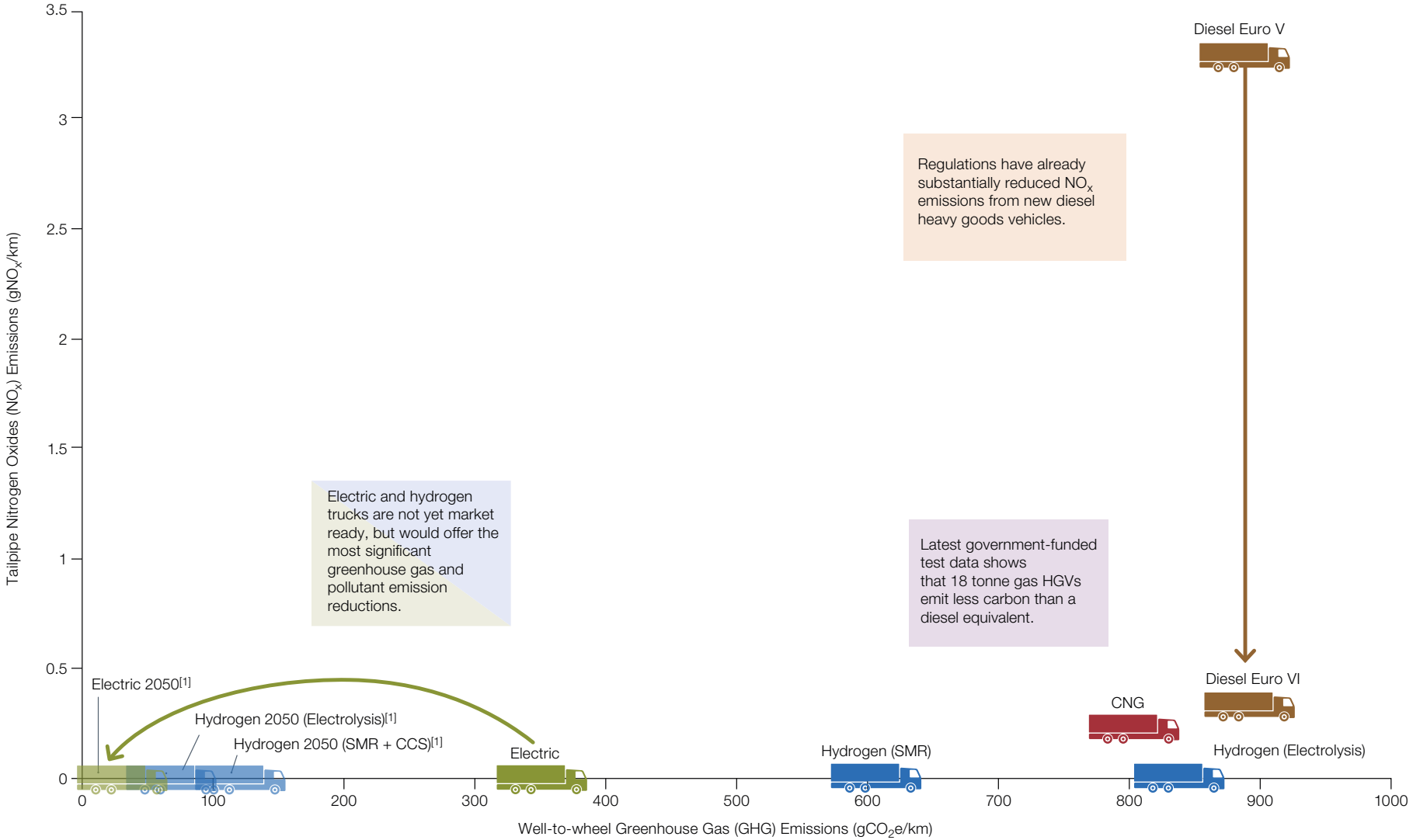
[1] RDE Limits included a factor accounting for measurement error.
[2] Future projections (vehicle energy consumption held at 2017 levels).

