



Office for
Low Emission
Vehicles

Driving the Future Today

A strategy for ultra low emission vehicles in the UK



September 2013



Office for
Low Emission
Vehicles

Driving the Future Today

A strategy for ultra low emission vehicles in the UK

September 2013

The Office for Low Emission Vehicles (OLEV) is a cross Government, industry-endorsed, team combining policy and funding streams to simplify policy development and delivery for ultra low emission vehicles. OLEV currently comprises people and funding from the Departments for Transport (DfT), Business, Innovation and Skills (BIS), and Energy and Climate Change (DECC). The core purpose is to support the early market for electric and other ultra low emission vehicles (ULEVs). OLEV is based in DfT and this document is published by the Department for Transport.

The Department for Transport has actively considered the needs of blind and partially sighted people in accessing this document. The text will be made available in full on the Department's website. The text may be freely downloaded and translated by individuals or organisations for conversion into other accessible formats. If you have other needs in this regard please contact the Department.

Office for Low Emission Vehicles
Great Minster House
33 Horseferry Road
London SW1P 4DR
Telephone 0300 330 3000
Website www.gov.uk/olev

General email enquiries olev.enquiries@olev.gsi.gov.uk

© Crown copyright 2013, except where otherwise stated

Copyright in the typographical arrangement rests with the Crown.

You may re-use this information (not including logos or third-party material) free of charge in any format or medium, under the terms of the Open Government Licence v2.0. To view this licence, visit <http://www.nationalarchives.gov.uk/doc/open-government-licence/version/2> **OGL** or write to the Information Policy Team, The National Archives, Kew, London TW9 4DU, or e-mail: psi@nationalarchives.gsi.gov.uk.

Where we have identified any third-party copyright information you will need to obtain permission from the copyright holders concerned.

Cover images:

Left: New Nissan LEAF plug-in electric car produced in Sunderland, UK; **Centre:** Drayson Racing Technologies' 204.2mph electric car; **Right:** Jaguar XJ-e plug-in electric hybrid.
(Sources: Nissan; Drayson Racing Technologies; Jaguar Land Rover.)

Contents

Foreword	4
Executive summary	6
Context – the inevitable transition	6
ULEV technologies	7
Progress to 2013	7
ULEVs and the energy sector	9
Lessons learnt	10
The way forward	11
Conclusion	14
1. Context – the inevitable transition	15
Change is coming	15
This document – purpose and scope	16
The drivers of change	16
The window of opportunity for the UK	27
The vision	30
The challenge	31
Summary	32
2. ULEV technologies	33
Powering cars and light commercial vehicles	33
Ultra low emission technologies in other vehicles	42
Summary	47
3. Progress to 2013	48
Helping to support the purchase of ULEVs	49
Lowering emissions from other vehicles	53
Supporting plug-in vehicle infrastructure	56
Preparing for hydrogen fuel cell vehicles in the UK	61
Industry and supply chain	63
Summary	67
4. ULEVs and the energy sector	68
The impact of the electrification of transport	68
Smart meters and tariffs: enablers to deliver plug-in vehicle benefits	72
Summary	76
5. Lessons learnt	77
The sources	77
What we have learnt	78
Summary	86
6. The way forward	87
Strategic approach	87
Key commitments	88
Conclusion	101
Annex: Full list of commitments	102

Foreword

The Coalition Government has recently set out an unprecedented programme of support for upgrading our road network, as well as ambitious plans for a new national high speed rail network. This is a bold programme showing we are ready to take the difficult decisions required to deliver a transport system that can drive growth for a generation.

We are taking a similar long-term view in other sectors such as energy and the automotive industry. In July we published an automotive sector strategy with industry to set out the actions we must take to secure the continuing success of the UK automotive industry. Fundamental to this objective is positioning the UK as a leading market for ultra low emission vehicles.

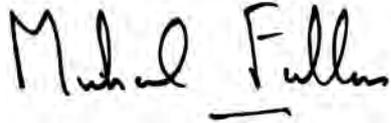
This document sets out our ambitious programme for ultra low emission vehicles in the UK. It is founded on our determination to relentlessly support wealth-generating economic activity and to ensure motoring is an environmentally sustainable and affordable mode of transport for the long-term.

The global automotive sector is now undergoing a once-in-a-generation transition in the types of vehicles it is bringing to market. Ultra low emission vehicles, using electric and other new power sources, are being built and sold in increasing numbers across the globe. Electric power means no tailpipe emissions and running costs a fraction of those that we are having to pay at the petrol pumps today – 100 miles in an ultra low emission vehicle can cost under £3. The industry and increasing numbers of drivers recognise that these vehicles can be the future.

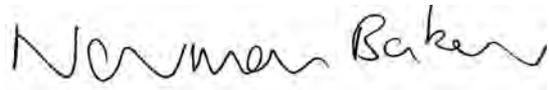
If the UK wants to benefit from the employment and economic opportunities, as well as the cleaner and quieter towns and cheaper motoring, which these new vehicles can bring, then it is vital that this country is in the vanguard of this change.

This strategy, drawn up with input from across the UK automotive sector and wider industry, is the Government's statement of intent on supporting ultra low emission vehicles in the UK. Our vision is clear and hugely ambitious – to see a UK car fleet with effectively zero emissions by 2050. Our committed package of support – worth over £1 billion to 2020 – is the strongest possible statement of our determination to achieve it.

We look forward to working with industry and other partners now to address the challenges and opportunities this document identifies – so that our automotive industry remains at the heart of our manufacturing renaissance, and so that motoring can continue as the backbone of our economy.



Rt Hon Michael Fallon MP
Minister of State for Business
and Enterprise and Minister
of State for Energy



Norman Baker MP
Parliamentary Under Secretary of State
for Transport



Executive summary

1. We have begun a period of change in the way we power our motor vehicles, a period which will provide hugely significant opportunities for the UK to grow its economy, improve our environment and deliver people the independence and mobility they want.
2. The UK Government is committed to grasping this opportunity. Our vision is that by 2050 almost every car and van in the UK will be an ultra low emission vehicle (ULEV), with the UK at the forefront of their design, development and manufacture, making us one of the most attractive locations for ULEV-related inward investment in the world.

Context – the inevitable transition

3. Around the world, governments are looking to simultaneously reduce their reliance on foreign energy imports, to clean the air in their towns and cities, and to reduce carbon emissions from their societies. There are now vehicle emission targets in place in the major trading blocks around the world. These are driving a revolution in the development of ULEV technologies. Increasing global urbanisation will only hasten this change.
4. Efficient transport is vital to the UK's economic wellbeing and road transport remains the dominant transport mode in the UK. However, traffic and new road capacity can bring with them concerns over air quality and noise. Increasing use of ultra low emission vehicles therefore has a very important role to play in supporting mobility while reducing the carbon and air quality impact of road transport. That is why we announced, in our Action for Roads paper, a funding commitment of over £500 million of new capital investment between 2015 and 2020 to continue to establish the UK as a premier market for ULEVs.¹
5. This is a once in a lifetime technology change. It offers huge opportunities for the UK automotive sector and supply chain. We already have a growing automotive sector with key skills and world leading foundations in the technologies required for this transition. The challenge is to maintain this momentum, grow a flourishing domestic market for the new vehicles and attract manufacturers and suppliers to site research, development and production facilities in the UK.
6. We recognise that industry needs a long-term and stable framework in order to invest and grow. That is why Government and industry published

¹ <https://www.gov.uk/government/publications/action-for-roads-a-network-for-the-21st-century>

a strategy for growth and sustainability in the UK automotive sector² in July 2013. This set a clear path for the research, development and commercialisation of the next generation of low carbon technologies – supported by the creation of a £1 billion Advanced Propulsion Centre, funded by Government and industry.

7. We are committed to supporting the development of a flourishing market for ULEVs in the UK. This will not be easy, there are challenges in helping to bring technologies to market that are affordable, accepted by consumers and have infrastructure in place to enable them to be used to their full potential. A mass market shift to ULEVs will also bring challenges and opportunities for the energy sector, which will need to be prepared for and managed.

ULEV technologies

8. It is not Government's role to identify and support specific technologies at this early stage. Ultimately, the mass market transition to ULEVs will happen through industry developing and bringing products to market and consumers deciding which products they wish to buy. The emerging consensus in the automotive industry is that a portfolio of solutions will be required to decarbonise road transport.
9. The internal combustion engine will continue to play a role in road transport for many years, with improvements in fuel efficiency and increased hybridisation providing incremental improvements in CO₂ emissions. As emissions targets become tighter and technologies continue to develop we expect that ULEVs, including plug-in vehicles and hydrogen fuel cell electric vehicles, will take an increasing share of the market for cars and vans. Sustainable biofuels have a role to play in delivering decarbonisation and could play a key role in sectors such as aviation and freight where there are few alternatives to liquid fuel and electrification is far more challenging. There is consensus that electrification will be at the core of the longer term decarbonisation of cars and vans.
10. This strategy focuses mainly on cars and vans as they present the biggest opportunity for the early adoption of ULEVs. We are, however, also keen to encourage the adoption of ULEV technologies in other vehicle sectors from heavy duty vehicles and buses to powered two wheelers and other small vehicles.

Progress to 2013

11. The emergence of ULEVs as a real option for consumers and businesses, and as an opportunity for the associated supply chain, has begun, and we are taking practical steps to put the UK at the forefront of this global market. We have funded the Office for Low Emission Vehicles (OLEV)³ to co-ordinate Government's support. Initially this was with a provision for £400 million funding to 2015, focused on the following areas.

² <https://www.gov.uk/government/publications/driving-success-uk-automotive-strategy-for-growth-and-sustainability>

³ OLEV is a cross-departmental unit comprising staff and funding from the Departments for Transport (DfT), Business, Innovation and Skills, (BIS) and Energy and Climate Change (DECC).

Helping to support the purchase of ULEVs

12. We launched the Plug-in Car Grant and the Plug-in Van Grant to help reduce the cost differential between ULEVs and conventional vehicles. Sales momentum is now beginning to build and we expect this to continue as new vehicles enter the market and costs continue to fall, providing a more diverse choice for consumers at different price points.
13. We are also providing incentives for ULEVs through the tax system. The Government recognises the importance of stability in taxes as the market for these vehicles develops. We have committed to involving industry and wider partners in the process for subsequent development of the tax regime.
14. Fleet sector purchasing decisions can have a crucial role in helping to accelerate ULEV sales. That is why we have been working with the Energy Saving Trust to provide independent advice to fleets through the Plugged-in Fleets Initiative.

Facilitating the provision of recharging infrastructure

15. *Making the Connection* (2011)⁴ set out the Government's initial vision for recharging infrastructure in the UK and the steps that it, and other industry players, needed to take to make it a reality. This would take the form of recharging provision where consumers would use it most, primarily at homes and workplaces, with some provision of public recharging infrastructure where needed.
16. To this end, the OLEV programme implemented the Plugged-In Places (PIP) scheme, which made available up to £30 million in matched funding to eight regional schemes. This programme accelerated the roll-out of recharging infrastructure in the UK, and has delivered over 5,500 chargepoints in the PIP areas up to the end of June 2013. It has also provided important lessons to inform future roll-out, which we are sharing through a PIP lessons learnt document, published alongside this strategy.
17. The real success of the PIPs has been in providing the platform for private sector organisations to enter the market and together create a strong and steadily growing infrastructure market. We estimate that non-PIP organisations have delivered more than 5,000 additional chargepoints to the end of June 2013.

Preparing for hydrogen fuel cell electric vehicles in the UK

18. The Government has consistently supported the development of hydrogen fuel cell vehicles alongside the roll-out of plug-in vehicles as part of its technologically neutral approach. Both technologies are likely to have an important role to play in our future mobility.
19. That is why we are actively working with companies in the ground-breaking UKH₂Mobility project to develop a business case for the roll-out of hydrogen fuel cell electric vehicles (and the associated hydrogen refuelling infrastructure) in the UK from 2015.

⁴ See <https://www.gov.uk/government/publications/making-the-connection-the-plug-in-vehicle-infrastructure-strategy>

Encouraging and investing in research and development

20. The Government is funding an £82 million programme of research and development to support this new generation of vehicles and to help build the skills and knowledge in the UK.
21. This funding is focused on identifying and supporting emerging technologies that the UK can exploit and lead on globally. This includes innovations in electric machines and power electronics; energy storage and energy management; lightweight vehicles and powertrains; as well as improvements to the internal combustion engine. It specifically targets areas where commercial funding has not been readily available, or where the cost of full commercialisation of new technologies has been too high, so that we can build value in the supply chain and create opportunities for the UK.

Lowering emissions from other vehicles

22. Government is also working intensively with other sectors to lower emissions from other types of vehicle.
23. We have provided support through the Green Bus Fund to encourage bus operators and local authorities to switch to low and ultra low emission buses. This £87 million fund has delivered more than 1200 new low carbon buses in England, with nearly 350 in London and 275 in Manchester. Many of these buses are being assembled in the UK. In recent years we have also seen the introduction of hydrogen fuel cell electric buses in London.
24. We are also working with industry in the Low Carbon HGV Technology Task Force. This includes proposals for a technology accreditation scheme to give operators information on the cost saving benefits of individual technologies as well as the development of a strategy for switching larger freight vehicles to gas engines. This builds upon the work already underway through the OLEV co-funded Low Carbon Truck and Infrastructure Trial, which aims to demonstrate low carbon technologies and provide confidence to the freight industry.

ULEVs and the energy sector

25. The mass adoption of ULEVs will have significant implications for the energy sector at both a local and a national level. As the number of plug-in vehicles on our roads increases, so will the demand for electricity, placing additional pressures on the electricity system.
26. However, ULEVs can also help to balance the demand for electricity at peak periods and support the efficient use of energy by consumers. This will be facilitated by the introduction of intelligent power supply networks (smart grids) and the roll out of electricity smart meters across all domestic properties in the UK by 2020.
27. The majority of plug-in vehicle owners will charge their vehicles at home, at night time, during the off-peak period. This is not only most convenient for drivers, but also maximises the environmental and economic benefits of plug-in vehicles by using cheaper, lower carbon night-time electricity generation.

28. To help people charge at home as easily as possible, the Government is ensuring that smart metering in Great Britain includes the functionality to support charging of plug-in vehicles. This will allow recharging to happen when it is cheapest for consumers and the energy system (subject to appropriate technology in the chargepoint or plug-in vehicle).
29. Plug-in vehicles could also act as distributed energy storage during periods when renewable (or nuclear) electricity generation exceeds demand. This could happen during the life of the vehicle or as a potential end-of-life use for batteries. There may even be the potential for these vehicles to be used as an energy store, to power the house or feed electricity back to the grid at peak periods.

Lessons learnt

30. Much has been learnt since we first launched the £400 million programme of policy measures in the UK. This comes from the evidence and feedback from industry, consumer organisations, academia and the wider research community as well as from Government's own experience with the Plugged-In Places scheme and the Plug-in grants. Some of the headline findings include:
 - Most people have little, if any, knowledge of ULEVs. Insufficient or inaccurate information can put off potential buyers.
 - High upfront costs are a key barrier. The Plug-in Car Grant was considered an important factor in the purchase decision of 85% of ULEV purchasers.
 - ULEVs can provide clear benefits for many fleets and there is an appetite among fleets to embrace the technology, if it can be done cost effectively. Over 60% of the initial Plugged-in Fleets Initiative participants have gone on to procure a plug-in vehicle or are planning to do so.
 - Once they have driven an ULEV, people's preconceptions are often contradicted and their response to the car's characteristics in terms of smoothness, quietness and acceleration is overwhelmingly positive.
 - As previous studies have shown, most charging continues to occur at home and overnight, with some charging at the workplace.
 - The provision of an accurate source of chargepoint information is important for convincing existing owners and potential purchasers that their charging needs can be met.
31. Overall, the evidence suggests that the Government's existing policies are broadly the right ones. Industry experience suggests that the adoption of new technology will take time. One of Government's key roles is to maintain a consistent policy framework that targets the barriers to adoption and hastens the normalisation of ULEV technology.

The way forward

Strategic approach

The vision

- 32.** The Government's overall vision for ultra low emission vehicles in the UK is ambitious, but realistic and for the long term. It wants to see:
- buoyant domestic fleet and private markets for ULEVs with every new car an ULEV from 2040 and an effectively decarbonised fleet by 2050 to meet our Carbon Plan targets;
 - a network of supporting infrastructure that ensures ULEVs are an attractive customer proposition;
 - world class skills and facilities for the development and manufacture of ULEV technologies, exporting vehicles globally;
 - a smarter electricity grid that maximises the benefits to vehicle owners and the electricity system from the shift to ULEVs; and
 - all of the above combining to make the UK the best place in Europe for the automotive sector and associated ULEV industries to invest.

Overarching principles

- 33.** In delivering this vision for the ULEV sector in the UK, Government's activities will be consistent with the following overarching principles:
- a. **Focusing on inward investment and the supply chain** – The Government will continue to pursue the wider prize of securing the maximum possible benefits to the UK economy from the mass market adoption of ULEVs. This means focusing on enabling the UK supply chain to become pre-eminent in low carbon technologies.
 - b. **Technological neutrality** – The Government will not seek to 'pick winners' in terms of emerging technologies at this early stage. Instead we will support activities that are backed by industry consensus, allowing the market to ultimately determine which technologies win through. We will generally specify the bulk of our policies in output rather than technology terms.
 - c. **Working with the EU on ambitious but realistic regulation** – The Government will work to agree regulations that are ambitious, consistent with our statutory carbon budgets and target for 2050, and which encourage innovation but which are also realistic, deliverable and neither penalise the ordinary motorist nor overburden industry.
 - d. **Addressing market failure** – Government can speed the transition to ULEVs by addressing areas where the market alone might not deliver the best outcomes in the shortest possible timescale. The 'chicken and egg' problem of ULEV uptake and the provision of refuelling infrastructure is a good example of this.

- e. **Consistent communications** – The Government will engage early, openly and proactively with industry on all aspects of the developing ULEV sector, and we will support clear and consistent communications with consumers.

Key commitments

Long term investment

34. The UK is seen as one of the most open automotive markets in Europe, which is both a strength and a weakness. Because many UK manufacturers are foreign-owned, with a global choice of manufacturing and development sites, the UK has to be particularly attractive to stimulate investments in advanced technologies.
35. The Government recognises this. In July 2013, it set out its long-term ambition for roads⁵ including a significant funding commitment of **over £500 million from 2015 until 2020** to continue to support the growing market for ULEVs. This, combined with the existing **£400 million support to 2015** and the recent **advanced propulsion centre announcement**, constitutes one of the longest and most comprehensive packages of support for ULEVs anywhere in the world.

Support to 2020 – call for evidence

36. This unprecedented funding commitment represents a significant opportunity for the UK. Government is therefore proposing an immediate period of dialogue with industry and other stakeholders to help shape the £500 million package of support for ULEVs in the 2015-2020 period.
 - *We will launch a call for evidence later this year to inform the development of this package of support, including consumer incentives. This will consider the balance of support between workstreams and plot the path to Government's exit from subsidy.*

Delivering the vision

37. Government will take forward the ULEV agenda in the immediate term through a number of practical actions and commitments in five workstreams. These activities are aimed at normalising the technology, addressing current barriers to adoption (such as price, the infrastructure 'offer', and the availability of accurate consumer information), preparing the ground for increased adoption and new technologies (such as hydrogen), stimulating the UK supply chain to make the most of the coming industrial opportunities, and working to ensure that regulatory structures are consistent with the UK's strategic aims.
38. The full list of commitments is in the Annex, with highlights detailed below.