Figure A3: Estimated greenhouse gas (GHG) and nitrogen oxides (NOx) emissions for a typical panel van on a mixed urban/extra-urban duty cycle (average speed 34km/h)



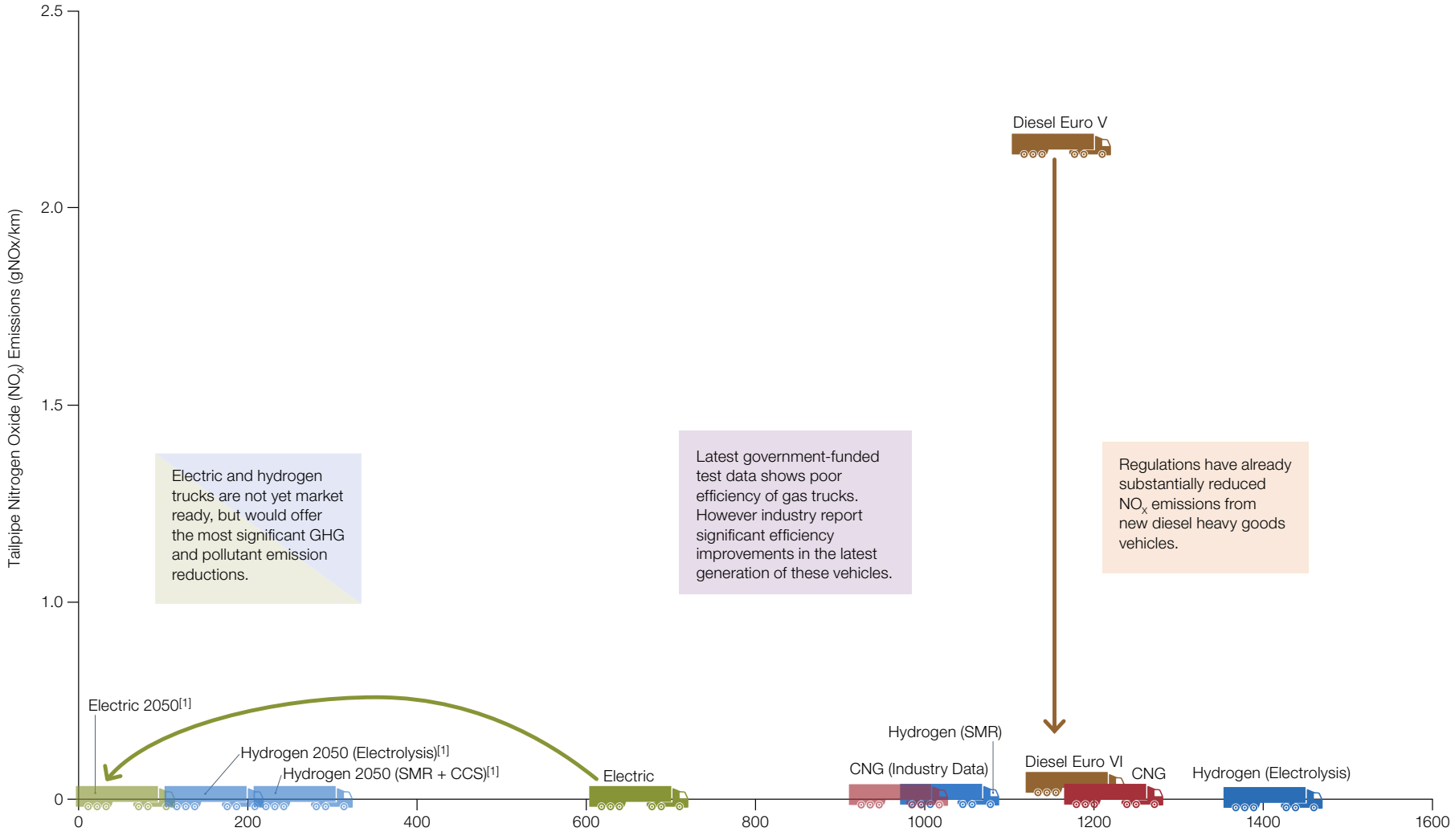
[1] RDE Limits included a factor accounting for measurement error.
[2] Future projections (vehicle energy consumption held at 2017 levels).

Figure A4: Estimated greenhouse gas (GHG) and nitrogen oxides (NO_x) emissions for an 18 tonne HGV on a 'regional delivery' duty cycle (average speed 53 km/h)



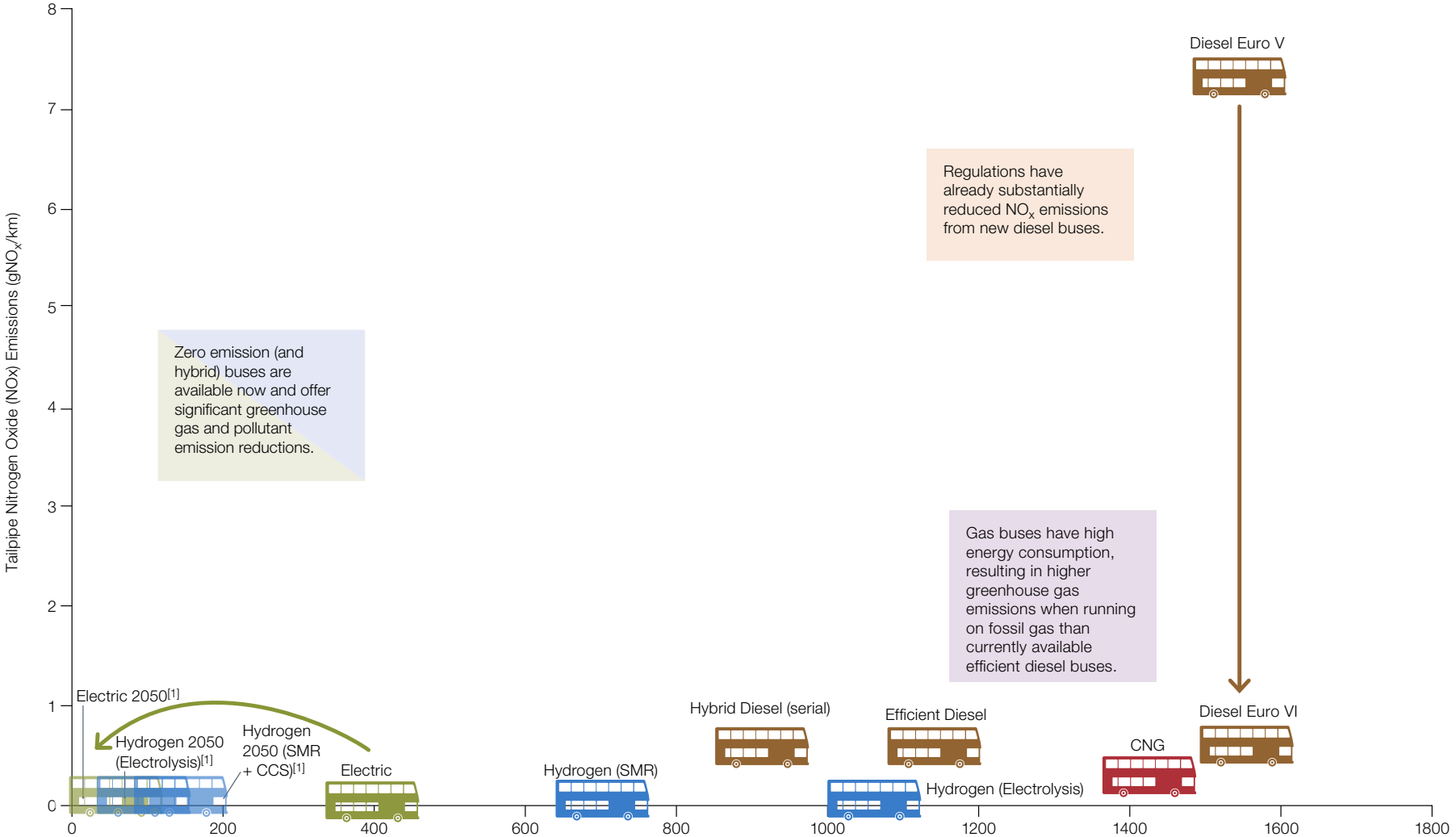
[1] Future projections (vehicle energy consumption held at 2017 levels).

Figure A5: Estimated greenhouse gas (GHG) and nitrogen oxides (NO_x) emissions for a 44 tonne HGV on a 'long haul' duty cycle (average speed 79 km/h)