⁵ <https://www.gov.uk/government/publications/action-for-roads-a-network-for-the-21st-century>

Workstream 1 – Supporting the early market

- *To provide certainty for investors and consumers the existing plug-in vehicle grants will remain unchanged to May 2015, and consumer incentives will remain in place beyond this date.*
- *We will work with a consortium of major ULEV manufacturers to explore the case for a national consumer communications campaign. Subject to agreement from all those involved, during 2014 we will launch a platform for providing robust and authoritative consumer information on ULEVs, supported by awareness raising activity.*
- *We will update the Government Buying Standard for Transport by summer 2014 to encourage higher ULEV uptake in the public sector. In addition, we will work to remove unintended administrative barriers to public sector purchase of ULEVs.*

Workstream 2 – Shaping the required infrastructure

- *We will continue to provide a national package of up to £37 million through to May 2015 to support the installation of chargepoints in homes, residential streets, railway station and public sector car parks and rapid chargepoints to facilitate longer journeys, inviting a second round of bids from train operators, local authorities and the wider public sector by 31 October 2013.*
- *Subject to further work in Phase 2 of UKH₂Mobility, we will explore the options for Government grant funding to support industry's investments in the initial network of around 65 hydrogen refuelling stations estimated to be required to support the introduction of hydrogen fuel cell electric vehicles in the UK – by May 2014.*

Workstream 3 – Securing the right regulatory and fiscal measures

- *We will maintain a strong, clear and lasting set of tax incentives for ULEVs until at least 2020. We will involve industry and wider partners in the process for subsequent development of the tax regime.*
- *OLEV will work with HMRC to clarify the tax position for ULEVs and publish this as a factsheet on the OLEV website by May 2014. This will enable fleet managers to better understand the likely costs of ULEVs for their fleets.*
- *We will work with industry and international partners to support ambitious but realistic and cost effective emissions targets in EU regulations for new vehicles beyond 2020 and to deliver UK ambitions on the Commission's Clean Power for Transport proposals.*

Workstream 4 – Investing in UK automotive capability

- *We will continue to work through the Automotive Council to identify specific activities to develop and strengthen the UK ULEV supply chain and, by December 2013, will discuss with industry how best to target ULEV R&D funding out to 2020.*

- *OLEV will continue to co-ordinate ULEV R&D and supply chain activity across Government, with industry and with the Technology Strategy Board to maximise economic benefits for the UK. This will include working with all stakeholders to ensure appropriate alignment of activities at the Advanced Propulsion Centre and the Energy Storage Centre with other ULEV programmes to maximise benefits for the UK from the move to ULEVs.*
- *We will offer a prize of up to £10 million to develop long-life battery technology for the next generation of electric vehicles. We will work with NESTA (the UK's centre of excellence for challenge prizes) and the Technology Strategy Board to develop the competition scope and criteria. The specific challenge to be met and the competition guidelines will be unveiled later in 2013.*

Workstream 5 – Preparing the energy sector

- *We will continue to require the national rollout of smart meters into homes by 2020. We will ensure that this new technology acts as a platform which can support plug-in vehicle charging.*

Conclusion

39. The move to ultra low emission vehicles is inevitable. There are hugely significant benefits for the UK from this transition in terms of energy security, air quality and carbon reduction. Most significantly the transition also represents a once in a lifetime industrial opportunity for the UK automotive sector if it successfully positions itself in the vanguard of this new technology – delivering jobs and growth for decades to come.
40. The UK Government is wholly committed to this agenda, and recognises that it will take time. This strategy sets out why this policy is so important and the comprehensive and compelling set of commitments that the Government is already making to make its vision a reality as fast as possible.

1. Context – the inevitable transition

Change is coming

- 1.1** At the beginning of the 20th century a dizzying array of different technologies was available for the discerning purchaser of a motorcar. These included steam power, petrol/gasoline power, electric drive, gas power and even gas/electric hybrids. Some vehicles had two or even four engines. This was a period when innovation was rampant as companies looked to find better ways of giving people the greater mobility they craved. Over time a dominant technology – the internal combustion engine – emerged as the pre-eminent way of powering vehicles.
- 1.2** That pre-eminence has remained in place to the present day. The incredible energy density of petrol and diesel liquid fuels, their relative abundance and low price, allied to a constant stream of innovation from vehicle manufacturers has led to the vehicles we know today: capable of travelling long distances conveniently, quickly and safely. Faster, cleaner, quieter, more powerful but more frugal than its early ancestors, the internal combustion engine of today is a world away from its first incarnation. But today's engines are nevertheless still largely based on the same principles of the four stroke engine invented by Nikolaus Otto back in 1876.
- 1.3** Internal combustion engines will continue to dominate in the global market for vehicles for years to come. But it is already clear that we have begun another era of significant change, much like the early 20th century. Rapid innovation is delivering a variety of different ways of powering our vehicles. Manufacturers are investing billions of pounds into the research, development and production of alternative powertrains, which are now being introduced to the market. By 2020 it is extremely unlikely that vehicles powered solely by internal combustion engine will remain the only realistic choice for consumers in all vehicle segments.

What is an ultra low emission vehicle (ULEV)?

An ULEV emits extremely low levels of carbon dioxide (CO₂) compared to conventional vehicles fuelled by petrol/diesel. They typically also have much lower or virtually nil emissions of air pollutants and lower noise levels. Since 2009, the Office for Low Emission Vehicles has considered ULEVs as new cars or vans that emit less than 75 grams of CO₂ from the tailpipe per kilometre driven, based on the current European type approval test. Other definitions exist that suggest 50g CO₂/km is a more appropriate threshold.

This document – purpose and scope

- 1.4** The Government's aspiration is that by 2050 almost every car and van in the UK fleet will be an ULEV, with the UK automotive industry at the forefront of their design, development and manufacture. This strategy sets out why this transformational change will happen, the opportunities it presents for the UK, and the challenges that must be overcome to exploit those opportunities. It articulates Government's clear and strong commitment to this agenda.
- 1.5** The main focus of this strategy is on cars and light vans, rather than heavy duty vehicles such as trucks and buses, or smaller vehicles such as motorcycles. Cars and vans form the largest number of vehicles on our roads and generate the largest proportion of greenhouse gas emissions from the transport sector. As a result, it is this market that provides the largest opportunities for the UK, both economically and environmentally. However, the Government is committed to, and active in, pursuing emissions reductions from all types of road vehicles.
- 1.6** This strategy is long term in scope, aligning with our Carbon Plan, and considers the drivers for change, opportunities and risks over the period to 2050. It explores the future benefits, but also focuses on what the UK can do, and is doing now, to exploit the opportunities.
- 1.7** This document is in 6 parts. This chapter sets out what is driving the change in technology, the scale of the UK opportunity and the Government's vision for the widespread adoption of ULEVs. This is followed by consideration of the technology underpinning the change in more detail. Chapter 3 sets out what the Government has done to support a growing market for ULEVs, and Chapter 4 sets out the implications and opportunities from this for the wider energy sector. Chapter 5 focuses on the lessons that have been learnt so far and Chapter 6 sets out a range of Government commitments and what more we propose to do to deliver on our strategic vision.

The drivers of change

- 1.8** One of the key messages of this document is that a change in how we power our vehicles has already started. It is a question of 'when' rather than 'if' for the mass market adoption of ULEV technology. The sections below give some background as to why there is such certainty about this change amongst vehicle manufacturers and policy makers.

Energy security

- 1.9** A well-functioning transport system is essential for our economic prosperity and way of life, yet transport remains heavily reliant on fossil fuels. In the UK the majority of our transport fuel comes from oil derivatives.
- 1.10** UK oil production is currently equivalent to around 65% of our oil demand, but it is declining.⁶ As domestic production declines, our dependence on imported oil and gas will grow and we will become increasingly exposed to the pressures and risks of global markets.
- 1.11** And this will take place in a period of significant change. The next two decades will see global energy consumption increase substantially and so we are likely to face greater competition for available resources. Global supply is also undergoing a quiet revolution as technological developments change the relative abundance of different fuel sources.
- 1.12** Many countries have recognised that a dependency on imported oil to fuel their economies puts their economic welfare effectively in the hands of others and are consequently trying to reduce their dependence on these imports.
- 1.13** Even without major price shocks, there is a significant cost associated with importing oil. In 2012 the UK spent over £24 billion (net) on imported traded energy, adding to our trade deficit.⁷ In addition, the value chain for oil exploration, exploitation and export sees a significant proportion of the total revenue from petrol and diesel fuel heading overseas.
- 1.14** So there are very real benefits to any country able to source an increasing proportion of its transport energy supply from within its own borders. The result would be more stable (and potentially lower) prices for consumers, a reduced trade deficit (if other things remain equal) and potentially increasing economic activity and employment in domestic energy production. Moreover, as Chapter 4 makes clear, the shift to ULEVs can also actually help to facilitate the roll-out of renewable technologies in the electricity generation sector.

Carbon and the role of vehicle regulation

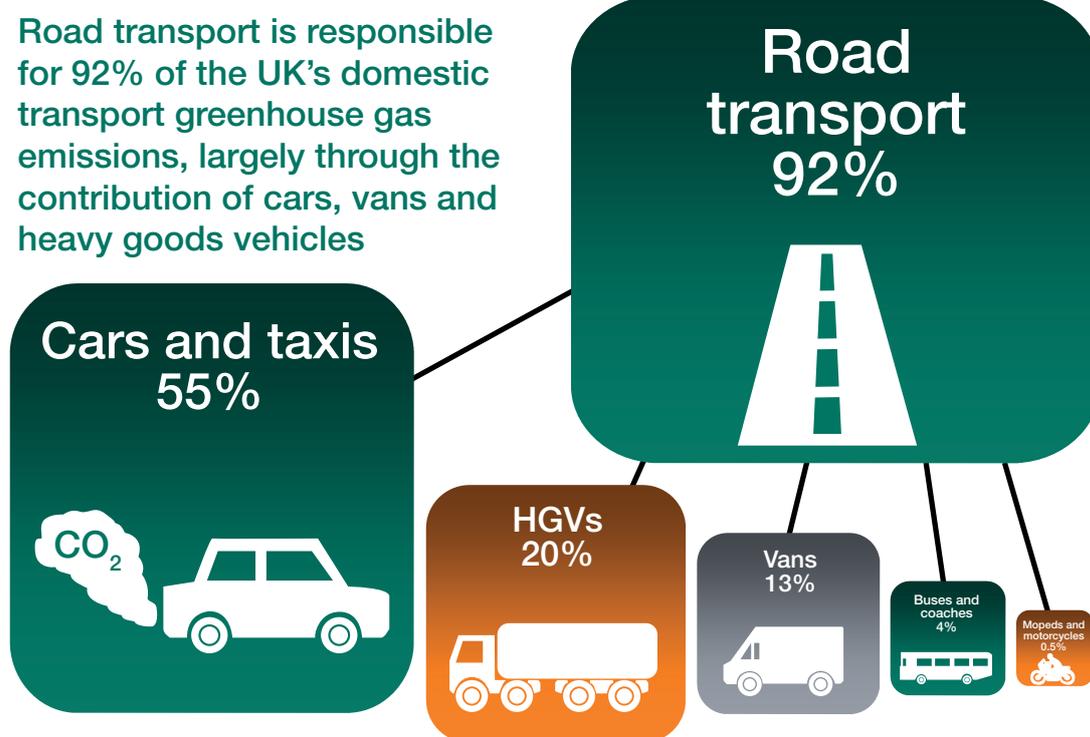
- 1.15** On 1 December 2011, the Government published its Carbon Plan,⁸ setting out in a series of five year carbon budget periods how we will meet the UK's legally binding carbon reduction targets over the next two decades and beyond. This will see a 50% reduction in total greenhouse gas emissions by 2025 compared to 1990 levels, on a path towards an 80% reduction by 2050.

6 Energy Security Strategy – UK Government, November 2012
www.gov.uk/government/uploads/system/uploads/attachment_data/file/65643/7101-energy-security-strategy.pdf and
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/208567/oil_and_oil_products.pdf

7 DUKES 2012, Table 1.4,
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/65739/dukes1_4-1_6.xls

8 www.gov.uk/government/publications/the-carbon-plan-reducing-greenhouse-gas-emissions--2

Figure 1.1 – The contribution of road transport to the UK’s domestic transport greenhouse gas emissions in 2011



Data source: National Atmospheric Emissions Inventory (NAEI)

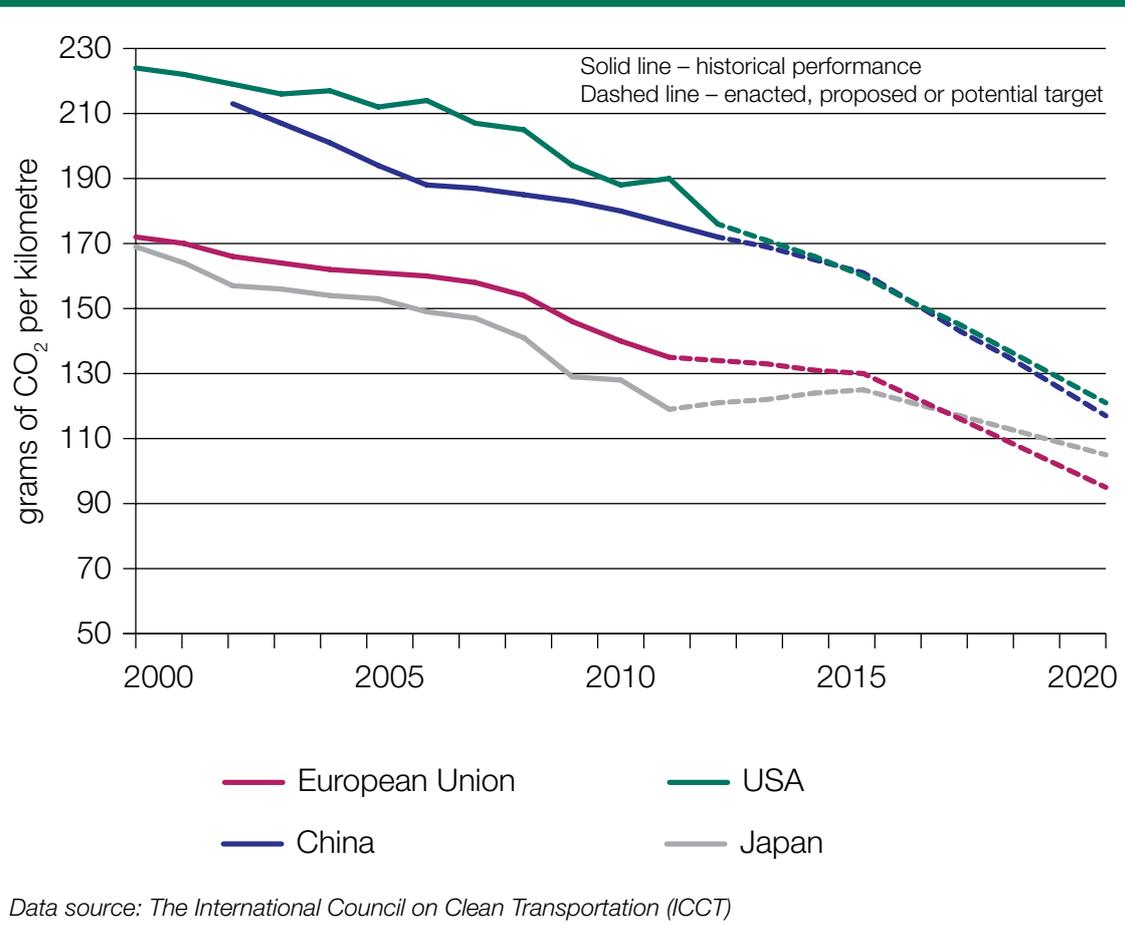
1.16 Meeting the UK’s overall carbon targets will require the road transport sector to be largely decarbonised by 2050. The implication of this is that from around 2040 every new car and van sold in the UK will need to be an ULEV. Other types of vehicle will also need to reduce their carbon emissions but there is a particular focus on ‘light duty’ vehicles because of their contribution to total CO₂ emissions, and because of the relatively greater technological challenges of reducing emissions from other vehicle types (see Figure 1.1).

Cars and vans

1.17 The UK is not acting unilaterally in seeking to reduce carbon emissions from road vehicles. Figure 1.2 shows the regulatory CO₂ targets in place for new cars in key markets around the world. It is this downward trend in global emissions targets, driving innovation from vehicle manufacturers and their suppliers, which will ultimately enable the UK to meet its carbon targets.

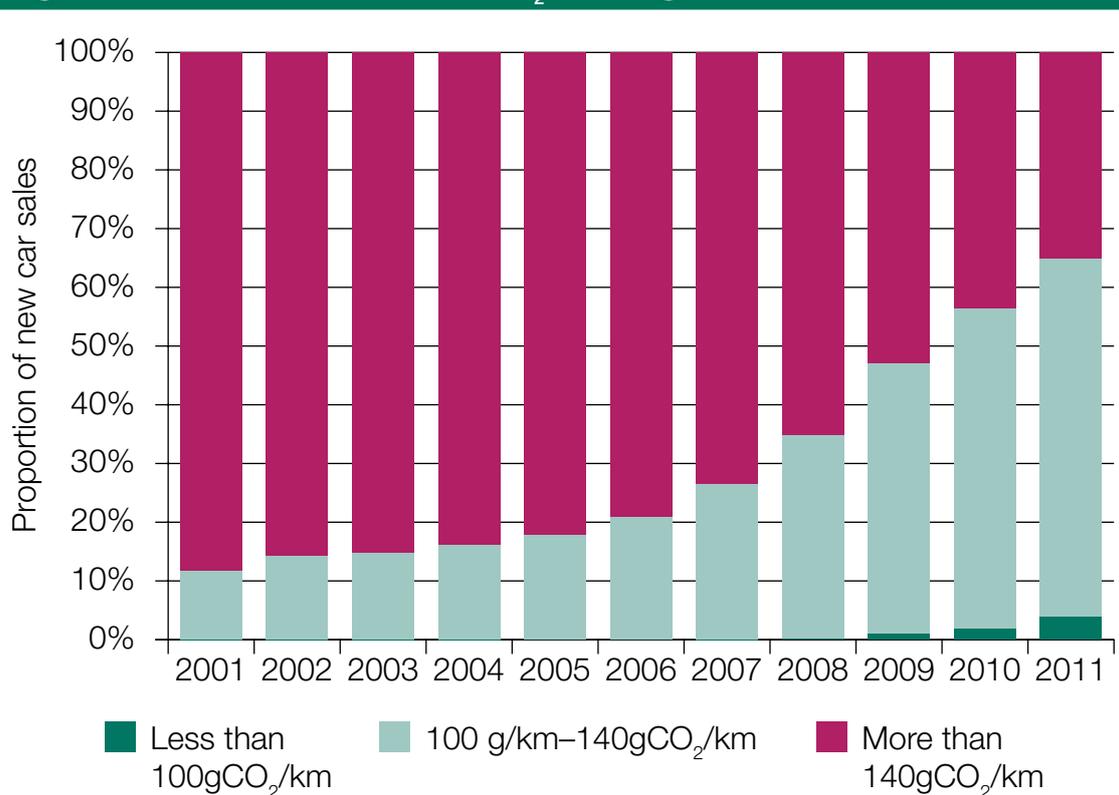
1.18 Europe has some of the most demanding vehicle CO₂ regulations in the world with manufacturers facing fines if they fail to meet strict average CO₂ targets for the fleet of cars or vans they sell. As targets become tougher, manufacturers need to compensate for the higher polluting vehicles in their fleets with commensurately cleaner ones to comply with fleet average targets. These targets have resulted in manufacturers bringing forward ULEV models in their product cycle plans.

Figure 1.2 – The downward trend in global emissions targets around the world, which is driving innovation from vehicle manufacturers



- 1.19** For passenger cars a combination of regulation, high oil prices and a trend to smaller cars has led to a steady decrease in fleet average CO₂ emissions since EU regulation was first proposed in late 2007. In 2012 the UK fleet average CO₂ emissions for new cars sold was 133g/km. A fall of 3.6% on the previous year and an impressive 26.5% reduction since 2000.
- 1.20** As well as consumers buying smaller, lower CO₂ emitting vehicles, this reduction is attributable to a range of technological innovations including improvements to the efficiency of the internal combustion engine, stop-start technology and vehicle lightweighting. However, the pace of these improvements is not sustainable with currently available technology. As CO₂ targets become ever tougher so it will become harder to develop internal combustion engines that meet them cost-effectively. CO₂ is an inevitable by-product of burning a hydrocarbon fuel. It is extremely challenging to engineer a car that relies solely on burning petrol or diesel fuel as its source of power, at a price consumers can afford, that emits less than 50g CO₂/km. This is why the increasing electrification of cars, in some form, is seen as inevitable. This is reflected in the UK Automotive Council's technology roadmap (see Chapter 2).