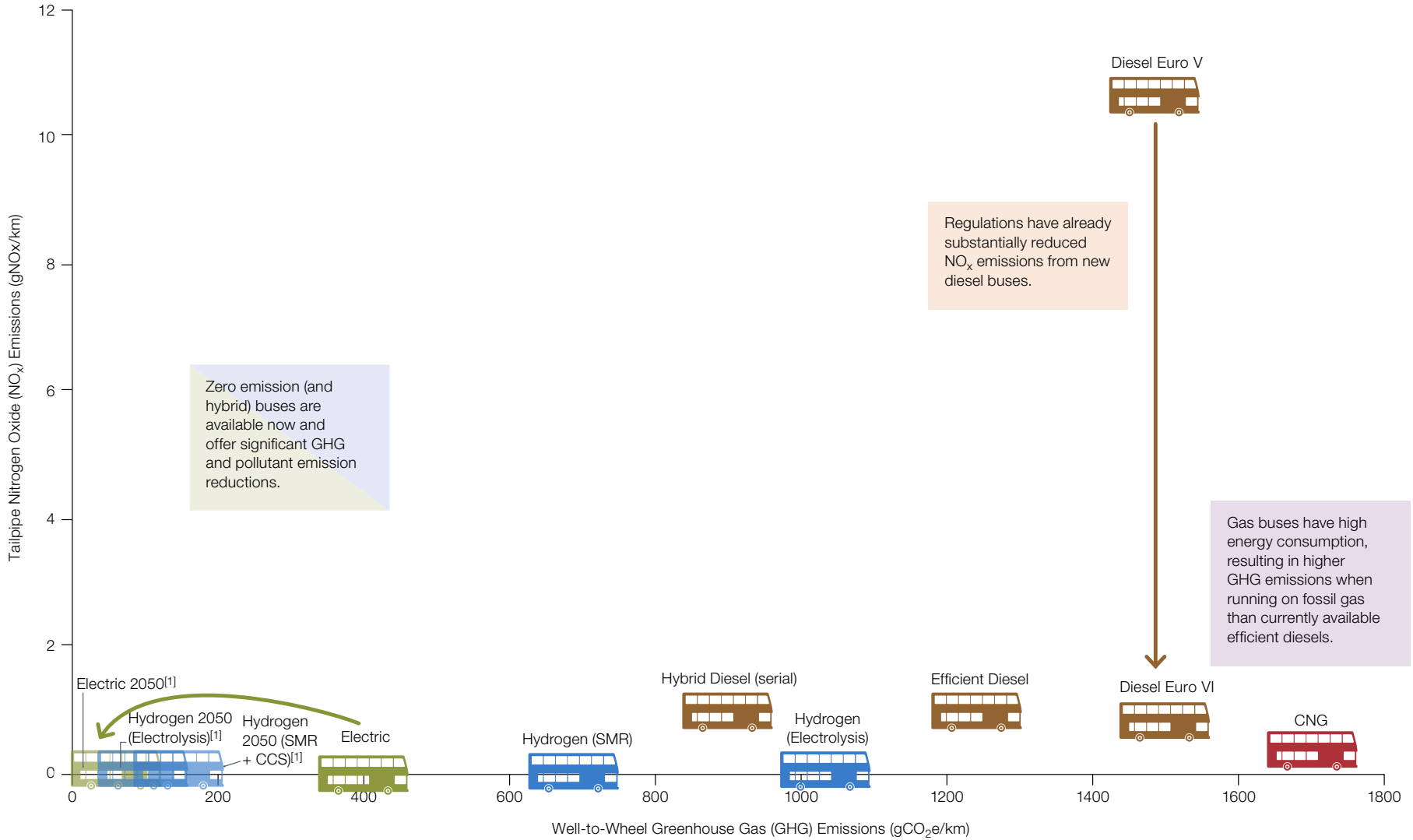
[1] Future projections (vehicle energy consumption held at 2017 levels).

Figure A6: Estimated (GHG) and nitrogen oxides (NO_x) emissions for a double deck bus on the LowCVP Urban Bus test cycle (average speed 22.4 km/h)



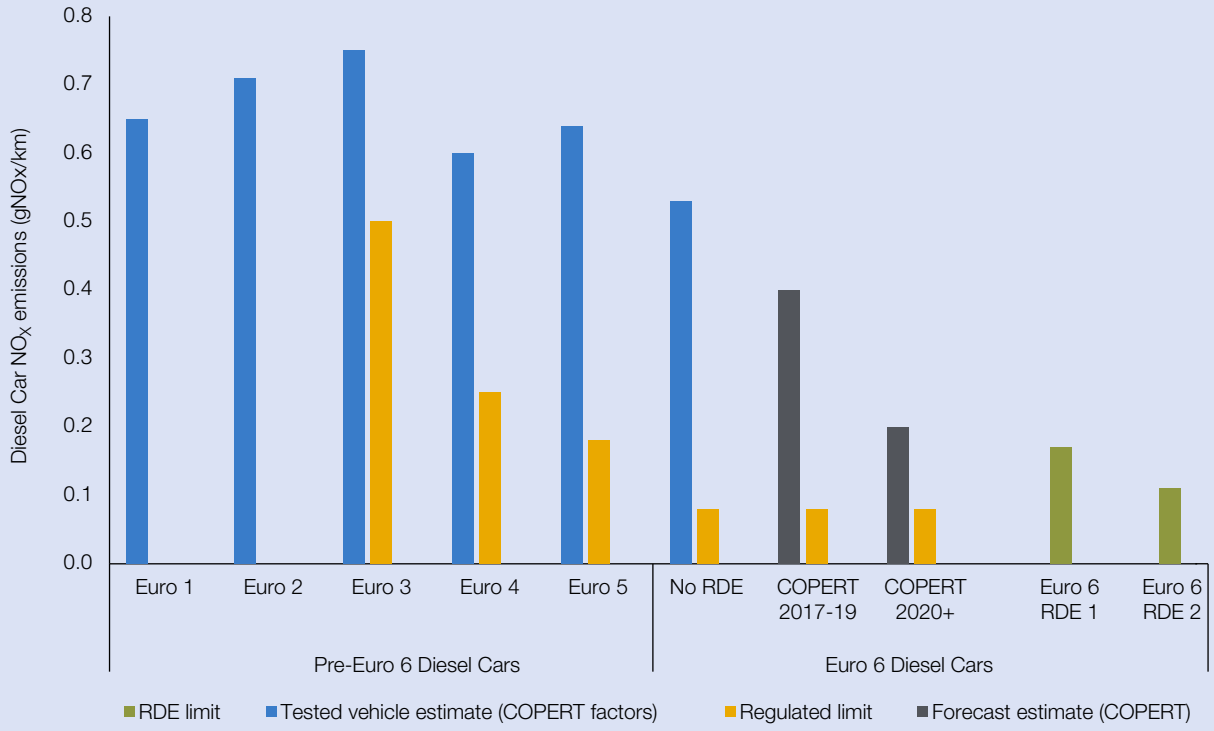
[1] Future projections (vehicle energy consumption held at 2017 levels).

Figure A7: Estimated greenhouse gas (GHG) and nitrogen oxides (NO_x) emissions for a double deck bus on the Milbrook London Transport Bus test cycle (average speed 14.9 km/h)



[1] Future projections (vehicle energy consumption held at 2017 levels).

Figure A8: The gap between estimated real world NO_x emissions for diesel cars and their regulated limits has increased, but new RDE limits should help close this



Source: DfT (2018), Transport Energy Model

Note: COPERT emission factors for Euro 6 diesel cars sold in current or future years (2017-19 and 2020 onwards) are not based on testing, but are forecasts of potential real world emissions which take into account that RDE compliant vehicles will make up an increasing proportion of Euro 6 diesel car sales over this time period, as well as that real-world usage conditions may not be fully captured by RDE requirements. In order to meet all RDE test requirements, which cover around 95% of all driving conditions, RDE compliant vehicles are expected to emit NO_x levels much lower than the test limit in standard driving conditions. Early evidence suggests this is the case.

RDE changes to the Euro standards

For NO_x emissions the new Euro standards require that new vehicles meet both laboratory and real world limits. The limits for the Real Driving Emissions (RDE) test are fixed in relation to the *laboratory* test by a ratio known as a conformity factor. This is the maximum permitted ratio by which the emissions recorded in the RDE test can exceed the laboratory emissions test limit.

RDE test limit = Conformity factor x laboratory limit

The changes will be implemented in two steps.[208]

- **Step 1** – From September 2017 **new model type approvals** had to comply with a NO_X conformity factor of 2.1.[209]

From September 2019 **all new cars being registered** (i.e. all new cars for sale, not just new models) must comply with a NO_X conformity factor of 2.1.[210]

- **Step 2** – From January 2020 **new model type approvals** must comply with a NO_X conformity factor of 1.0 (i.e. parity with the laboratory test), plus an additional factor of 0.43 to account for measurement uncertainty.[211]

From January 2021 **all new cars being registered** must comply with a NO_X conformity factor of 1.0 (i.e. parity with the laboratory test), plus an additional factor of 0.43 to account for measurement uncertainty.

RDE Step 1 vehicles are starting to be available in showrooms. These cleaner diesel vehicles are expected to have dramatically lower real world NO_X emissions than many current Euro 6 "pre-RDE" diesel cars and vans.

Petrol

In the UK, petrol use is widespread in cars but is only available as an option for a limited number of vans, and is not used in heavy vehicles (buses and trucks). Petrol engines are generally less efficient than diesel engines and therefore have higher overall greenhouse gas emissions per kilometre than a diesel equivalent. However, petrol engine efficiency in cars and vans is improving due to the use of engine downsizing, turbo-charging and direct injection technology. This is in response to European new car and van CO_2 regulation and consumer demand for improved fuel efficiency, and will reduce the greenhouse gas emissions penalty associated with petrol cars.