Figure 1.3 – The move to lower CO₂ emitting new cars in the UK



Source: DfT/ DVLA

Heavy duty vehicles

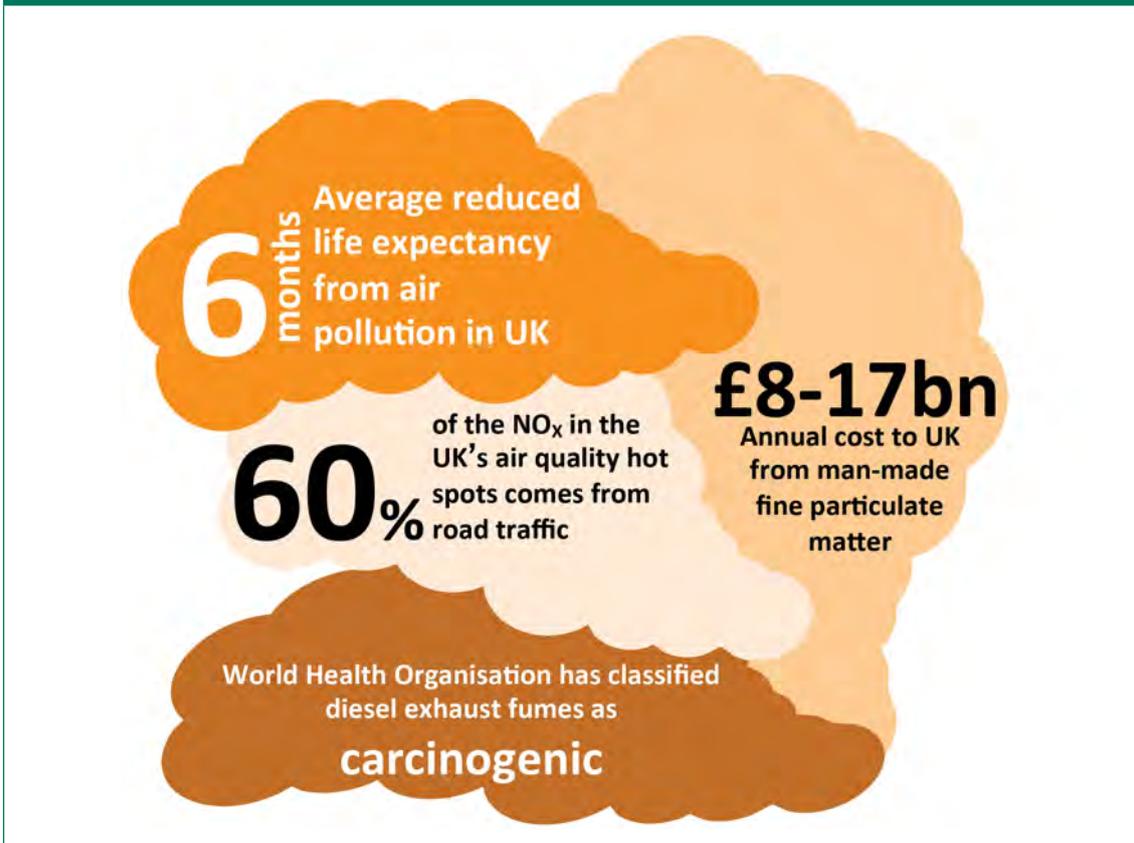
1.21 Heavy duty vehicles (HDVs – trucks, buses and coaches), unlike cars and vans, are not yet within the scope of European CO₂ emissions legislation. While greenhouse gas emissions from passenger cars have decreased during the period 2009-2010 there was an 11% increase in road transport greenhouse gas emissions from heavy goods vehicles. Some form of mandatory European emissions targets for HDVs are considered inevitable. In the first instance regulation could require manufacturers to monitor, report and publish the CO₂ emitted from their vehicles followed by the introduction of mandatory CO₂ targets through regulation as a second stage.

Air quality

1.22 Air pollution is a global issue and whilst air quality has improved significantly in recent decades, poor air quality continues to reduce life expectancy here in the UK by an average of six months, and costs our economy an estimated £8-17 billion each year.⁹ The Committee on the Medical Effects of Air Pollutants (COMEAP) estimates that particulate matter (PM) in the air has an effect equivalent to accelerating 29,000 deaths in the UK per year (at 2008 levels of fine particulates). Emissions from road transport make a significant contribution to poor local air quality.

⁹ Air Pollution: Action in the Changing Climate (Defra, 2010) (www.gov.uk/government/uploads/system/uploads/attachment_data/file/69340/pb13378-air-pollution.pdf)

Figure 1.4 – The impacts of air pollution



Air pollutants from road transport

CO₂ is not the only inevitable by-product of burning hydrocarbon fuels. Other air pollutants can include:

Particulate matter (PM) – consistently associated with respiratory and cardiovascular illness and increased mortality. Diesel engine exhaust has been classified as carcinogenic to humans by the World Health Organization.¹⁰ Secondary PM contributes to the acidification of ecosystems.

Oxides of nitrogen (NO_x) – can cause inflammation of the airways and long term exposure may affect lung function and respiratory symptoms. High levels can also have an adverse effect on vegetation. NO_x contributes to acidification and/or eutrophication of habitats and to the formation of secondary particles and ground level ozone, both of which are associated with ill-health effects.

Oxides of sulphur (SO_x) – causes constriction of the airways of the lung. Involved in the formation of PM. Contributes to acidification of terrestrial and aquatic ecosystems, damaging habitats and leading to biodiversity loss.

¹⁰ <http://www.iarc.fr/en/media-centre/iarcnews/2012/mono105-info.php>

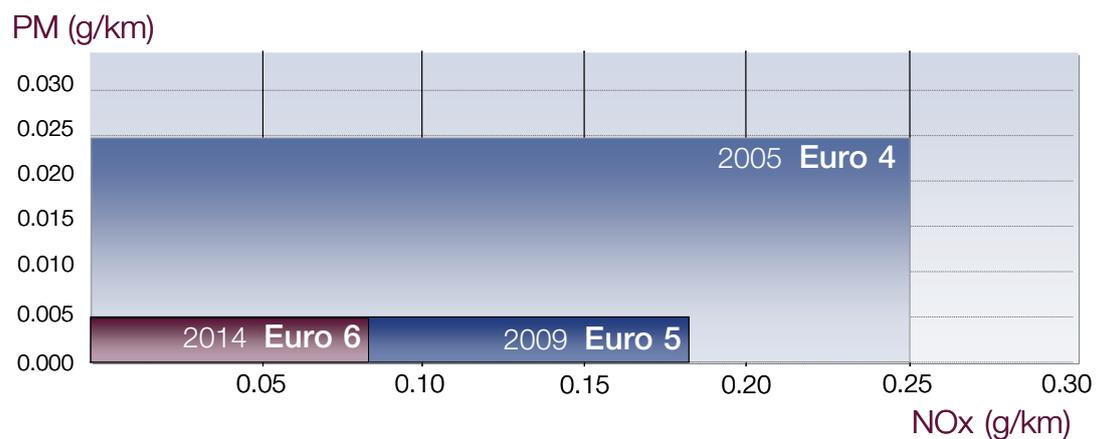
1.23 The UK is far from alone in having problems with air quality. Cities across Europe and around the world, especially those experiencing rapid economic growth, are grappling with the significant health impacts of poor air quality (pictured, smog in Beijing).



© Lou Linwei/Alamy

1.24 In 1992 the European Union introduced new emission standards (Euro standards) for vehicles. These have progressively tightened limits for the main atmospheric pollutants. For example the maximum emissions of PM from a new bus are 30 times less than that permitted twenty years ago. Euro VI for heavy diesel vehicles that will apply from the end of 2013 will reduce NOx to a twentieth of the 1992 limits. For cars, Euro 6 is scheduled to enter into force in January 2014 and will reduce the emissions of NOx from diesel cars from 180mg/km to 80mg/km.

Figure 1.5 – Tightening regulation of diesel cars



Source: Toyota

1.25 However, ever tighter standards have not yet led to the expected improvements in air quality in urban areas in the UK or wider EU. There are legally binding limit values in place that constrain the level of permissible pollutants and these levels are regularly exceeded in a number of locations. The under-performance of some Euro standards for diesel vehicles especially in relation to NOx has been a particular issue here.¹¹

1.26 Although there are a variety of sources of pollution from vehicles (including tyre and brake wear), cars driven under electric power, be they a plug-in or fuel cell electric vehicle emit no pollutants from the tailpipe at the point of use. City authorities around the world are increasingly recognising the benefits of this and seeing vehicles driven by electricity as part of the long term solution to their air quality problems.

¹¹ Trends in NOx and NO2 emissions and ambient measurements in the UK, Defra (July 2011) http://uk-air.defra.gov.uk/reports/cat05/1108251149_110718_AQ0724_Final_report.pdf

London, creating a low emission megacity

Central London has much of the capital's poorest air quality and is forecast to continue to do so in 2020. Half of its emitted pollution is from road transport. This is why in early 2013 the Mayor of London set out his vision to create the world's first big city Ultra Low Emission Zone (ULEZ) in central London by 2020. The overarching aim is to deliver dramatic benefits in air quality and provide a spur for the mass take-up of zero and low emission vehicles.

As part of his ambition, the Mayor is keen to ensure all buses in central London are hybrid by 2020 and that a new taxi vehicle which is capable of zero emissions is available on the market. This is also supported by the provision of ULEV infrastructure through Source London. This has provided 1,300 publicly accessible charging points across London, making it Europe's largest urban charging network.¹²

Noise

- 1.27** Although it is unlikely that there will be a single dominant technology for powering ULEVs, there is a degree of consensus that electric motors will almost certainly be increasingly used in our cars and vans. One of the advantages of electric motors is that they are exceptionally quiet. Noise caused by current road traffic is significant and numerous studies show that this is likely to have consequences for human health including high blood pressure, cardiovascular disease, heart attacks and strokes.
- 1.28** In urban areas, most vehicle noise comes from engines because, at low speed, engine noise dominates over the noise generated by tyres and road surfaces. There are both risks and opportunities here from the move to ULEVs.
- 1.29** Some groups have expressed concern that electric vehicles are *too* quiet and therefore might represent a risk to the blind and partially sighted. On the other hand, a significant shift to electric propulsion in urban areas could have a transformative effect on those living and working close to busy urban and suburban roads.

The shaken kaleidoscope – wider factors

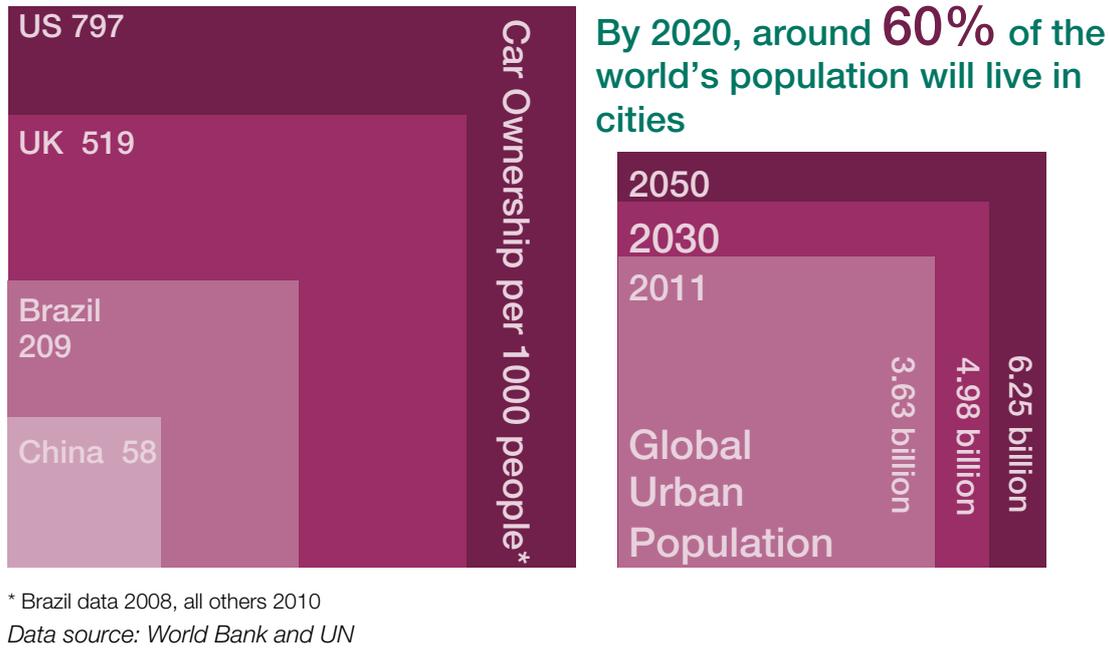
- 1.30** A global drive to improve energy security, tackle carbon and improve air quality all point towards an inevitable change in how we power our cars. But there are also a number of other wider factors which all point to fundamental changes in the design and use of cars over the coming decades.

Urbanisation – the rise of the city

- 1.31** There is enormous scope for increased car ownership around the world. If developing countries emulate the ratio of cars to people seen in the developed world then the rise in the global number of vehicles will be huge.

¹² <https://www.sourcelondon.net/source-london-charges-ahead-deliver-1300-electric-vehicle-charging-points>

Figure 1.6 – Global vehicle penetration



- 1.32** The global population is growing, and ageing but it is also moving. As a country's economy develops, so the number of people living in its cities increases. Around 60% of the world's population could be living in cities by 2020 – and this figure could be even higher in developed countries.
- 1.33** This increase in urbanisation will put huge pressures on city infrastructure. City planners and policy makers around the world are grappling with the problems of securing the most efficient use of the available space in their urban areas. The increasing density of urban populations will only exacerbate the problems of congestion and air quality that many cities experience today. This could have profound implications for both the nature of the vehicles in our cities, and how we use them. Consumers are likely to think hard about what sort of vehicle they need to get around, its cost and local impact.
- 1.34** Already in Beijing there is significant demand for small electric vehicles which suit the needs of many city dwellers. Ordinary bicycles, electric bicycles, electric motorcycles and scooters are all likely to form part of an increasingly diverse range of options for getting around cities. Car manufacturers are now thinking about how vehicles specifically adapted to suiting urban environments might work (pictured, the General Motors RAK e Concept lightweight electric vehicle).

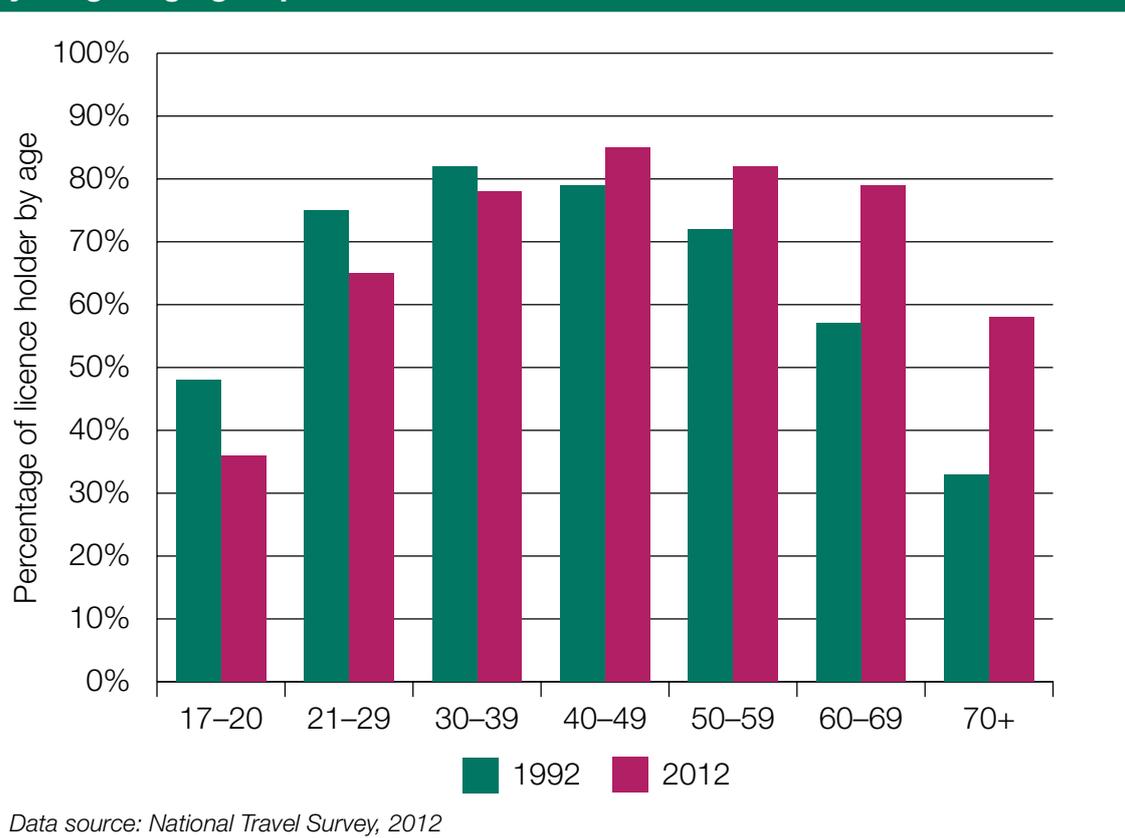


Source: GM

Changing ways of using cars

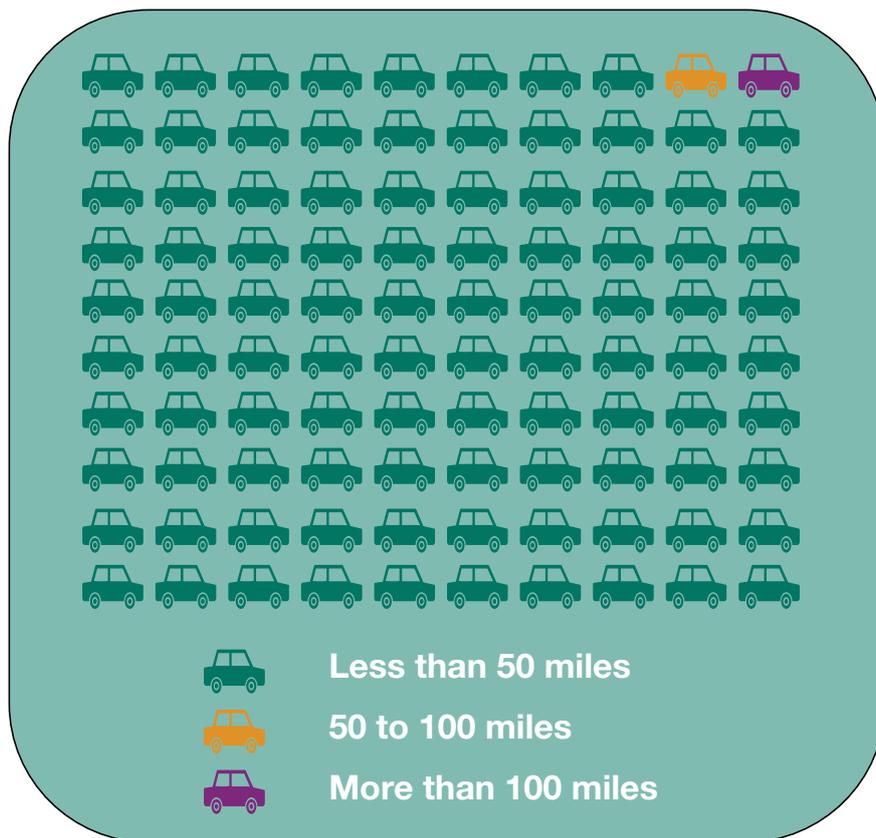
- 1.35** It also seems likely that the global population of the future may have a different relationship with the car than that of many people today. A number of countries around the world, including America and the UK are seeing a decline in the uptake of driving licences amongst young people.
- 1.36** No-one is yet sure what is causing this change, or whether it is a temporary phenomenon. It might be that the high cost of car ownership and insurance, coupled to problems of congestion and improvements in public transport accessibility are dissuading young people from learning to drive and pursue traditional models of car ownership. There is also evidence that car ownership may actually be increasing in older age groups. But car ownership trends are also being impacted by the rise of different ways of using cars – specifically car clubs, car sharing and the rise of short term hire.
- 1.37** Research suggests that members of car clubs are up to 30% less likely to consider owning a car and also use their shared vehicles less. A study by TRL (Transport Research Laboratory) in 2011 suggested that for every vehicle operated by a car club, more than 20 vehicles are taken off the roads.
- 1.38** Manufacturers are aware of these trends and of the potential impacts they could have on their ways of doing business. Many are actively exploring new ways of generating revenue outside of their traditional build, sell and maintain model. Some are offering ‘mobility solutions’ which allow the consumer to access a range of vehicles to suit their needs. The implications of these changes for the move to ULEVs could be significant.