In contrast, real-world emissions of NO_X from petrol cars and vans are typically substantially lower than from diesel equivalents. Petrol engines also produce much lower levels of particulate matter than diesel engines. As such, legislation has been introduced since 2007 that has driven the use in diesel vehicles of particulate filters, which are very effective at controlling tailpipe particulate emissions. As a result, even though they have similar limits, in the real world the number of particulates emitted from the tailpipe of some petrol cars and vans (particularly those with direct injection engines) can be higher than from diesel equivalents. The introduction of Real Driving Emissions standards will address this as, in order for direct injection petrol engines to meet particulate standards in real world use, it is expected that particulate filters will also be fitted to petrol engines.

Liquid Petroleum Gas

Liquid Petroleum Gas (LPG) is a fossil fuel which is currently used in a relatively small number of vehicles in the UK, primarily cars, taxis and vans, which are served by an existing network of refuelling sites.

Air pollutant emissions from LPG vehicles are generally lower than for diesel vehicles. NO_X and particulate matter emissions are

estimated to be similar to petrol vehicles, although some industry stakeholders suggest particulate emissions can be substantially lower.

LPG typically has lower greenhouse gas emissions per unit of energy than petrol or diesel, but LPG vehicles tend to have relatively inefficient engines (when compared to diesel) which affects the overall greenhouse gas impact of the vehicle. LPG greenhouse gas emissions per kilometre are therefore similar to diesel.

Although the UK LPG market is small, and is likely to remain a niche market, LPG's environmental performance relative to diesel makes it a good current alternative to diesel, particularly for vehicles being used in urban driving conditions.

Natural Gas

Natural gas (methane) is a fossil gas which is currently used in a relatively small but growing number of road vehicles in the UK, in particular in heavy goods vehicles and buses. It can be used in vehicles either as compressed natural gas (CNG) or liquefied natural gas (LNG).

Air pollutant emissions from natural gas vehicles are generally lower than for diesel vehicles. NO_X and particulate matter emissions are estimated to be similar to petrol vehicles, although some industry stakeholders suggest particulate emissions can be substantially lower.

Natural gas typically has lower greenhouse gas emissions per unit of energy than petrol or diesel. However, gas vehicles tend to have relatively inefficient engines (when compared to diesel) which affects the overall greenhouse gas impact of a gas vehicle.

Our analysis of 44 tonne gas HGVs (which is based on the latest available independent test data) shows a potential increase in greenhouse gas emissions of between 4% (CNG) and 20% (LNG) from heavy duty trucks running on natural gas when compared with an equivalent diesel truck.[212] However, industry representatives claim that gas truck efficiency has improved significantly and that the latest generation of gas trucks are now delivering greenhouse gas emissions savings of 15% (CNG) compared to equivalent diesel vehicles. As we set out in Part 2c, government is working with industry to undertake further testing of the latest gas trucks; the test results will be used to inform decisions on future government policy and support for the use of natural gas in road transport. If significant greenhouse gas emissions savings are clear, then natural gas could be a good lower emission option for a sector where market-ready zero emission technologies are still in development.

For buses, the use of natural gas is estimated to reduce greenhouse gas emissions by 8% compared to a standard diesel bus over a mixed urban and extra-urban drive cycle. However, when compared to the latest 'efficient diesel' models, which are increasingly becoming the default choice for operators, gas bus greenhouse gas emissions were found to be 24% higher. As gas bus energy consumption is very sensitive to driving speed (i.e. energy consumption is high at low average speeds), gas buses are therefore more suited to use in higher speed inter-urban use, rather than the slow speed stop-start conditions we see in urban areas.

Low Carbon fuels

Low carbon fuels can be made from wastes or crops and can replace fossil petrol, diesel and natural gas (methane). There are a range of different types, including biodiesel, bioethanol, biomethane and bio-LPG.

Since 2008, with the introduction of the Renewable Transport Fuel Obligation (RTFO), fuel suppliers in the UK must be able to show that a percentage of their fuel comes from sustainable renewable energy sources. Biofuels are currently blended with conventional petrol, diesel and natural gas in the UK: these shares amounted to 5% bioethanol in petrol in 2017, 3% biodiesel in diesel in 2017 and 0.2% biomethane in natural gas in 2016.

On average, low carbon fuels supplied in the UK provide greenhouse gas savings of around 70% compared to standard fossil fuels.[213] In 2016/17, they delivered over 2.5 million tonnes of CO_2 savings, equivalent to taking over 1m cars off the road.