Figure 1.7 – The decline in the uptake of driving licences amongst younger age groups in the UK



1.39 It remains the case that most car journeys in the UK are short with 99% being under 100 miles and 98% being under 50 miles.¹³ With increased use of car hire or sharing, individuals could use different types of vehicles for different types of journeys, rather than buying a single vehicle to cover all their possible journey needs.

Figure 1.8 – Most car and van journeys in the UK are short with 99% of car journeys under 100 miles and 98% under 50 miles



Data Source: National Travel Survey, 2012

Technology – the rise of the autonomous vehicle

1.40 As well as radical changes in engine technology, the coming years will almost certainly see a transformation in the way we own and use vehicles, and how public and private transport interact. Rapid developments in vehicle control systems and sensors are creating new opportunities for advanced vehicle systems that increasingly help the driver with the driving task. These developments are generating new ways in which vehicles could use the road network in the future, for example, vehicle platooning on highways is now a possibility – opening the way for more efficient use of our highway infrastructure.

13 National Travel Survey 2012

1.41 Vehicles are also becoming increasingly connected both to the wider world and to each other, and this is helping the recent breakthroughs in autonomous vehicles (or self-driving cars). A number of vehicle manufacturers are researching these systems including a team at Oxford University where they are currently trialling a robot car based on a Nissan LEAF (see pictures below). Other integrated transport designs using alternative infrastructures such as Personal Rapid Transport systems have been shown to work in various locations around the world and are currently in operation at Heathrow airport (pictured above).



Source: Ultra Global

1.42 In each of these systems the technology is not dependent on the type of engine or propulsion used: it is equally suited to ULEV or conventionally fuelling and so offers the prospect of further changing people's relationship with cars. Consumers are likely to want very different things from a vehicle if they only occasionally drive it and paying for access to vehicles rather than for ownership might become the norm.



© John Cairns

The window of opportunity for the UK

The transition

- 1.43** Because the move to ULEVs is considered inevitable by every major motor manufacturer, they are all investing heavily, and investing now, in developing the new technology needed.
- 1.44** It is in this period, when the technology for mass market zero emission motoring is being developed, that there is a huge industrial opportunity for the UK. This is a transition that will happen only once. But it is a chance to strategically re-position the UK automotive sector for the rest of the 21st century, building on existing strengths across its supply chain.

The UK automotive sector

Manufacturing is central to the Government's strategy for growth. It provides half of our exports, a high proportion of our business R&D and much of the productivity growth of the economy.

The automotive industry is at the heart of the UK's advanced manufacturing industry, representing 7% of manufacturing output and 5.3% of manufacturing employment. Following decades of transformation, the industry, supported by a strong Government partnership, is recovering from the recession and once again growing. It is now the fourth largest automotive producer in Europe, producing 1.58 million vehicles in 2012 (up 7.7% on 2011) and exporting in excess of 80% of this production. Some forecasts suggest production could reach as high as two million by 2016 as the euro area recovers.

It is vital that the UK capitalises on this momentum to secure its long term future: growing the UK share of the value chain and securing strong global competitive positions in ultra-low carbon R&D and premium and niche vehicles. The automotive industry and the Government are working together through the Automotive Council to ensure the future health of the industry in the UK. In July 2013, industry and Government jointly published 'Driving success, a strategy for growth and sustainability in the automotive sector.'¹³ This includes a shared vision for a UK automotive manufacturing industry that is:

- Diverse, dynamic, growing and globally competitive
- Making a large and increasing economic contribution to employment and prosperity in the UK
- Playing a decisive role in developing and manufacturing low and ultra-low emission vehicles and technologies
- Supported by a highly skilled workforce
- Inspiring young people to pursue careers in engineering

The supply chain

1.45 The UK manufacturing sector has key skills in the technologies required for the transition to ULEVs. Our comparative advantage extends from our world-leading foundations in electrochemical research, through technology specialisms in batteries, fuel cells, lightweighting, motors and power electronics to niche and mass volume manufacturing.

1.46 A growing ULEV market in the UK therefore presents a major opportunity to boost the UK supply chain for these technologies, which will supply the next generation of vehicles and beyond. If every UK-made vehicle had a 50% UK supply content rather than the current estimate of around 36%, this would be worth at least 30,000 more direct manufacturing jobs at first tier suppliers, quite apart from the spin-off to their suppliers.

1.47 To fully realise this opportunity two simultaneous developments are required. First, UK academics, research centres and companies (existing

¹⁴ <http://www.gov.uk/government/publications/driving-success-uk-automotive-strategy-for-growth-and-sustainability>

suppliers and SMEs) need to develop and bring to market technologies and products and expertise that can help manufacturers in their transition to ULEVs. Second, UK consumers need to be buying ULEVs in ever increasing numbers.

- 1.48** A growing market for ULEVs will also provide opportunities further along the value chain (see Figure 1.9) where the UK already has a number of active companies, for example in the provision of chargepoint infrastructure or in the hydrogen for transport supply chain.

Figure 1.9 – Value chain for the development, deployment and integration of plug-in and fuel cell electric vehicles



Automotive investment decisions

- 1.49** The UK currently has eight volume car assembly plants and seven volume engine plants, together with a wide range of niche and speciality vehicle and engine makers. In deciding where to invest globally to build new models, manufacturers will consider carefully the potential size of the local market for the vehicle to be produced. Volume market models are best made on the continent where they are sold, in order to minimise transport costs and achieve a competitive price in the local market, whilst premium and luxury products are more cost-effectively made in one location and transported around the globe.
- 1.50** Manufacturers will also look to build a resilient supply chain for their plants. Where possible they will want to source the parts for the vehicles being assembled locally because of the reduction in transport costs and the ability of local supply lines to respond more quickly to changing demands. But

automotive manufacturers have stringent quality, cost and production standards and there need to be suitable parts available locally for this to work.

The UK automotive opportunity

- 1.51** The UK is the second largest car market in Europe, accounting for nearly 18% of Europe's car sales. If the UK can develop a steadily growing market for ULEVs then multinational car makers are far more likely to consider the UK as a site for ULEV production as global sales increase. If they decide to site production here then they will look to the UK to supply parts for the vehicles. If the UK is in the vanguard of the global shift to ULEVs then it is well placed to secure new inward investment and create a resilient and technologically advanced supply chain that can meet the needs of an ever growing global ULEV market for decades to come.
- 1.52** The potential of this policy is best demonstrated by inward investment that has already occurred. For example, in 2010 Nissan decided to site European production for its LEAF ULEV in the UK. This £420 million investment supported by a Grant for Business Investment offer of £20.7 million secured in excess of 200 direct jobs but also brought many hundreds more in the supply chain. The decision brought with it a brand new battery plant built next to the car assembly plant in Sunderland. These batteries are unique to ULEVs and will serve Nissan's entire European market for years to come. Pictured, the Nissan LEAF production line in Sunderland.



Source: Nissan

The vision

- 1.53** The transition to ULEVs has the potential to impact on almost everyone in the UK. The earlier this transition happens then the faster the benefits this change can deliver will be realised. **If the Government achieves its aim of transforming the UK fleet to being almost exclusively ULEV by 2050** then the UK could secure the following benefits:
- A far more **secure and diversified supply of energy** for transportation with a greatly reduced dependency on imported oil and far less susceptibility to sudden oil price shocks. This will also help to facilitate the move to renewable forms of energy generation, provided additional electricity demand is anticipated and intelligently managed.

- Road transport's contribution to the UK's **carbon emissions** cut by about 90%.
- The UK's **automotive sector** in the forefront of the development and supply of ULEVs to a growing global market. We will have a mature and sophisticated low carbon supply chain with globally recognised expertise in areas such as electric machines and power electronics, lightweighting and energy storage and management – generic technologies that can be exported around an increasingly urbanised world.
- Our **towns and cities** much quieter and cleaner places to be. Traffic noise and the visible signs of air pollution will be significantly reduced. They will also be much healthier places with improved air quality extending life expectancy and reduced incidence of respiratory disease. A direct consequence of this is that towns and cities will become more attractive places to live, encouraging urban regeneration and a move to more sustainable ways of living.



Source: Renault

The challenge

Developing an early market

1.54 Although the drivers for change and opportunities detailed above are all hastening the move to ULEVs, there are also a number of challenges for manufacturers in rolling out technologies that are a radical departure from what has gone before. There are also elements of market failure where it is right that Government should intervene. Specific challenges include:

- **Upfront purchase price:** New technology is often more expensive than the technology it replaces and this can be a barrier to adoption. However as volumes increase and manufacturers further develop their products so the price can be expected to reduce.
- **Consumer acceptance:** Some of the benefits from the move to ULEVs (improved air quality, and new jobs and growth) are societal rather than individual benefits and there can be a challenge in helping consumers understand how suitable new technology can be for them.
- **Infrastructure:** All of the likely ULEV technologies considered in this document require some sort of infrastructure to facilitate refueling and to reassure consumers that they will be able to make the journeys they want to make. But there is a limited business case for private investment in new infrastructure until there are sufficient volume of vehicles. This is the 'chicken and egg' challenge faced by the ULEV industry and an area where Government intervention is required.

Summary

- 1.55** The UK Government is committed to supporting the transition to ULEVs and to securing the significant benefits that will flow from this in the short, medium and long term.
- 1.56** This chapter has:
- Set out the Government's vision for the widespread adoption of ULEVs.
 - Explained what is driving the change in vehicle technology – regulation, energy security, air quality, noise, as well as a host of wider factors.
 - Explored the window of opportunity for the UK and the scale of that opportunity for generating jobs and attracting inward investment.
- 1.57** The remainder of this document sets out how ULEV technology is evolving, what the Government has done and learnt so far and what our strategic approach will be to addressing the challenges and realising the vision set out above.

2. ULEV technologies

- 2.1** The era of using the same type of fuel in everything from planes to motorcycles is coming to an end. From now on a portfolio of energy solutions will increasingly be on offer to meet different needs. This is a view that is shared by other commentators, including the RAC Foundation and UK Petroleum Industry Association in their *Powering Ahead* report.¹⁵ This chapter reviews the range of ultra low emission technologies that are now providing a real alternative to the internal combustion engine.

Powering cars and light commercial vehicles

- 2.2** The Government and industry are working collaboratively through the Automotive Council to position the UK as a leading global player in the development of ULEVs. A key area of this work has been in agreeing a consensus view on the type and likely timing of new technologies.
- 2.3** The Automotive Council's roadmap at Figure 2.1 provides this view. It sets out how low carbon technologies are likely to evolve for cars over the next 30 years and reflects the views across the UK's leading automotive developers and manufacturers. The roadmap acknowledges that the internal combustion engine will continue to have an important role to play for years to come, but also makes clear that a wide portfolio of technologies and systems, including hybrid, electric and fuel cell vehicles, will play an ever greater role in the coming years and decades (see Figure 2.2). There are also efficiency savings that can be realised across each of these technologies from making vehicles lighter and more aerodynamic.

¹⁵ <http://www.racfoundation.org/media-centre/powering-ahead-future-low-carbon-cars-fuels>

Figure 2.1 – The technology roadmap for cars and vans

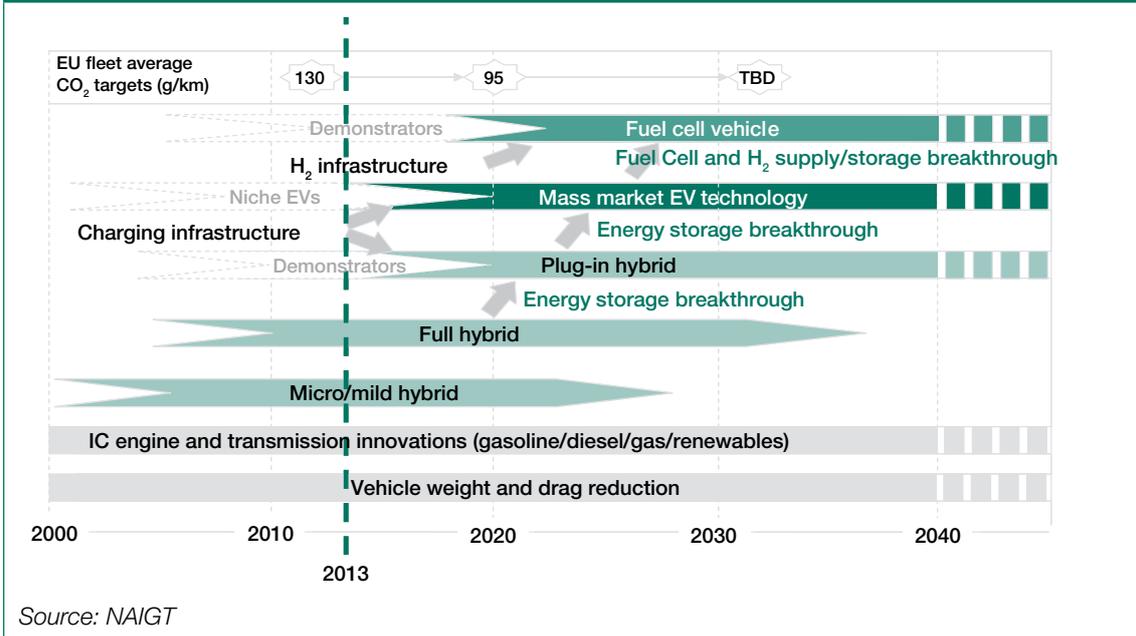
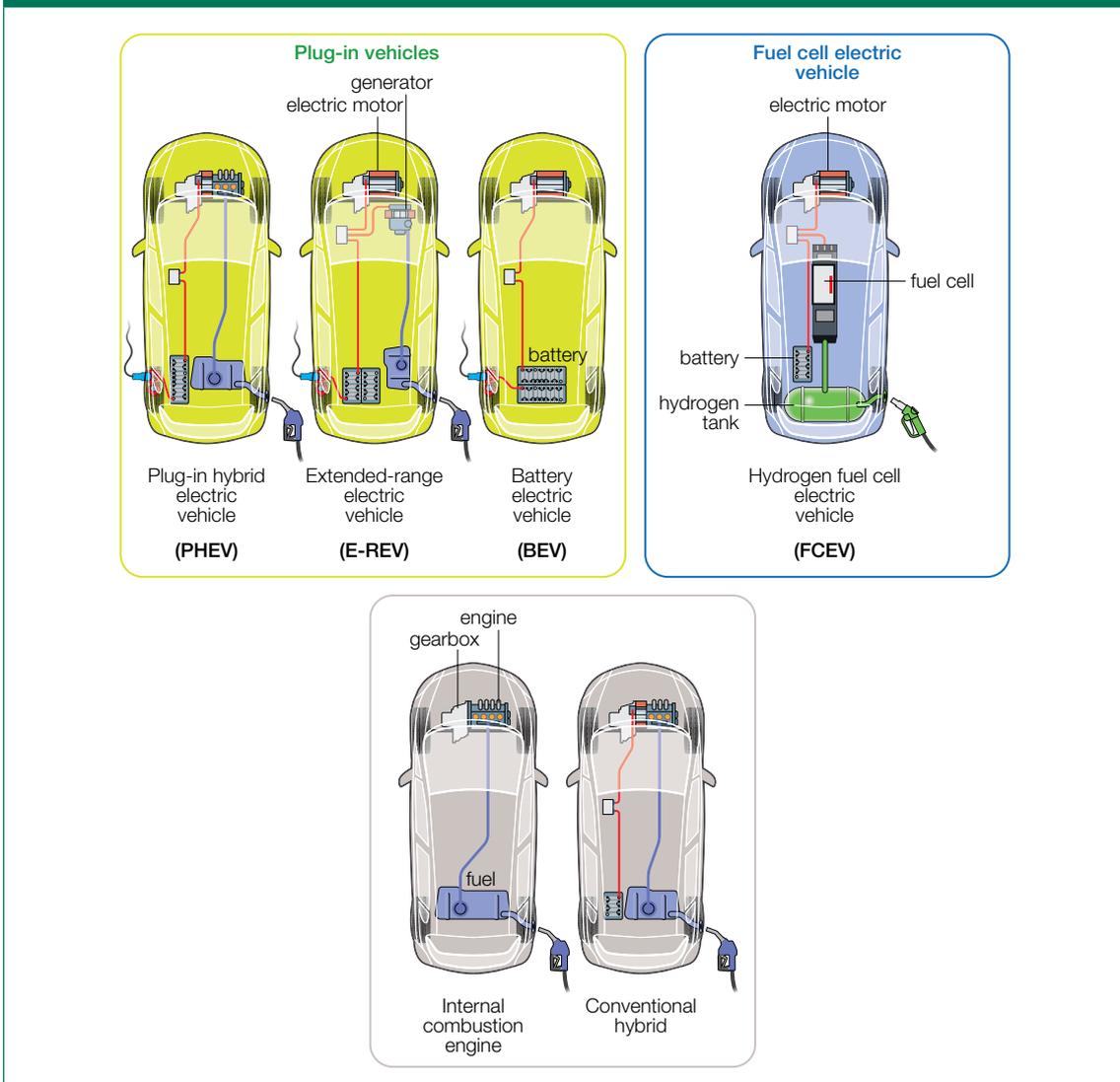


Figure 2.2 – The technology portfolio for cars and vans

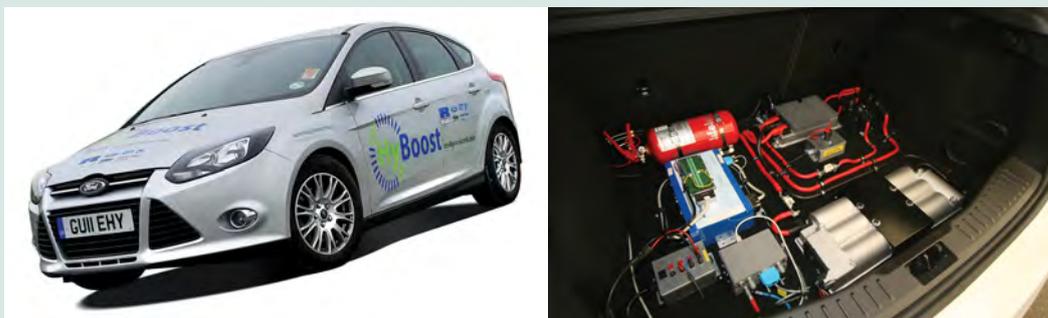


The internal combustion engine

- 2.4** In the near to medium term, industry expects to see continued improvements to the fuel efficiency of the internal combustion engine. This will have a significant impact on the UK's road transport emissions by providing moderate benefits for a large proportion of the current fleet. Projects like the HyBoost programme demonstrate that there are significant efficiency improvements that can be achieved by optimising the performance of internal combustion engines (see box).

Hyboost – improved efficiency for internal combustion engines without compromising performance

The HyBoost collaborative research project developed an ultra-efficient, highly optimised gasoline engine concept that demonstrated practically what could be achieved in terms of CO₂ reduction. It brought together existing technologies and systems through an engineering collaboration developed through the Technology Strategy Board's Low Carbon Vehicle Innovation Platform that OLEV co-funds. This resulted in a radically downsized 1.0 litre gasoline engine (pictured below) that delivered the performance of a 2.0 litre engine when installed in a Ford Focus, but with CO₂ emissions reduced to 99g per km from 169g per km (as measured on the current European test cycle) and comparable reductions under normal driving also demonstrated.

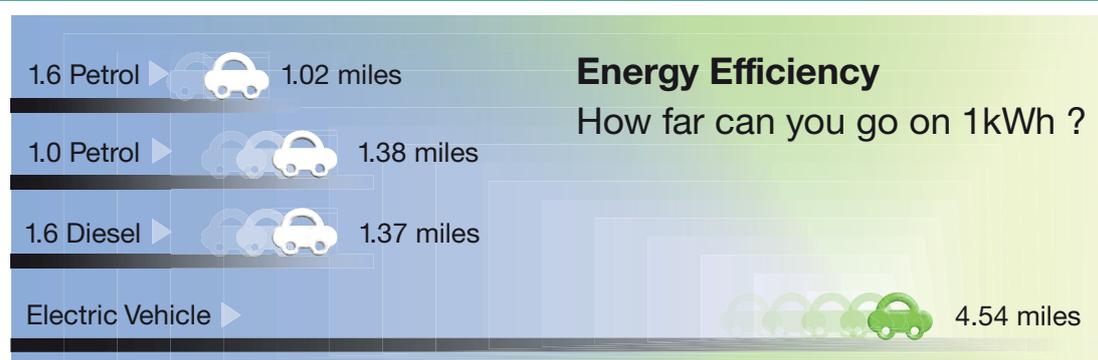


Source: Ricardo

The practical mix of technologies have been estimated to cost manufacturers less than £500 per vehicle and are considered to be fully scalable to larger vehicles delivering significant engine downsizing, but without loss of drivability. Since the funding required partners to develop a five-year plan of how to promote these technologies, it is hoped the concept will make it onto production vehicles by 2016 at the latest.

- 2.5** But despite over a century of development the internal combustion engine remains, in absolute terms, a relatively inefficient way of powering a vehicle. Indeed, even the most efficient internal combustion engine vehicles on the market today still lose over 60% of the energy stored in a tank of petrol or diesel through heat, noise and other losses. In comparison, electric motors can have efficiencies as high as 80-90%. As a consequence electric vehicles can travel far further on a given amount of energy than traditionally powered vehicles (see Figure 2.3). That is why the roadmap identifies increasing levels of hybridisation and electrification as the European emissions targets tighten.

Figure 2.3 – The efficiency advantages of electric power



(Distances approximate, theoretical calculations using best in class vehicles)

Increased hybridisation

2.6 In recent years we have seen an increase in the hybridisation of the UK vehicle fleet. Conventional hybrid vehicles combine an internal combustion engine with varying degrees of power recuperation and electric propulsion. This is helping to provide incremental improvements in fuel efficiency and introduce the mass market to increasing levels of electrification. Toyota alone has sold more than 5 million hybrid vehicles globally up to March 2013, including the new UK-built Auris hybrid (pictured).¹⁶



Source: Toyota

2.7 Conventional hybrid technologies can offer improved fuel efficiency. The Powering Ahead report identified greenhouse emission savings of 15-25% over a comparator internal combustion engine vehicle.¹⁷ But ultimately, they do still rely largely on a petrol or diesel powered engine as their primary source of power. This means they are unlikely to provide the step change in greenhouse gas and other emissions that ultra low emission vehicle technologies can make.

2.8 It is also worth noting that even as the efficiency of the internal combustion engine is increased, vehicles that are primarily propelled by this means will typically still emit more local air pollution and noise than an equivalent plug-in or fuel cell vehicle using an electric motor.

Biofuels

2.9 As highlighted in the Government's Bioenergy Strategy, sustainable biofuels have a role to play in decarbonising transport.¹⁸ Biofuels are already playing a part in helping to decarbonise the existing fleet of cars and vans. In the

¹⁶ www.toyota-europe.com/about/news_and_events/editorial/5-million-hybrids-sold.tmex

¹⁷ www.racfoundation.org/media-centre/powering-ahead-future-low-carbon-cars-fuels

¹⁸ www.gov.uk/government/uploads/system/uploads/attachment_data/file/48337/5142-bioenergy-strategy-.pdf

longer term, and if advanced biofuels can be commercialised, they could play a key role in decarbonising sectors such as aviation and freight where there are few alternatives to liquid fuel and electrification is far more challenging. The Government has recently announced £25 million of capital funding for a demonstration competition intended to underpin significant private sector investment in one or more demonstration-scale advanced biofuel plants and drive the development of a domestic industry.

Ultra low emission vehicles

Plug-in vehicles

2.10 The majority of ultra low emission cars and vans on sale today or coming to market within the next few years are plug-in electric vehicles. The term 'plug-in vehicle' is used to describe a variety of different technologies that are powered in part or in full, by a battery that can be directly plugged into the mains. For the purpose of this strategy, 'plug-in vehicle' is used as a generic term to describe Battery Electric Vehicles (BEV), Plug-in Hybrid Electric Vehicles (PHEV) and Extended-Range Electric Vehicles (E-REV).

2.11 Battery Electric Vehicles (BEVs) are sometimes referred to as pure electric vehicles. They are wholly driven by an electric motor, powered by a battery that can be plugged in to the mains. They rely entirely on electricity for fuel, which means they do not produce any tailpipe emissions from the vehicle. At present, most of the BEVs on the market typically offer a range of around 100 miles, though some offer more. The UK-built Nissan LEAF (pictured) is the biggest selling BEV on the market.



Source: Nissan

2.12 Plug-In Hybrid Electric Vehicles (PHEV), like the Toyota Prius plug-in hybrid (pictured), combines both a plug-in battery pack and electric motor with an internal combustion engine. Both the electric motor and the internal combustion engine can drive the wheels. The battery is much smaller than in a battery electric vehicle, tending to only drive the wheels at low speeds or for limited range. However, it is still sufficient in most models to cover the average journey length of the UK driver. After the battery range is utilised, the hybrid capability means that the vehicle can continue journeys powered by its conventional engine. The use of an internal combustion engine means that PHEV's tend to have tailpipe emissions of around 40-50g/km CO₂ when measured against the current European test cycle.



Source: Toyota

2.13 Extended-Range Electric Vehicles (E-REV), like the Vauxhall Ampera (pictured), have a plug-in battery pack and electric motor, as well as an internal combustion engine. The electric motor always drives the wheels, with the internal combustion engine acting as a generator to recharge the battery when it is depleted. Typically, these vehicles have a pure electric battery range of around 40 miles, before the vehicle switches to the range extender mode to continue the journey without range compromise. This typically results in tailpipe emissions of around 20-30g/km CO₂.



Source: Vauxhall

The importance of battery technology

- 2.14** The battery system is at the heart of a plug-in vehicle and has a big impact on its cost and electric driving range. Manufacturers and suppliers are continuing to develop more affordable batteries with greater energy and power densities which will help to bring down the costs of the vehicles and enable them to cover greater driving distances between recharges. A 2012 study¹⁹ by consultants McKinsey and company predicted that the price of a complete automotive lithium-ion battery pack could fall from \$500 to \$600 per kWh today to about \$200/kWh by 2020 and to about \$160/kWh by 2025. The cost of battery packs has already fallen by 20 to 40% in the last five years.²⁰
- 2.15** There are also concerns about the longevity of battery packs and about the environmental impacts of their manufacture and disposal. The latter point is considered in more detail in Chapter 4. On longevity, it is probably too early to draw any firm conclusions because the technology is still relatively new, but plug-in vehicle manufacturers are now confidently warranting that their battery packs will stay above 80% capacity for a number of years. In the US a Nissan Leaf owner recently reported the first signs of a reduction in capacity (to 85%) after completing 78,600 miles in two years.

Electrifying motorsport

Motorsport is increasingly turning to electric powertrains to complement or replace internal combustion engines.



Source: Drayson Racing Technologies

In Formula 1 the cars are increasingly adopting energy recovery systems, with plans in place for the cars to be powered by electric motors alone whilst in the pit lane from 2017.

¹⁹ http://www.mckinsey.com/insights/energy_resources_materials/battery_technology_charges_ahead

²⁰ Source: Strategic Outlook of the Global EV Market in 2013 (Frost and Sullivan)

The Formula E series will commence in London in September 2014, with Formula cars powered exclusively by electric energy racing in major cities around the world. The FIA, the governing body of motorsport worldwide, see Formula E as ‘a vision for the future of the motor industry over the coming decades, serving as a framework for research and development around the electric vehicle’. Beyond this it will also act as a showcase for the driving performance of electric vehicles.

In terms of straight line speed, Drayson Racing Technologies set a new world land speed world record for a lightweight electric car in June 2013. Its adapted Le Mans car produces 850 horsepower, with a 0-60 mph time of 3.0 seconds, and was clocked at 204.2 mph. The company intends to use technologies developed for this car in future road and race projects.

Nissan has developed its own electric Le Mans car with similar intentions. The 24-hour Le Mans race acts as a challenging test bed for Nissan to trial technologies that could subsequently be used in conventional road cars.

Plug-in vehicle infrastructure

- 2.16** A key benefit of plug-in vehicles is that they are able to be conveniently charged at home or at the workplace. Nevertheless, some targeted publicly accessible infrastructure is required to facilitate longer journeys, particularly for battery electric vehicles.
- 2.17** There are a range of different types of plug-in infrastructure chargepoints that charge a vehicle at different speeds to suit different needs. These are generally classified as standard, fast and rapid, which are characterised by the power output (although terminology can vary).
- 2.18** Although the slowest (3kW) chargepoint can take up to eight hours to fully charge a typically battery electric vehicle, others are much quicker. The emergence of increasing numbers of genuinely rapid chargepoints which can charge a vehicle to 80% capacity in around 20 minutes means that longer journeys are now a practical proposition for battery electric vehicle drivers should they need to undertake them.

- 2.19** From a number of different approaches the industry is moving to increasing standardisation around plugs and chargers. But complexity in this area does persist with, for example, some manufacturers preferring to rapid charge their vehicles using Alternating Current (AC) rather than Direct Current (DC). (The pictured Siemens rapid chargepoint has three connectors for different vehicles – CHAdeMO and CCS DC connectors, and a Type 2 AC connector.)



Source: Siemens

- 2.20** The standardisation of plugs and connectors is currently being discussed within the European Parliament and European Council as part of the ‘Clean Power for Transport’ package of measures. The UK Government support

efforts to agree and harmonise technical standards across the EU and is actively engaged in these negotiations.

Emerging charging technologies

Although plug-in (conductive) charging is the predominant method of charging a plug-in vehicle today, there are a number of other battery charging technologies emerging. Some of these are already commercially available, while others are in a demonstration phase. The UK Government is keen to support the commercialisation of such technologies.

Static wireless charging

This technology is already widely used in electric toothbrushes and mobile phones. And there are several wireless charging bus schemes around the world, including Genoa and Turin (Italy), Utah (USA), Mannheim (Germany) and Milton Keynes (UK), which are demonstrating its potential viability for the operation of passenger transport. The Milton Keynes trial will replace several diesel buses with all electric vehicles to improve air quality, save around 500 tonnes of CO₂ and reduce bus running costs each year. The buses will charge whenever they are parked over coils at either end of the route, while one placed mid-route will top up the battery. This method of charging, when the vehicle is stationary over the primary coil, is known as 'static' charging.

We are also seeing trials conducted for lighter vehicles such as cars, vans and taxis. Qualcomm Halo are currently working in collaboration with Chargemaster and vehicle manufacturers to trial wireless charging in London.

Dynamic wireless charging

Many organisations are also looking into developing dynamic wireless charging systems, where the vehicle is charged whilst moving above a strip embedded in the road. While this is viewed by many as a longer term prospect, it could enable longer journeys by charging vehicles on the move. As well as established wireless technology organisations such as Qualcomm Halo, several R&D based organisations, such as Ampium Ltd, have designed, built and tested the technology and are seeking to work in partnership with the wider industry to bring demonstrator projects to fruition.

Hydrogen fuel cell electric vehicles (FCEVs)

- 2.21** Hydrogen fuel cell electric vehicles share a large proportion of the electric motor and drive train technology with other electric and plug-in hybrid vehicles. However, their energy storage and conversion devices are different. Instead of taking electricity directly from the mains, these vehicles use a fuel cell to produce electricity to drive its electric motor. A fuel cell is an electrochemical device which generates electricity when continuously fed with hydrogen from an onboard tank that can quickly be refuelled.
- 2.22** Fuel cells are highly energy efficient devices (50-60%). Fuel cell electric vehicles produce no emissions or pollutants at the tailpipe and reduced overall well-to-wheel emissions when compared with today's petrol and diesel equivalents. This means that, like plug-in vehicles, they can contribute to the improvement of air quality and the reduction of CO₂.

- 2.23** Fuel cell electric vehicles have been widely viewed as the future of motoring for many years but the imminent commercial availability (from 2015) of models from a number of manufacturers shows just how far the development of this technology has now come (pictured, the Hyundai ix 35 and the Toyota FCV-R fuel cell cars). Fuel cells have become increasingly compact and more powerful and problems such as operating at low temperatures and safely storing hydrogen under pressure have been overcome. Although there is significant research into lots of different aspects of hydrogen as a transport fuel, manufacturers have coalesced around a *de facto* standard of using gaseous hydrogen stored at 700bar pressure as the most practical current way to launch fuel cell vehicles.



Source: Hyundai



Source: Toyota

Hydrogen infrastructure



Source: BOC

The fuel cell electric vehicles coming to market from 2015 will be refuelled by gaseous hydrogen enabling a driver to refuel their vehicle in about 5 minutes and provide a range of some 300 miles.

With a conventional petrol station, a large storage tank is buried in the ground and filled with fuel. At a hydrogen refuelling station, hydrogen is also stored and then dispensed into a customer's car. The difference is that the hydrogen will be delivered as a gas, under pressure. In order to store a reasonable amount of fuel on board the vehicle, the hydrogen needs to be compressed. A compressor pressurises the hydrogen gas and it is then housed in storage tanks from which it gets pumped via a dispenser into the vehicle (see picture of the UK's first commercial hydrogen filling station in Swindon, Wiltshire).

The hydrogen can be delivered to site (e.g. in cylinders or by road-trailer) or produced on-site. The size and location of hydrogen refuelling stations will depend on the business cases developed by early investors. Hydrogen refuelling stations could be integrated into conventional petrol stations, operate as stand-alone sites, be linked to renewable electricity generation or even offer a mobile refuelling capability.

Whilst the use of hydrogen for refuelling vehicles is relatively new, hydrogen has been deployed as an industrial gas for over a hundred years, with large volumes used safely across a wide range of applications every day. The UK Government has directed funding at a number of demonstration projects in recent years and there are now 13 small-scale hydrogen refuelling stations operational in the UK.

Ultra low emission technologies in other vehicles

2.24 As outlined in Chapter 1, whilst the focus of this strategy is primarily the car and van sectors, the Government remains keen to accelerate the adoption of ULEV technologies in other vehicle sectors. Several sectors are already making advances in the development and adoption of low and ultra low emission vehicle technologies. Hybrid and fully electric buses, heavy goods vehicles and, at the other end of the scale, ULEV motorcycles, electric pedal cycles and other smaller vehicles are all now in use on the UK's roads.

Large commercial vehicles

2.25 There are a number of low emission power train technologies either on, or entering, the market for commercial vehicles. Typical technologies include dedicated or dual-fuel gas engines (fuelled by liquefied natural gas, compressed natural gas or biomethane), hybrid commercial vehicles comprising an electric power train in parallel with the conventional diesel engine and pure electric commercial vehicles.

2.26 Additional on-vehicle technologies such as low rolling resistance tyres and aerodynamic improvement devices can also contribute to improving fuel economy and reducing emissions. While these technologies may give small (single digit %) reductions in fuel consumption individually, the combined savings could total up to 10% (typically) and be attractive to operators due to their short payback periods. Further reductions can be made from operational measures, such as driver training and performance monitoring, reduced empty running, improved routeing and scheduling.

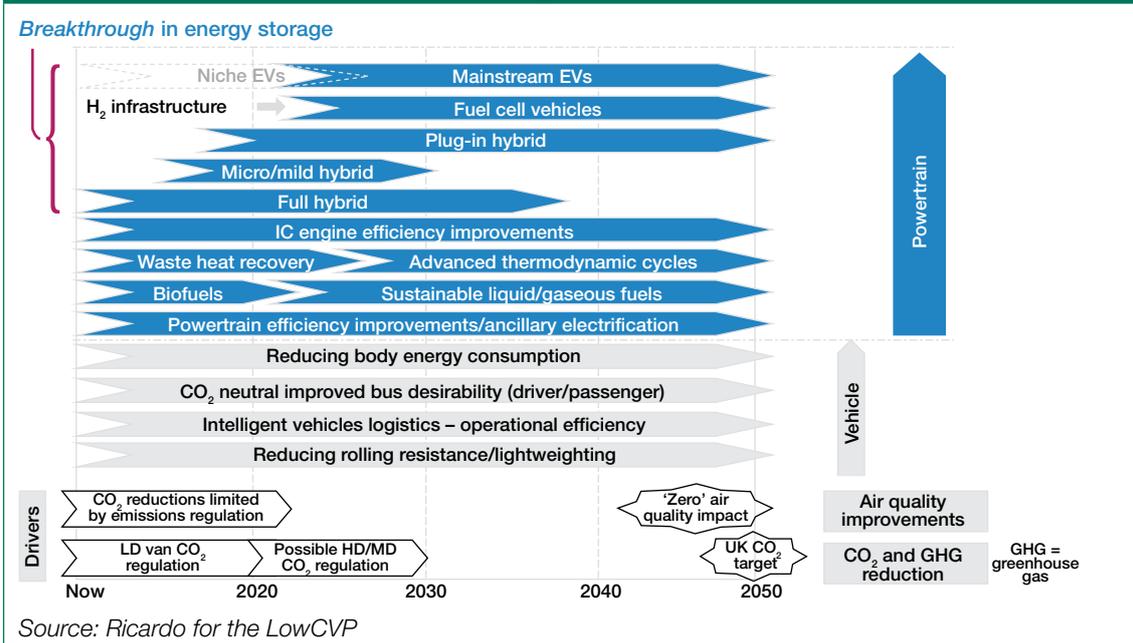
2.27 Not all ultra low emission technologies will be suitable for every commercial vehicle type or duty cycle. Long haul trucks, for example, tend to carry large payloads over significant ranges and some operate around the clock on 'triple shifts'. Current battery electric technology will not be suitable for duty cycles such as this, as the size and weight of current batteries capable of delivering the necessary range and power would significantly reduce load-carrying capacity.

2.28 Chapter 3 identifies the Government and industry actions to date to support the lowering of emissions from large commercial vehicles.

Buses

- 2.29** In July 2013, the Low Carbon Vehicle Partnership (LowCVP) published a report prepared by consultants Ricardo.²¹ The aim of the study was to identify fuels and technologies which can cost-effectively reduce well-to-wheel CO₂ emissions for urban buses in the UK. The report included a technology roadmap (see Figure 2.4), supported by the Automotive Council, which illustrates when technologies are likely to be ready for deployment into the bus market through to 2050.
- 2.30** The report focuses on a variety of promising vehicle and powertrain technologies including light weighting, battery electric and various hybrid architectures including stop-start, mild hybrid, diesel electric, mechanical flywheel, and hydraulic hybrids. The study also covered a range of alternative fuels including compressed natural gas, biomethane, hydrotreated vegetable oil, second generation biodiesel and hydrogen. The study confirmed a number of technologies are already able to provide significant improvements to bus CO₂ emissions, while offering bus operators a return on their investment in less than five years. Other technologies have the potential to offer greater CO₂ savings (more than 30%), but may require interventions to help bring them to market more quickly. The Government's actions to support low carbon buses are discussed in Chapter 3.

Figure 2.4 – The long term bus CO₂ reduction roadmap



Taxis

- 2.31** The technology that powers both taxis (Hackney carriages) and minicabs (Private Hire Vehicles) is generally based on that used in typical passenger cars and vans. Because the numbers of taxis relative to private cars is very small, the transition to ultra low emission motoring for taxis and minicabs will inevitably follow a similar transition to cars.

²¹ Preparing a low CO₂ technology roadmap for buses, final report, Ricardo (July 2013). Available to download from www.lowcvp.org.uk/

2.32 However taxis and minicabs can have a disproportionate impact on urban air quality because of the nature of their role and the potential for dense clusters of taxis in certain areas. On the streets of central London, the black cab alone generates 34% of the total exhaust particulates created by all motorised transportation.²² Because of this, there is significant interest from policymakers at both the local and national levels in putting taxis and minicabs in the vanguard of moves to reduce emissions from vehicles.



Source: Intelligent Energy

2.33 A demonstration fleet of five hydrogen fuel cell taxis operated in London during the 2012 Olympics (pictured above) and a number of manufacturers are bringing plug-in versions of taxis to market. Taxis are likely to place a higher demand on infrastructure than private cars because of the nature of their duty cycles. For battery electric taxis that will possibly require access to a dedicated network for rapid charging, for fuel cell taxis it might require dedicated hydrogen refuelling infrastructure.