It is possible to use (or claim the use of) biodiesel, bioethanol and biomethane in higher blends than are currently used in conventional petrol, diesel and gas. In particular, the operators of many of the UK's gas trucks and buses using gas from the grid claim significant greenhouse gas emissions savings from the use of 100% biomethane.

However, low carbon fuels can also be used to decarbonise other sectors, such as the heat sector. Limited production capacity and, in the case of biofuels, availability of sustainable feedstock materials mean that there are limitations on the extent to which low carbon fuels can meet energy demand across sectors.

This cross-sectoral use of energy means the baseline environmental case for the use of alternatives to petrol and diesel vehicles (for example gas vehicles) should be justified on the basis of the marginal UK renewable/ fossil fuel mix to ensure additional greenhouse gas savings are being gained. For example in the case of biomethane where production is insufficient, and unable to be sustainably scaled up, to meet overall UK energy demand, any increase in total UK gas demand due to new gas vehicles will often largely be met by an increase in the use of fossil gas.

Decisions on further increases in the use of bioenergy across sectors are taken in the context of the Government's carbon budgets and advice from the Committee on Climate Change; the Committee is currently conducting a bioenergy review which is due to be published in autumn 2018.

Research on the air quality impacts of low carbon fuels indicates emissions for low carbon fuels are not significantly different from those of their fossil equivalent, particularly where they are supplied in low-level blends of fossil fuels as is typically the case in the UK.[214]

In Part 2a we set out how recent changes to the RTFO and supporting policies will support increased blends of biofuel and realisation of the greenhouse gas benefits, including taking into account indirect land use change.

Other fuels

Other fuels that are covered in our analysis include aqua-methanol; a liquid fuel (a blend of methanol and water) that can be used in petrol vehicles. Our analysis shows that the

greenhouse gas emissions from the production and use of methanol vary significantly depending on the production pathway. Assuming production from remote natural gas (a typical production pathway), methanol used in cars and vans has greenhouse gas emissions 6% higher than equivalent petrol vehicles. Air pollutant emissions are similar to those from petrol cars and vans.

Zero emission options

Battery Electric Vehicles

Battery Electric Vehicles (BEVs) are driven solely by an electric motor, powered by a battery that can be plugged in to be recharged. No combustion takes place within the vehicle so there are no tailpipe emissions of air pollutants. BEVs use less energy per mile than conventional vehicles. A typical electric vehicle uses 19kWh of energy to travel 100 km, while the average petrol vehicle uses 67kWh.[215] Therefore, electric motors are highly energy efficient.

In addition, our modelling makes clear that, even with current UK electricity grid emissions, BEVs produce the lowest emissions of greenhouse gases irrespective of vehicle type and operation.[216] For example, a battery electric car is estimated to have greenhouse gas emissions 66% lower than a petrol car and 60% lower than a diesel car. Between now and 2050, we project electricity grid emissions will fall by around 90%, with total greenhouse gas emissions from electric vehicles falling in parallel.[217]

As well as considering the greenhouse gas emissions from electricity production, we have also considered the emissions from battery production. The results of adding battery production to our assessment of the environmental performance of battery electric vehicles are set out in the Transport Energy Model Report. As battery production currently requires a lot of electricity, these greenhouse gas emissions are also expected to fall over the period to 2050.

The results are clear: battery electric vehicles have substantially lower greenhouse gas emissions than conventional vehicles, even when taking into account the electricity source and electricity used for battery production.

Hydrogen

Like battery electric vehicles, fuel cell electric vehicles (FCEVs) use electric motors to drive the wheels. However, they store energy on-board as compressed hydrogen, rather than just in a battery. Hydrogen reacts with oxygen from the air in an on-board fuel cell to produce electricity. Water is the only by-product. No greenhouse gas or air pollutant emissions are produced meaning FCEVs are zero emission vehicles.

Fuel cells are typically 40-60% efficient (comparing energy input to energy output) and since hydrogen occurs rarely in its pure form, energy is required to create it. Overall greenhouse gas emissions from hydrogen as a transport fuel are therefore highly dependent on its production method.

Hydrogen is primarily produced for chemical feedstock applications. Used in a fuel cell, hydrogen produced via steam methane reformation (SMR) – currently the typical hydrogen production pathway – delivers greenhouse gas savings of between 10% (compared with a diesel HGV) and 43%

(compared with a petrol car). The addition of carbon capture and storage (CCS) technology to the SMR production pathway could significantly increase greenhouse gas savings, but has yet to be demonstrated at a commercial scale in the UK.