Electric taxis

A taxi firm in the North East of England is proving that battery electric vehicles make good business sense in helping to reduce costs and boost environmental credentials.

Phoenix Taxis began introducing electric vehicles into its fleet in early 2013, supported by the installation of chargepoints at its head office with funding from the Charge you Car Plugged-In Places scheme.



Source: Phoenix Taxis

Phoenix Taxis believe that battery electric vehicles are becoming a more sensible vehicle choice as a means of saving fuel – the main cost to any taxi driver. From their own experience, they found the average fuel costs for 500 miles travelled in a Nissan LEAF was less than £17, whereas a diesel vehicle cost £207, a LPG vehicle cost £130 and a hybrid cost £115.

They are now looking to introduce thirty electric vehicles onto the road by summer 2014, supported by rapid charging infrastructure.

²² <http://data.london.gov.uk/datastore/package/london-atmospheric-emissions-inventory-2010>

Smaller vehicles including powered two wheelers and quadricycles

- 2.34** The changing patterns of mobility mentioned in Chapter 1, point towards the increasing global importance of smaller vehicles during the 21st century. With increasing urbanisation and pressure on road space, we anticipate a buoyant future for electric powered two wheelers (ePTWs) and other small ULEVs as part of an increasingly diverse range of options for getting around towns and cities.
- 2.35** Sales of electrically assisted pedal cycles are increasing significantly in Europe and can offer people an alternative route into cycling as a viable commuting option by extending possible commuting distances but still giving fitness benefits (see box).

Electrically assisted pedal cycles

Pulling away and riding uphill and for longer distances are made easier through assistance in pedaling from an electric motor. These bikes can provide mobility to those with limited transport options and open up cycling to those who might otherwise turn to other transport modes. Whilst there are requirements about the maximum power output and weight



Source: British Electric Bike Association

of electrically assisted pedal cycles that can be used in Great Britain, they have the advantages of being exempt from compulsory registration, insurance and vehicle excise duty. They are a flexible and economic form of transport that is capable of meeting a large proportion of most people's typical urban journeys. These bikes are available with modern, high-capacity lithium ion batteries and motors that are virtually zero maintenance.

- 2.36** Motorcycles can have a clear advantage over cars in terms of reducing levels of congestion and emissions. The smaller machines that dominate urban environments tend to have CO₂ emissions per kilometre travelled of less than half of those of the average car, though larger motorcycles can emit more. Electric motorcycles and mopeds are now commercially available which offer further advantages for reducing CO₂ and improving air quality (see box). In the near future, we may also see hydrogen fuel cell bikes entering the market.

Electric motorcycles

Motorcycles are well suited to electric powertrains, and there is a growing number of e-motorcycles now available. Zero Motorcycles (pictured), Vectrix and Yamaha are amongst the companies now selling e-motorcycles in the UK. Pike Research forecasts that annual sales of e-motorcycles and e-scooters will reach 18.6 million by 2018.



Source: Zero Motorcycles

As with other electric vehicles, instant torque and no gear shifting mean responsive and smooth acceleration. Significantly reduced running and maintenance costs are possible, and as e-motorcycles produce no engine noise or tailpipe emissions, they are well suited to urban mobility.

E-motorcycles typically have a range of around 100 miles, with smaller e-scooters usually designed to have a lower range. They can be recharged using conventional three-pin domestic plugs (subject to suitable checks by a qualified electrician).

Hydrogen fuel cell bikes

In 2011, the Suzuki Burgman Fuel Cell scooter (pictured), powered by UK company Intelligent Energy's hydrogen fuel cell, became the world's first fuel cell vehicle to achieve European Whole Vehicle Type Approval.



Source: Intelligent Energy

The fuel cell scooter demonstrated a range of approx 220 miles, with a refuelling time of less than 5 minutes. Suzuki and Intelligent Energy formed a Joint Venture (SMILE FC) in 2013 with the aim of accelerating the commercialisation of Suzuki's fuel cell vehicles, particularly scooters.

- 2.37** Other small vehicles, including electric quadricycles like the Renault Twizy (see photo), can also be valuable in the effort to decarbonise road travel. Electric quadricycles are motorised vehicles that have a mass of 400kg or under (when unloaded) and which must have a maximum net engine power of less than 15 kW. Quadricycles can offer a competitive low carbon alternative to traditional cars.



Source: Renault

Summary

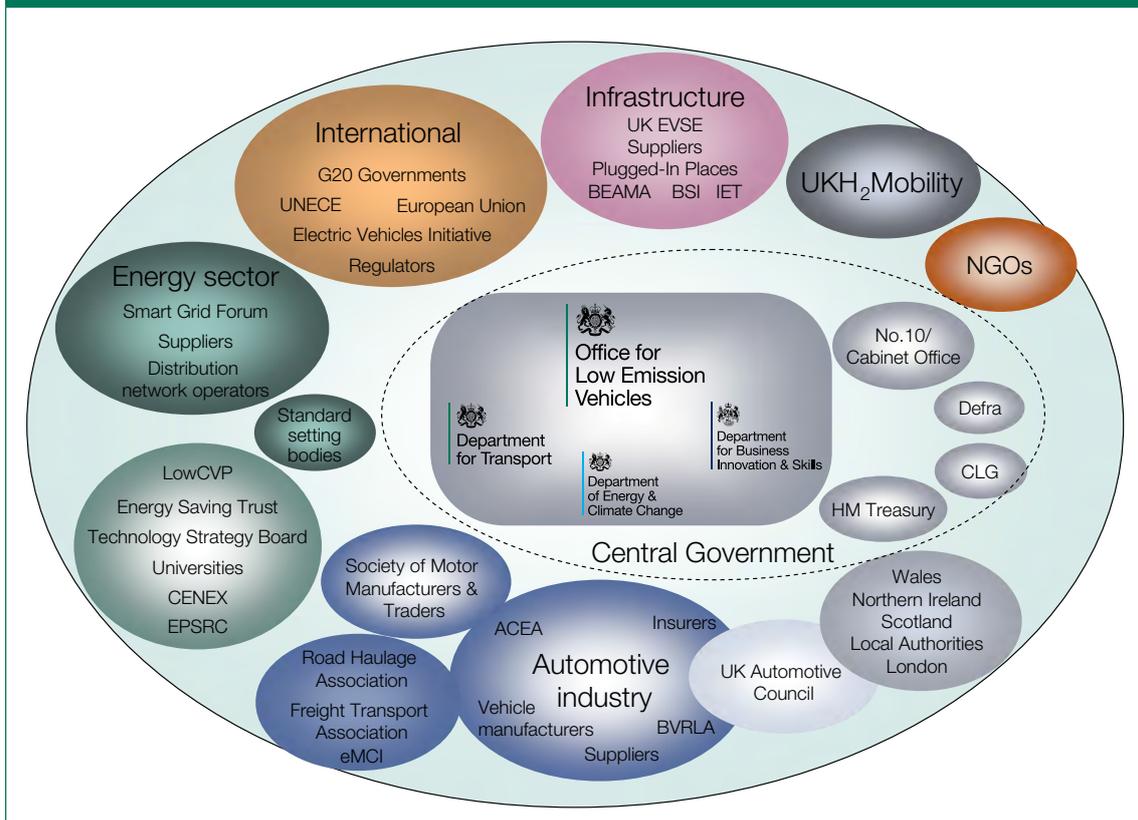
2.38 This chapter has:

- Provided a brief overview of current ULEV technologies.
- Described developments with respect to hydrogen fuel cell electric vehicles (FCEVs) and hydrogen infrastructure.
- Looked at the range of vehicles that are already adopting ULEV technologies – from pedal cycles to heavy goods vehicles.

3. Progress to 2013

- 3.1 The Government's current policies aim to both stimulate and accommodate the expected growth in ultra low emission vehicles, and £400 million funding has been made available over the lifetime of this Parliament (2010-2015). This includes provision to support the purchase of eligible vehicles and to kickstart the installation of chargepoints throughout the UK. In addition, there is funding for a programme of research and development to support this new generation of vehicles and to help build ULEV-related skills and knowledge in the UK. This chapter provides an overview of these key policies.
- 3.2 Recognising both the importance of the ULEV agenda, and its cross-cutting nature, the UK Government maintains the Office for Low Emission Vehicles (OLEV) – a dedicated team based in the Department for Transport but also including staff from BIS and DECC. OLEV operates as a one-stop shop for interaction between Government, industry and other stakeholders on the developing ULEV market (see Figure 3.1).

Figure 3.1 – OLEV relationships



Helping to support the purchase of ULEVs

3.3 It was always anticipated that ULEVs would initially be more expensive than conventional vehicles, due to low production volumes and the relatively high cost of the new technology. As technology develops and production volumes rise, the price of the components and the vehicles will fall. This process has already begun.

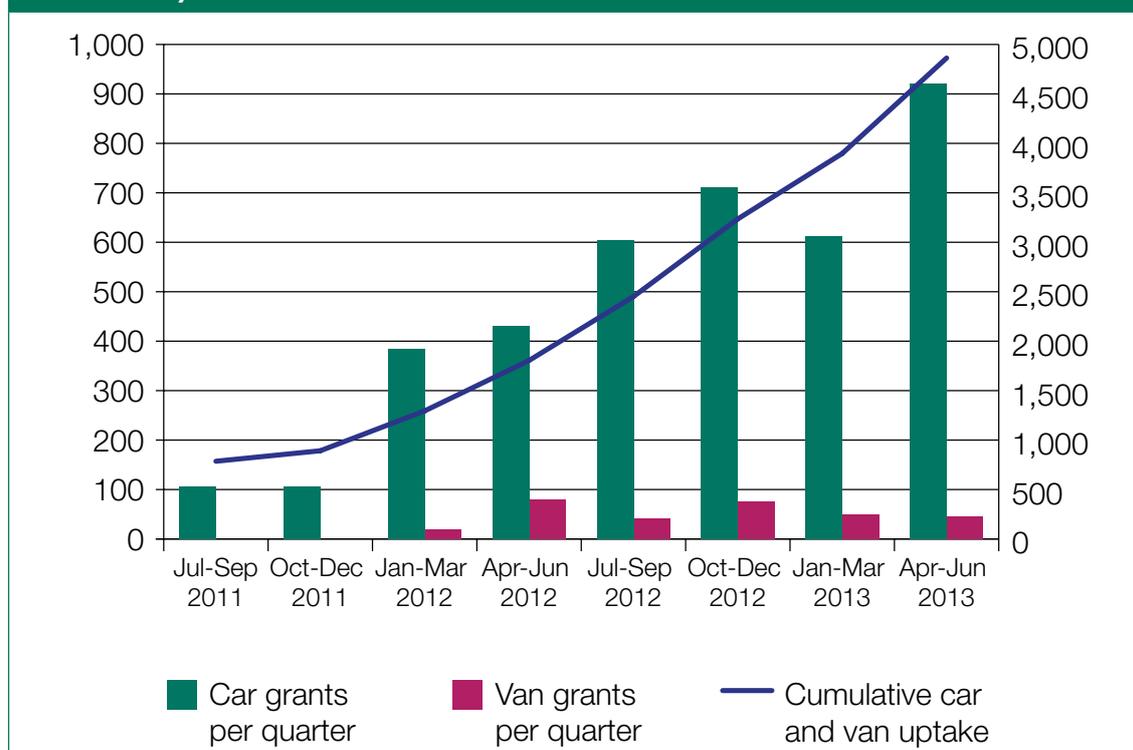
Plug-in Car Grant and Plug-in Van Grant

3.4 The Plug-in Car Grant was introduced in January 2011, and extended to vans in February 2012. Both grants are technology neutral and available to both business and private users, purchasing or leasing any eligible vehicle. Levels are set at 25% off the upfront cost of an eligible car (up to a cap of £5,000) and 20% of an eligible van (up to a cap of £8,000) until May 2015.²³

3.5 The grants were set up to help the move to a mass market for ULEVs by making the total cost of ownership of a ULEV increasingly comparable with that of a conventional vehicle. As of September 2013 there are 12 eligible cars and seven eligible vans on the market, and we expect the number of eligible cars to double by 2015.

3.6 A recent study into the impact of Government's ULEV policies showed that the plug-in car grant was important in the purchase decision of 85% of ULEV purchasers,²⁴ and the graph below confirms that grants have already had a positive effect on the ULEV market.

Figure 3.2 – The growing Plug-in Car and Van Grant uptake (July 2011 to June 2013)



²³ <http://www.gov.uk/plug-in-car-van-grants/overview>

²⁴ Assessing the role of the Plug-in Car Grant and Plugged-in Places scheme in electric vehicle take-up (2013) – Transport Research Laboratory on behalf of the Office for Low Emission Vehicles.

- 3.7 Record levels of grant uptake were achieved during the second quarter of 2013/14 and we expect this to continue as new vehicles enter the market, providing a more diverse choice for consumers at different price points.

Other incentives

- 3.8 The Government recognises the importance of stability in taxes for ULEVs over at least the medium-term as the market for these vehicles develops. We have committed to discussing with industry any changes under consideration and to provide long lead-in times before changes are introduced.
- 3.9 The UK has a range of fiscal benefits to enhance the attractiveness of ULEVs, including:
- **Fuel Duty.** This is paid on each litre of road fuel purchased (or per kilogram in the case of gases). Electricity is not subject to fuel duty so battery electric vehicles are exempt, and plug-in hybrid and extended range electric vehicles benefit from lower rates of fuel consumption than internal combustion engine equivalents.
 - **Vehicle Excise Duty.** Cars that are not solely powered by petrol or diesel are classified as alternative fuel vehicles. Alternative fuel vehicles that emit less than 100g/km of CO₂ are exempt from VED.
 - **Company car tax (CCT).** To support the earliest stages of the ULEV market CCT has been set at 0% until 2015. Thereafter and until 2020, CCT for ULEVs will be at least 3% lower than conventionally fuelled vehicles. Rates for future years will be announced at least three years in advance to provide greater clarity on the whole-life costs of an ULEV.
 - **Capital allowances.** All vehicles emitting less than 75g/km of CO₂ and company cars emitting less than 95g/km are eligible for a 100% first year capital allowance to March 2015.
- 3.10 A number of further benefits for ULEV drivers have also been introduced in different parts of the country, including:

- **London Congestion Charge exemption.** An exemption from the £10 per day charge for vehicles that are either pure electric or that emit 75g/km or less of CO₂ and meet the Euro 5 emission standard for air quality.
- **Discounted parking.** Local authorities are operating a range of schemes to provide discounted or even free parking for ULEVs. Parking for residents, visitors and businesses are included.



Source: Vauxhall

- **Traffic restriction.** A number of cities are reviewing options for future restrictions on traffic in key hotspots to reduce congestion and improve air quality. An ULEV exemption is being considered as part of several of these.
- **Taxis.** York currently operates a discount from their taxi licensing fee for hybrid and electric taxis that emit 100g/km or less of CO₂, and also offers a grant to assist with vehicle purchase.

Support for fleet buyers

- 3.11** The fleet sector buys around half of all new cars in the UK (54% in 2012). Their purchasing decisions influence the rest of the market, so they have a crucial role in helping to accelerate ULEV sales. The Government is keen to work closely with this sector to ensure ULEVs are considered for appropriate application in fleets. That is why we funded the Energy Saving Trust (EST) to run the 'Plugged-in Fleets Initiative' (PiFI) in partnership with Transport for London in 2012-13.

Plugged-in Fleets Initiative – Fruit 4 London



Source: Fruit 4 London

Fruit 4 London is a fruit delivery business that operates a small fleet of vans and bicycles. They participated in the PiFI scheme to explore whether there was a good business case to operate plug-in vehicles on their fleet.

Energy Saving Trust provided free and independent advice, which showed that it would cost around £9,000 less to operate an electric Renault Kangoo Maxi ZE over 36 months compared to a diesel Kangoo. The whole life cost analysis demonstrated that lower running costs (including 100% capital allowances, the Plug-in Van Grant and no congestion charge in London for EVs), add up to make the electric vehicles far more cost effective than a diesel equivalent for Fruit 4 London.

This has supported Fruit 4 London in its decision to begin operating electric Kangoo vans (pictured), with a view to replacing its fleet with plug-in vehicles in the medium term.

- 3.12 EST worked with 20 public and private sector organisations to look at their options for integrating plug-in hybrid and electric vehicles. In the majority of cases it demonstrated that these vehicles can help fleets to save money while meeting the business needs of the organisation. The findings, published in the *Charging Forward* report, identify that businesses that switch to plug-in vehicles could reduce fuel costs by up to 75%. When this is combined with incentives and favourable tax treatment, it can make clear business sense to integrate these vehicles into many different types of fleet.²⁵
- 3.13 These findings are backed up by a British Gas study in December 2012. This study, conducted by the Transport Research Laboratory, showed that the UK's largest fleets could save an average £350,000 each year if they switched 10% of their current fleet to electric vehicles.²⁶

Public sector fleets

West Midlands Police

West Midlands Police trialed a Nissan LEAF in 2012 after seeing a viable gap in their fleet for electric vehicles. The results were positive and they took delivery of 30 LEAFs in June 2013 – the largest single order of plug-in vehicles by a fleet in the UK to date. This was supported by the installation of chargepoints at 11 sites with funding from the Plugged in Midlands scheme.



Source: Nissan

West Midlands Police recognise the environmental and cost benefits that electric vehicles bring to their fleet. They have found that the LEAFs are well suited to be deployed for scheduled non-emergency duties, while providing much lower running costs than a diesel car and helping to reduce the Force's carbon footprint.

²⁵ www.energysavingtrust.org.uk/Organisations/Transport/Products-and-services/Fleet-advice/Plugged-in-Fleets-Initiative-100

²⁶ www.centrica.com/index.asp?pageid=1041&newsid=2631

3.14 It is important that fleets across the public sector lead by example in their fleet purchases. The Government Procurement Service, which manages frameworks through which central government departments and their agencies are mandated to purchase vehicles, has already led fleets to decarbonise at a rate that exceeds legislated carbon reductions. We are now working with them to develop new ULEV specifications for use in mass purchasing activities which would allow Government departments and the wider public sector to access ULEVs at discounted prices. In the meantime, wider public sector authorities are already starting to integrate ULEVs into their fleets.

Lowering emissions from other vehicles

Supporting the introduction of low and ultra low emission buses

- 3.15** With around 4.7 million bus passenger journeys in England every year, buses represent an essential part of our transport system connecting communities with jobs, vital health and education services, shopping and leisure opportunities and their friends and families. Buses therefore have a key role to play in enabling the country's economic growth.
- 3.16** At the same time, we want this growth to be as sustainable as possible, which is why the Government has provided support through the Green Bus Fund. This funding is provided to encourage bus operators and local authorities to switch to low and ultra low emission buses, by making the costs more comparable with that of a standard diesel bus.
- 3.17** In total, the £87 million fund has helped to deliver more than 1200 new low carbon buses in England, with nearly 350 in London and 275 in Manchester. This includes ultra low emission buses that operate completely on electricity or biomethane gas (see box), as well as highly efficient diesel-electric hybrid technology.
- 3.18** The Green Bus Fund has supported the introduction of 81 fully-electric buses, including:
- Thirty-six plug-in battery electric buses in Durham, Nottingham, Coventry and Dorset.
 - Eight electric buses in Milton Keynes, which will utilise inductive charging technology. The Department for Transport provided an additional £100,000 towards the infrastructure costs involved with this project.
 - Thirty-seven new electric buses will come into service in Nottingham, York, Manchester, London and Cheshire with support from the fourth round of the Green Bus Fund.²⁷

²⁷ www.gov.uk/government/news/12-million-boost-for-greener-bus-journeys

Electric buses in Nottingham

Nottingham City Council will benefit from the latest round of the Green Bus Fund, with support for the purchase of 15 new electric buses. This will increase the number of electric buses in Nottingham to 43 vehicles, which is thought to be the



Source: Nottingham City Council

largest fleet in Europe. This includes an order for 20 electric buses that the City Council recently placed with UK-based Optare (pictured).

Gas buses in Reading

The UK's largest fleet of natural gas-powered buses are being rolled out on the streets of Reading during 2013. Twenty buses are starting to operate on routes around the town, running solely on Compressed Natural Gas (CNG). They produce no harmful particulates, significantly lower levels of carbon emissions and much lower levels of Nitrogen Oxide (NOx). The buses are not only expected to improve the air quality along the routes, but also deliver fuel savings compared to their diesel counterparts.

3.19 Four bus manufacturers will benefit from orders for their hybrid, electric and gas buses, with many of the buses being assembled in the UK. The manufacturers which stand to benefit from the latest round are Alexander Dennis Limited, Optare, Scania and Volvo.

3.20 In recent years we have also seen the introduction of hydrogen fuel cell electric buses on our roads. A new fleet of fuel cell buses has been operating in London since 2011 (see picture), supported by a hydrogen refuelling facility. This followed a successful trial of the technology in London and nine other cities across Europe.



Source: Transport for London

3.21 In August 2013, the Government also announced a £5 million Clean Bus Technology grant award to 11 local and transport authorities to support the upgrade of older buses to reduce emissions in areas of poor air quality.²⁸ Local authorities outside of Greater London (funding has already been made available from DfT and the Mayor to upgrade 900 London buses) were invited to bid for up to £1 million to upgrade buses on routes where air quality does not meet European standards. After careful assessment, 11 authorities have now been awarded grants to upgrade nearly 400 older buses with five types of technology. Further information is available on the DfT website.

²⁸ <https://www.gov.uk/government/news/5-million-boost-to-cut-pollution-from-local-buses>

Lowering emissions from large commercial vehicles

- 3.22** The take up of ultra low emission technologies for heavy goods vehicles (HGV) has been relatively low. Evidence suggests that high upfront costs, availability of refuelling infrastructure, uncertainty over long term running costs and residual payback periods are the major barriers to uptake by freight operators. Research by Ricardo AEA on behalf of the LowCVP has indicated that clear opportunities exist to address these barriers and promote uptake of low emission HGV technologies and fuels.²⁹
- 3.23** OLEV is part of the joint Government and Industry Low Carbon HGV Technology Task Force, which is working to take forward the measures identified in this research. This includes proposals for a technology accreditation scheme to give operators information on the cost saving benefits of individual technologies as well as the development of a strategy for switching larger freight vehicles to gas engines. This builds upon the work already underway through the OLEV co-funded Low Carbon Truck and Infrastructure Trial.³⁰ The trial aims to demonstrate existing low carbon technologies and deliver confidence to industry cautious with their investments in new technology (see box).

Low carbon truck and infrastructure trial

The Office for Low Emission Vehicles has committed £6.5 million towards an £11.3 million Government trial of low carbon lorries and their supporting infrastructure. This aims to encourage the uptake of heavy goods vehicles whose CO₂ emissions are at least 15% lower than those emitted by equivalent diesel vehicles.

Over 300 low-carbon commercial vehicles will be involved in the demonstration programme, mostly using some form of gas power in dual fuel vehicles (diesel and gas). The programme also includes the launch of several gas refuelling points, which will be open access to help encourage other operators to consider using gas or dual-fuelled HGVs. The successful projects have now been announced and all should commence during 2013 and finish during 2015.



Source: DfT

- 3.24** OLEV will also be working with stakeholders and the Low Carbon HGV Technology Task Force to identify further opportunities to improve the business case for switching to gas, hybrid or pure electric commercial vehicles and to consider how to improve the uptake of additional technologies that can reduce CO₂ emissions from these vehicles.

²⁹ Opportunities to overcome the barriers to uptake of low emission technologies for each commercial vehicle duty cycle, Ricardo AEA (December 2012). Available to download from www.lowcyp.org.uk/
³⁰ www.gov.uk/government/news/truck-trials-to-drive-down-carbon-from-freight

Leyland DAF hybrid lorry

DAF Trucks started manufacturing the 12 tonne LF Hybrid model at its Leyland facility in Lancashire in December 2010 and was the first European manufacturer to enter serial production with a hybrid lorry. This followed a successful three-year field trial (in the UK and Netherlands) to demonstrate the benefits of the technology. This identified that a

24% fuel and carbon saving can be achieved when operating on a suitable stop/start duty cycle compared to an equivalent diesel truck. The trial also proved that the hybrid technology could meet the customers' demanding operational requirements. DAF LF hybrid trucks are now operating in eight different countries around Europe.

The DAF LF hybrid is a 'parallel Hybrid configuration' vehicle, with an electric motor installed between the engine and gearbox. The vehicle is fitted with a lithium ion battery, which allows up to 2 km of electric driving. This is recharged automatically when the vehicle is coasting or braking. The vehicle automatically decides which mode to drive in – either electric, blended electric and diesel power or diesel only modes – depending on the driving conditions.



Source: DAF Trucks

Supporting plug-in vehicle infrastructure

- 3.25** *Making the Connection* set out the Government's initial vision for recharging infrastructure in the UK and the steps that it, and other industry players needed to take to make it a reality.³¹ This has helped both in providing a clarity of approach and in removing barriers to those wishing to invest in, provide, or benefit from such infrastructure.
- 3.26** The strategy identified that it was not Government's role to mandate a chargepoint on every corner. Rather infrastructure should be targeted where it is needed most, to allow people and businesses to make the journeys they want. It identified that we expected to see the majority of recharging taking place at home at night, after the peak in electricity demand. This could then be supported by workplace recharging for commuters and fleets, with a targeted amount of public infrastructure where it is needed most.
- 3.27** Recognising the early nature of the market, we made available up to £30 million in matched funding to support the trial and installation of recharging infrastructure in eight pilot cities and regions across the UK through the Plugged-In Places (PIP) programme (see Figure 3.3). This programme was set up with two primary aims: to support the initial rollout of recharging infrastructure in the UK, and to learn from this to inform future policies to support the uptake of vehicles.

³¹ *Making the Connection*, Office for Low Emission Vehicles (June 2011):

<https://www.gov.uk/government/publications/making-the-connection-the-plug-in-vehicle-infrastructure-strategy>

Figure 3.3 – The Plugged-In Places (PIP) schemes

The PIPs have been led by the following local consortia including private and public sector organisations:

- Charge Your Car (North) Ltd, covering the north east
- eCar, covering Northern Ireland
- Greater Manchester Electric Vehicle scheme
- Milton Keynes PIP scheme
- Plugged-in Midlands, managed by Cenex and covering the Midlands
- Source London, a TfL lead scheme covering Greater London
- Source East, managed by Evalu8 and covering the east of England
- Transport Scotland

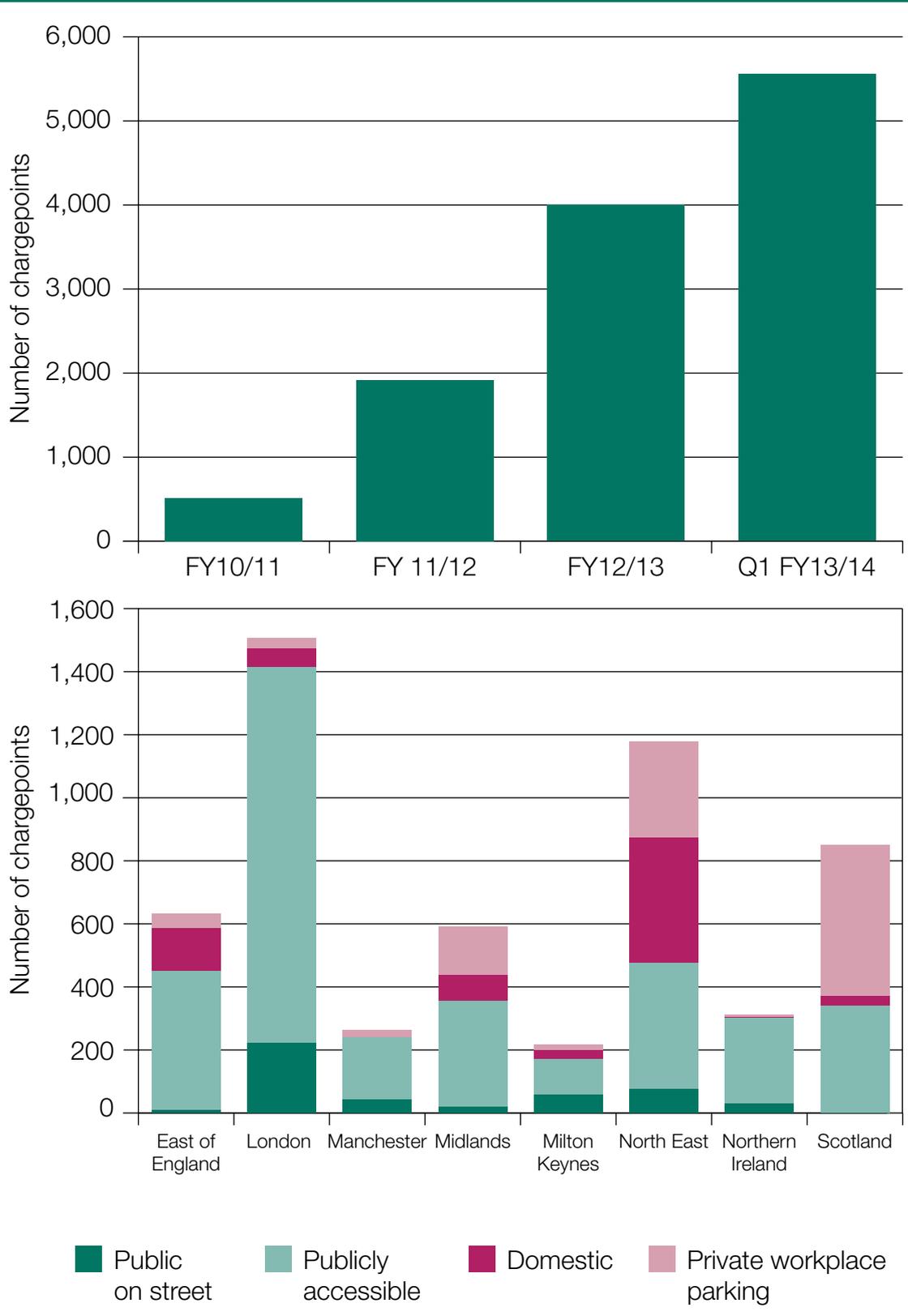
Plugged-in places

Electric vehicle infrastructure



- 3.28** Launched in 2010, the eight schemes have delivered over 5,500 chargepoints (to the end of June 2013), of which some 65% are publicly accessible. Each scheme is different in its approach, allowing the industry and government to learn as much as possible. This includes the infrastructure drivers require, the development of standards and technology, how to increase interoperability, how to overcome the challenges of installing infrastructure and creating networks, and how to build sustainable business models.

Figure 3.4 – Plugged-in Places chargepoint numbers



Northern Ireland PIP scheme

ecar NI³² has worked to deliver a recharging network across Northern Ireland to support the uptake of plug-in vehicles. As well as installing 14 50kW rapid chargers and 320 22kW fast chargepoints since it started in 2010, ecar NI has:



Source: ecar NI

- Secured funding from the European Union's TEN-T programme to roll out a cross-border rapid charger network. This is one of the first international plug-in vehicle highways in the world, allowing drivers to seamlessly use chargepoints across Northern Ireland and the Republic of Ireland, with a strong 'ecar' brand recognised in both jurisdictions. Charge points in Northern Ireland and the Republic of Ireland are internationally interoperable.
- Successfully used multiple communication channels to engage with consumers and industry, including the development of a successful multi-day event, a strong website and smart phone app, and the use of social media.
- Developed and rolled out training for EV dealers in Northern Ireland. The information and training has established ecar as a trusted source of information for EV customers.
- Introduced workplace and domestic schemes which have provided new opportunities for SMEs to develop skills in the sector, as well as working with South West College to create training courses for plug-in vehicle mechanics.



3.29 The PIP programme has been a success. What we have learnt from the programme has allowed us to understand where else Government should incentivise, resulting in a new £37 million package of infrastructure measures announced in February 2013.³³

3.30 We have also used information from the PIPs to engage with local authorities outside of PIP areas and help them in their infrastructure rollout. We continuing to do this with the PIP lessons learnt document, published alongside this strategy.

³² Led by the Department for Regional Development and the Department of the Environment in Northern Ireland, and working with Northern Ireland Electricity (NIE), the Strategic Investment Board (SIB), ESB and Power NI.

³³ www.gov.uk/government/news/new-measures-announced-to-support-the-uptake-of-plug-in-vehicles

Plugged-in Places achievements

As well as the installation of more than 5,500 chargepoints, the PIP projects have also boosted the plug-in vehicle and recharging industry by increasing awareness of the vehicles, building and sharing knowledge and expertise and by driving technology development and innovation:

PIP experts have worked closely with a range of UK and international bodies to share knowledge and contribute to the development of the sector and related standards such as the IET code of practice. For example, representatives from the Source East scheme have contributed to the development of the Open Charge Point Protocol and shared best practice across the world.

Several PIPs have developed industry training, including the North East scheme, Charge you Car (CYC) who provided tailored training courses for fleet managers and dealerships.

Plugged in Midlands have worked with technology companies to advance the recharging market, for example, the development of a mobile Quick Charger as well as metering solutions to provide cheaper communications and chargepoint data.

The PIP scheme in London is the largest urban chargepoint network in Europe and the scheme brand 'Source London' has been adopted by other charging networks across the UK.

Transport Scotland have jointly initiated Ecosse – bringing together government, car manufacturers, power companies, local authorities and WWF Scotland to maximise opportunities for plug-in vehicles to become a central part of Scotland's greener transport system.

Milton Keynes have integrated their charging scheme with wider low carbon transport initiatives including an electric bus scheme, a plug-in vehicle car club (E-car) and the Hertz-to-go electric car hire scheme.

The first Pay As You Go plug-in vehicle charging network in the UK was recently launched by Greater Manchester Electric Vehicle Scheme along with a related phone app allowing plug-in vehicle owners easy access to chargepoint infrastructure.

- 3.31** But the greater success of the PIPs has been in providing the platform for private sector organisations to enter the market and together create a strong emerging market. We estimate that non-PIP organisations have delivered more than 5,000 chargepoints to the end of June 2013. These chargepoints are located in the workplace, at home and in a range of publicly accessible places.
- 3.32** Fuelled by the requirements of the PIPs, chargepoint manufacturers based here in the UK and abroad have been able to expand their business and supply not only chargepoints, but create their own networks and provide back office solutions to infrastructure scheme operators.
- 3.33** Together with the PIPs, this emerging infrastructure industry has developed partnerships with a multitude of organisations across the energy,

automotive and IT sectors to push the UK to being one of the leading markets in plug-in infrastructure.³⁴

Preparing for hydrogen fuel cell vehicles in the UK

Hydrogen vehicles

- 3.34** The Government has long recognised that hydrogen fuel cell electric vehicles (FCEVs) are likely to form one of the portfolio of solutions for the decarbonisation of road transport and has been funding demonstrator projects for a number of years. The Government has also been working with industry through the UKH₂Mobility project since January 2012 to understand the particular challenges to deploying these vehicles and to position the UK in the vanguard of their use as they start to come to market from 2015.



- UK H₂Mobility, launched in 2012, brings together industrial participants from the utility, gas, infrastructure, fuel retail, global car manufacturing sectors and three Government departments in a ground breaking project to evaluate the potential for hydrogen fuel cell electric vehicles in the UK.
- The project is looking in detail at hydrogen production pathways and distribution options, fuel cell electric vehicle supply, customer demand, and the hydrogen refuelling station requirements.
- The consortium is working collaboratively to develop a joined-up approach to the commercialisation of hydrogen FCEVs, including addressing the chicken and egg problem of hydrogen refuelling infrastructure and hydrogen vehicle roll-out.

































- 3.35** The UK has some world-leading companies across the hydrogen transport value chain which are well-placed to seize the growth opportunities that the UK being a lead market could deliver. The first phase of UKH₂Mobility focused on the evaluation of the opportunity. A full report was published in April 2013,³⁵ which included the following findings:

³⁴ See for example 'Strategic Technology and Market Analysis of Electric Vehicle Charging Infrastructure in Europe,' Frost and Sullivan, June 2013

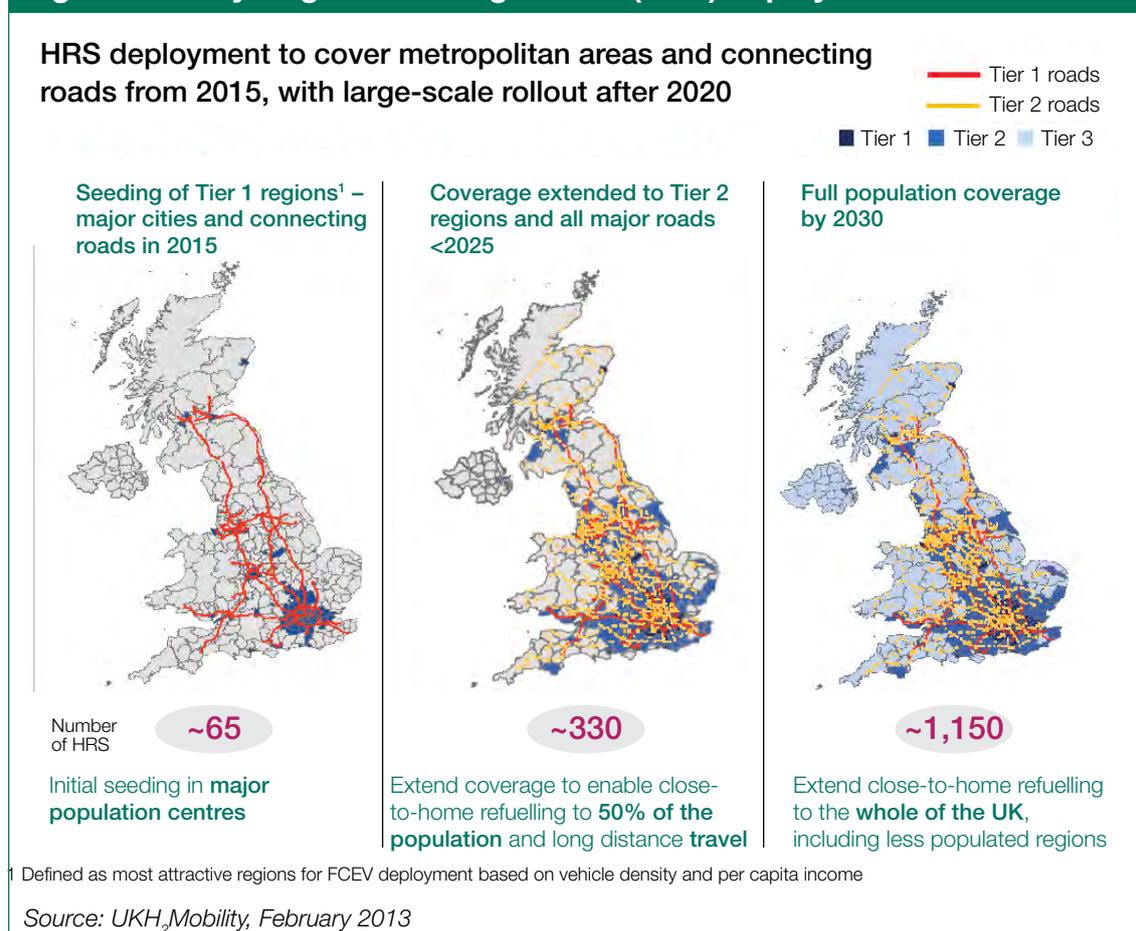
³⁵ www.gov.uk/government/publications/uk-h2mobility-potential-for-hydrogen-fuel-cell-electric-vehicles-phase-1-results

- Some 10% of new vehicle buyers could be potential early adopters of fuel cell electric vehicles, being both receptive to new technology and environmentally motivated. Availability of hydrogen refuelling stations (HRS), together with the higher purchase price of a FCEV (compared to a conventional diesel vehicle) were identified by consumers as the two main barriers to buying these vehicles.
- Sales of FCEVs could reach approximately 10,000 vehicles per annum by 2020. As the vehicle costs become more competitive and the refuelling network develops, uptake could increase rapidly, such that by 2030 there could be UK annual sales of more than 300,000.