Hydrogen can also be produced by electrolysis: using electricity to split water into hydrogen and oxygen. Assessed using current electricity grid emissions, this pathway does not deliver significant greenhouse gas savings compared to conventional fuels. Using electricity to produce hydrogen creates an efficiency loss compared to the direct use of electricity in a battery electric vehicle. However, as the electricity grid decarbonises, this pathway has the potential to deliver larger greenhouse gas savings.

A range of technological improvements in hydrogen production are under development, and there are significant potential energy system benefits to be derived from the high volumes of energy storage and flexibility hydrogen can provide.

As well as being used in FCEVs, hydrogen can be used as a fuel in an internal combustion engine. Its combustion has not been assessed here, but the poor energy efficiency of combustion engines compared to fuel cells suggests that the greenhouse gas emissions would be considerably higher than from FCEVs.

Hybrids

Hybrid electric vehicles are powered partly by electricity and partly by a conventional engine (most commonly a petrol engine). Hybrids can offer some of the same benefits as BEVs: lower greenhouse gas and air pollutant emissions compared with conventional vehicles. The overall emissions performance of a hybrid vehicle is very dependent on how much the electric motor contributes to propulsion, the effectiveness of the vehicle exhaust after-treatment during hybrid operation, and the amount of time when the conventional combustion engine is switched off.

There is a range of hybrid electric vehicle types, ranging from mild and full hybrids to plug-in and even range extended electric vehicles. The ways in which these work are explained below and, where they have been included in our analysis, details of their environmental performance are provided.

Mild and full hybrids

Mild and full hybrids both have an internal combustion engine and an electric propulsion motor. In these vehicles, energy is typically captured by regenerative braking and stored within a small battery. They cannot be plugged in to be recharged.

In mild hybrids the electric motor is used to support the main engine rather than to power the vehicle independently. Manufacturers are producing 48V mild hybrids which they claim reduce energy consumption by around 15% to 20%.[218]

In full (non-plug-in) hybrids, the electric motor is capable of propelling the vehicle in zero emission mode, but the zero emission range of these vehicles is currently very limited (typically 1-2 miles).

Full petrol hybrid electric cars and vans are included in the Transport Energy Model. The model estimates greenhouse gas emissions for a full petrol hybrid car to be 20% lower than a conventional petrol car and 5% lower

than a conventional diesel car. For a full petrol hybrid van the model estimates greenhouse gas emissions to be 17% lower than a conventional petrol van and 1% higher than a conventional diesel van. These differences are due to the relative efficiency of petrol and diesel engines outlined previously. The model also estimates considerable air quality benefits from full petrol hybrids compared to diesel equivalents, with NO_X emissions over 95% lower than a Euro 6 conventional diesel car or van sold before 2017 (before RDE came into force).

Plug-in hybrids

Plug-in hybrid electric vehicles (PHEVs) have an internal combustion engine and an electric motor which is charged from an external power source (i.e. the vehicle needs to be plugged in). Both the engine and the electric motor are capable of solely propelling the vehicle. Plug-in hybrids are therefore able to complete zero emission journeys. The environmental benefits of plug-in hybrids are heavily reliant on (i) their zero emission range (i.e. the battery capacity); and (ii) how they are used.

The Transport Energy Model includes plug-in hybrid cars and vans. The model estimates greenhouse gas emissions for a petrol plug-in hybrid car to be lower than from a conventional petrol (by 43%) or diesel (by 33%) car. The model also estimates greenhouse gas emissions to be lower for a petrol plug-in hybrid van compared to a conventional petrol (by 58%) or diesel (by 48%) van. The model also estimates air quality benefits from plug-in hybrids compared to diesel equivalents, with car NO_X emissions significantly lower than those from a conventional pre-RDE Euro 6 diesel car (by 98%) or van (by 99%). These figures assume efficient use of the vehicle, i.e. 73% of driving in electric mode.

Range extended electric vehicles (REEVs or Rex)

Range extenders are battery electric vehicles which use an on-board internal combustion engine to recharge the battery. The internal combustion engine is not used directly to power the vehicle. Range extenders typically have relatively large batteries compared to other hybrids and longer electric-only ranges (e.g. the BMW i3 REx's zero emission range is 100+ miles). As with plug-in hybrids, though to a far lesser extent, the environmental benefits of range extenders depend on their zero emission range (i.e. battery capacity) and how they are used.

Endnotes

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