Hydrogen refuelling station infrastructure

- 3.36** A network of hydrogen refuelling stations needs to balance maximum customer convenience (and therefore encourage vehicle uptake) with the investment required.
- 3.37** The analysis and network modelling undertaken within the project indicated that around 65 stations across the UK could provide sufficient initial coverage to start the market, covering major population centres (with more than one refuelling station) and connecting roads. Thereafter, the network would develop in line with the demand for hydrogen by vehicle owners/user, with full national coverage being delivered by some 1,150 stations by 2030, providing close-to-home refuelling for the whole of the UK (see Figure 3.5).

Figure 3.5 – Hydrogen refuelling station (HRS) deployment



- 3.38** The vehicle uptake curve seen in the UKH₂Mobility Phase 1 report, whilst similar to that seen in other new vehicle technologies, presents two significant challenges for the development of the market. One is that vehicle manufacturers might be deterred from viewing the UK as a viable lead market because of slow uptake and the second is that the low utilisation of the refuelling network before 2020 impacts profitability and makes securing the initial investment in such a network a challenge.
- 3.39** The Government is engaging fully in Phase 2 of UKH₂Mobility to identify innovative business cases for the initial network of stations, including identifying how first mover commercial advantage could be secured. We are also working with the consortium to identify and evaluate potential options to reduce the upfront costs of the vehicles and to improve the early consumer proposition.

Production of hydrogen

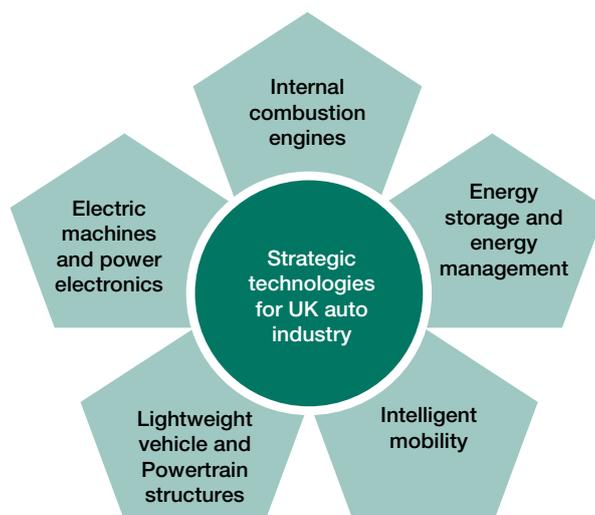
- 3.40** While fuel cell electric vehicles themselves emit no CO₂, some processes for hydrogen production do. The UKH₂Mobility project identified that a hydrogen production mix of about 50% water electrolysis and 50% steam methane reforming (SMR) would ensure the ‘well to wheel’ CO₂ emissions of FCEVs are similar to those of plug-in hybrid electric vehicles and some 60% lower than comparable diesel vehicles.
- 3.41** However, the production of hydrogen by water electrolysis is currently more expensive than producing hydrogen using SMR. The Government is working with industry during Phase 2 to identify appropriate mechanisms to ensure the hydrogen produced enables the FCEVs to deliver the CO₂ emission reductions needed out to 2030.

Industry and supply chain

Research & Development

- 3.42** Industry will be in a better position to achieve and maintain competitive advantage in an increasingly global marketplace if it can sustain its R&D investment at the right level. The Office for Low Emission Vehicles has committed investment of £82 million to 2015 to support UK innovation and R&D primarily through the Technology Strategy Board. This has focused on identifying and supporting emerging technologies that the UK can exploit and lead on globally. It specifically targets areas where commercial funding has not been readily available, or where the cost of moving from the research and demonstration phases to the full commercialisation of new technologies has been too high.
- 3.43** The research funding is targeted onto specific evidence gaps identified within three of the five priority R&D areas determined by the UK’s Automotive Council to be of strategic importance: a) energy storage and energy management; b) lightweight vehicles and powertrain structures; c) electric machines and power electronics.

Figure 3.6 – Automotive Council strategic technology themes



Source: Automotive Council/BIS

- 3.44** The Technology Strategy Board’s (TSB) Low Carbon Vehicle Innovation Platform (LCVIP) typically brings together vehicle manufacturers, supply chain companies and academic institutions along with a minimum of industry match funding. Engaging interested partners in industry ensures that research is well aligned with policy and ensure that organisations working collaboratively have both the capability to do so and the competence to exploit the opportunity.

The Technology Strategy Board (TSB)

The TSB is the UK’s innovation agency, set up to offer support and funding to help businesses to bring products to market more quickly. It spots opportunities, brings together partners and helps reduce the risk around innovative projects. Its collaborative R&D aims to help companies tackle specific technical challenges encouraging knowledge exchange, supply chain development, and parallel working on complex system challenges. Over 60% of its investments are to small and medium-sized enterprises. TSB’s Innovation Platform’s uniquely use Government action to stimulate innovation and its Low Carbon Innovation Platform has been estimated to return 30 times the value of its original investment to UK plc.

- 3.45** Our commitment to the Low Carbon Vehicle Innovation Platform (LCVIP) has helped it leverage over £350 million of match funded investments in collaborative projects aligned with Automotive Council priority areas. The funding has been used to support six separate Innovation Platform competitions, two niche vehicle network programmes and the Ultra Low Carbon Vehicle Demonstrator Programme – Europe’s largest real-life trial of ultra low emission vehicles (see Chapter 4).
- 3.46** The LCVIP aims to integrate the low carbon vehicle innovation chain from the academic science base through collaborative R&D and into fleet level demonstration. Many of the projects are led by major vehicle manufacturers such as Ford, Jaguar Land Rover and Nissan though a large number of

small and medium sized companies including suppliers are closely involved in the demonstration work (see box on REEVolution).

REEVolution

Jaguar Land Rover, Nissan and Lotus joined forces for the REEVolution project. This has led to the development of three high-end, range extended electric demonstration cars capable of achieving 70% lower carbon emissions compared to the equivalent best vehicles in class. The three major manufacturers collaborated with smaller specialist vehicle technology suppliers including Axeon Technologies Ltd, EVO Electric Ltd and Xtrac Ltd. The consortium aimed to create new high performance extended range and plug-in hybrid electric vehicles.

This project has helped to build a UK supply chain for new, ultra low carbon vehicle technologies. The benefits to the companies are considerable. They have all developed through working together, with the smaller suppliers growing employee numbers and output and the car manufacturers have proven themselves capable of creating cutting edge low carbon vehicles attractive to the global market. The three cars developed were:

a) the Infiniti Emerg-E (pictured) developed by Nissan UK at Cranfield – a hybrid vehicle capable of 0-60mph in four seconds with a target range of 30 miles on battery alone and a combined range of 300 miles on a full tank;



b) the Evora 414E (pictured) developed by Lotus Engineering in Norfolk – a hybrid vehicle with similar performance characteristics to the Emerg-E; and



c) the Jaguar XJ-e (pictured) developed at Gaydon – an advanced parallel plug-in hybrid capable of a 70% reduction in CO₂ emissions without compromising performance with an electric only range of 25 miles and a combined range of 679 miles on a full tank.



- 3.47** A further £6.5 million has also been used to support the Low Carbon Truck Trial (see text box on page 55).
- 3.48** We have also made provision of £2.5 million to support a Low Carbon Vehicle Public Procurement Programme (see box). This has provided financial assistance to public sector organisations wishing to procure innovative, lower carbon vehicles for their fleets. In doing so, it has helped to transform original research into commercial products that are being bought by fleets.
- 3.49** Building on the success of these activities the Government's Automotive Sector Strategy published in July 2013 announced the establishment of a new Advanced Propulsion Centre supported by a joint government industry investment of around £1 billion over the next 10 years. This represents a

step change in the scale of support for ultra low carbon propulsion technologies enabling them to be developed and industrialised in the UK supporting manufacturing of next generation vehicles and safeguarding up to 30,000 jobs.

Low Carbon Vehicle Public Procurement Programme (LCVPPP)

This programme was launched in 2009 to demonstrate a range of low carbon technologies in public sector fleet operations. This included the Ashwoods Automotive developed hybrid electric power unit for diesel vans, which typically offers 15% fuel and CO₂ savings compared to an equivalent diesel vehicle. In parallel, Government support was also provided to Ashwoods Automotive to develop their technology, resulting in a major reduction in the hybrid unit cost.



Source: Ashwoods

In 2012, the Government launched a second phase of the LCVPPP programme to offer a grant to public sector fleets to help make the purchase cost of an Ashwoods Hybrid Transit equivalent to a standard diesel equivalent. In this phase almost 500 hybrid vans are being supplied to a wide range of fleets, from local authorities to government departments. With this level of adoption by the fleets, sales are expected to continue to grow without the need for further grant support. Since 2009, the company has grown significantly from a micro-business to an SME and become well established as a lead UK supplier of hybrid and other low carbon vehicle technologies.

Hybrids in the UK

3.50 A clear success story for the UK Government's consistent efforts to decarbonise new car purchases can now be seen at Burnaston, near Derby. Consistent fiscal incentives to drive ever cleaner cars has made the UK a growing market for mild hybrid vehicles. Low company car tax rates and zero vehicle excise duty rates have resulted in the UK being one of the biggest markets for this sort of technology in Europe. This explains Toyota's decision to manufacture its Auris hybrid here using the same technology that goes into their Prius model. Burnaston is



Source: Toyota

the only Toyota plant outside Japan to manufacture hybrids and over half of all the Auris models sold are now hybrids.

Summary

3.51 This chapter has:

- Charted what the Government has been doing to support the growing market for ULEVs – including the provision of Plug-in Grants, fiscal and taxation incentives, and support for fleet buyers.
- Summarised our initiatives to support the introduction of low and ultra low emission buses and trucks.
- Set out what we have done to promote plug-in vehicle infrastructure – including the Plugged-In Places (PIP) programme.
- Detailed how we have worked with industry to prepare for hydrogen fuel cell vehicles in the UK, through UKH₂Mobility.
- Explained our work on industry and supply chain issues, in particular our package of support on Research & Development.

4. ULEVs and the energy sector

The impact of the electrification of transport

- 4.1** The mass adoption of ULEVs will have significant implications for the energy sector on both a local and a national level.
- 4.2** As the number of plug-in vehicles on our roads increases, so will the demand for electricity.³⁶ This represents a series of challenges, which must be anticipated and prepared for – issues which the Government and industry are working together now to address. There is also a potential prize as ULEVs can help to balance the demand for electricity at peak periods and support the efficient use of energy by consumers.
- 4.3** It is important to note that the increase in the demand for electricity from the wholesale adoption of plug-in vehicles is unlikely to be entirely an additional load on existing peak generating capacity. This is because of the time at which most of the evidence suggests people will choose to charge their vehicles – principally at work or at home at night (see Chapter 5).³⁷
- 4.4** By providing additional demand for electricity at night, plug-in vehicles mean that energy generated from intermittent sources of supply such as renewables or those which are difficult to vary quickly – nuclear – can be used where they might otherwise be wasted.
- 
- 4.5** Similarly, the production of hydrogen for use as a transport fuel can offer synergies with the increasing deployment of renewables. Hydrogen can be created through water electrolysis which uses electricity to split water into its constituent hydrogen and oxygen molecules. Electrolysers can respond very quickly to demands to turn on or off and are therefore also very useful for so-called demand response, in that they be made flexible if necessary according to broader patterns of demand. Electrolysed hydrogen created in this way can be stored, used as a transport fuel, or even added to the national gas grid. The UKH₂Mobility project quantified these benefits and determined that this would have the effect of reducing the cost of hydrogen produced by electrolysis by 20%.

Source: Vauxhall

³⁶ http://webarchive.nationalarchives.gov.uk/+http://www.hm-treasury.gov.uk/independent_reviews/king_review/king_review_index.cfm

³⁷ http://www.utilityweek.co.uk/news/news_story.asp?id=196934&title=Electric+vehicle+users+'happy+to+charge+off-peak'+says+SSE or for example http://eprint.ncl.ac.uk/pub_details2.aspx?pub_id=189264

- 4.6** So the increase in ULEVs will also present opportunities for better and more efficient energy management. This will be particularly true with the introduction of intelligent power supply networks (smart grids)³⁸ and the roll out of electricity and gas smart meters across all domestic properties (and several million smaller non domestic businesses) in Great Britain by 2020. Separately, in July 2012 the Northern Ireland Government announced a roll out of electricity smart meters in homes by 2020.

The challenge: keeping the lights on as more vehicles plug-in

- 4.7** It is important that the electricity network is able to accommodate additional electricity demand and, in particular, that the right investments in the distribution networks are made at the right time and place. The overall forecast level of uptake in plug-in vehicles to 2020 is not expected to represent an issue for the national grid, though clustering of vehicles in particular locations could lead to the need for local grid-reinforcement.
- 4.8** These costs are currently borne by the Network Operator as described in this section – and so they are in a sense socialised, across all electricity users. Ofgem, the regulator of the energy sector, has decided that this will continue into the next price control period.³⁹
- 4.9** To this end, OLEV has provided vehicle uptake scenarios to the energy industry, via the Smart Grid Forum.⁴⁰ These estimates have been used by the Distribution Network Operators (DNOs) to consider the potential impacts of plug-in vehicle charging on their regional supply networks. This is helping to inform the investment element of their business plans for the next price control period (2015-2023), which they submitted to Ofgem in July 2013.
- 4.10** Network operators are strongly incentivised to distribute electricity effectively. Supply interruptions are dealt with by Ofgem through the Interruption Incentive Scheme. This incentivises DNOs to anticipate what is required to enable householders to plug-in electric vehicles without overloading network assets, such as cables or transformers, and causing interruptions.
- 4.11** The installation of most domestic chargepoints does not require a new connection to the grid, because the existing connection to that property is sufficient to accommodate the power being drawn. In these cases, where the DNO would not otherwise be notified, the IET Code of Practice for chargepoint installers stipulates that the installer inform the relevant DNO of the installation within a month.⁴¹ There are some questions about the level of compliance with this and about how suitable such a system would be at higher uptake levels. As the installation of a number of chargepoints in the same areas may have a cumulative effect, known as clustering, which may require the local network to be strengthened, it is vital that the Distribution Network Operators have a full picture of the changing demands on their network.

³⁸ A smart grid can be defined as ‘an electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies. (*A Smart Grid Vision*, Electricity Networks Strategy Group, November 2009).

³⁹ Details of electricity distribution regulation and the Price Control Period here:

<https://www.ofgem.gov.uk/network-regulation-%E2%80%93-riio-model/riio-ed1-price-control>

⁴⁰ <https://www.ofgem.gov.uk/electricity/distribution-networks/forums-seminars-and-working-groups/decc-and-ofgem-smart-grid-forum>

⁴¹ The requirements are explained here: <http://www.energynetworks.org/electricity/futures/electric-vehicle-infrastructure.html>

The Smart Grid Forum

Government, Ofgem and the electricity industry are working together through the Smart Grid Forum which considers how the electricity network will need to develop as a key part of the low carbon transition. The forum works to:

- identify future challenges for electricity networks and system balancing, including current and potential barriers to efficient deployment of smart grids; Guide the actions that DECC/Ofgem are taking to address future challenges, remove barriers and aid efficient deployment;
- identify actions that DECC/Ofgem, the industry or other parties could be taking to facilitate the deployment of smart grids;
- facilitate the exchange of information and knowledge between key parties, including those outside the energy sector;
- help all stakeholders better understand future developments in the industry that they need to be preparing for;
- track smart grid developments and their drivers; and
- track smart grid initiatives in Europe and elsewhere.

The third year programme of the Smart Grid Forum will look at:

- the development of a ‘Smart Grid Vision and Routemap’ which will refresh the shared objectives for a GB smart grid and provide a framework to track progress in overcoming the challenges to smart grid deployment;
- an assessment of the options for the development of smart grids, particularly in terms of how customers will engage with smart grids;
- an investigation to confirm how a future smart distribution network will operate safely and securely.

Further details on the Smart Grid Forum can be found on the Ofgem website.⁴²

The opportunity: making a smarter grid work better

- 4.12** Evidence from trials suggests that the majority of plug-in vehicle owners want to charge their vehicles at home, typically at night, as this is the most convenient time. The introduction of smart meters and the use of incentives, such as cheaper off-peak tariffs for plug-in vehicle owners, could help to support this.
- 4.13** Charging off-peak will also maximise the benefits that plug-in vehicles represent for the energy system. At a local level, it will lower the risk of stresses being placed on local distribution systems and could reduce the need for potential reinforcement of the grid. At a system level, it could reduce the need for additional electricity generation and offer a further use for low carbon night-time electricity: the carbon intensity of night time, off peak electricity is often lower than electricity generated at peak time.⁴³

⁴² <https://www.ofgem.gov.uk/electricity/distribution-networks/forums-seminars-and-working-groups/decc-and-ofgem-smart-grid-forum>

⁴³ This assumes that the marginal plant used to generate electricity off-peak is natural gas and that the marginal plant at peak is coal. Data from Electricity: Chapter 5, Digest of United Kingdom Energy Statistics (DUKES), www.gov.uk/government/uploads/system/uploads/attachment_data/file/65818/DUKES_2013_Chapter_5.pdf

- 4.14** One potential benefit from larger numbers of plug-in vehicles is demand side response – smarter networks enabling the scheduling of charging patterns to suit both the consumer and the broader electricity system. Government and industry are working through the Smart Grid Forum to explore different options for implementing demand side response measures. This includes considering the changes which they would imply for relationships between energy customers, distributors and suppliers.
- 4.15** Plug-in hybrid and electric cars could also act as distributed energy storage during periods when renewable (or nuclear) electricity generation exceeds demand. This could happen both during the life of the vehicle and also as a potential second-life use for batteries. The Government is supporting innovative and diverse energy storage ideas under the Energy Storage Technology Demonstration Competition. This aims to encourage the development of innovative, pre-commercial energy storage technologies that can address grid-scale storage and balancing needs in the UK electricity network. Several of the studies approved at the phase 1 feasibility stage involved electric vehicles.⁴⁴
- 4.16** There may even be the potential for plug-in vehicles to be used as an energy store, to power the house when the vehicle is plugged in during peak periods (see box below). Although further from market than electric vehicles, hydrogen fuel cell electric vehicles could also offer similar potential benefits for energy storage.

Vehicle to home and vehicle to grid

As the smart grid and battery technologies develop, there may be the potential for plug-in vehicles to act as backup energy sources for homes and supplement the grid during peak demand periods. Nissan already offers a 'power control system' to its customers in Japan which allows their LEAF car to power a house for up to two days from its battery pack. Development of this technology was brought forward following the Fukushima nuclear reactor disaster.



Source: Zero Carbon Futures

There remain issues about the potential impact of taking charge from vehicles on battery life and the investment necessary to facilitate this on a large scale. However, Government will continue to talk to industry and researchers in this area and monitor developments.

Storage has the technical ability to provide a number of benefits to the electricity system – for example, smoothing supply profiles from variable generation and potentially reducing constraint costs by allowing generation to run during periods of low demand. It can also potentially save or defer network upgrade costs that may be required in the future to meet peak demand.

Sixteen organisations have recently been awarded a share of £2 million by Government to help develop innovative storage solutions for energy. This funding is helping to drive forward innovation and encourage private sector investment.

⁴⁴ www.gov.uk/innovation-funding-for-low-carbon-technologies-opportunities-for-bidders#page-navigation

Smart meters and tariffs: enablers to deliver plug-in vehicle benefits

- 4.17** The Government's vision is that every home and smaller business in Great Britain should have smart energy meters by 2020 – a key enabling technology for managing energy systems more efficiently in the future, and providing new information and services to consumers which reduce costs and carbon emissions.
- 4.18** Energy supply companies will be responsible for the procurement and installation of these units. Domestic customers will be additionally offered an In-Home Display, to help them to monitor and manage their energy usage. Smart meters are the next generation of gas and electricity meters, offering a range of intelligent functions and both consumer and industry benefits.
- 4.19** The latest impact assessment estimates an overall net benefit to Great Britain of the move to smart meters of around £6.7 billion. They are also an essential enabler of a smart grid, which can play a key role in helping plug-in vehicle owners manage the domestic charging of their vehicles. There are three respects in which smart meters could act as a platform to help to control plug-in vehicle charging:
- enable **active load control** to support scheduled control of electric vehicle chargers;
 - facilitate a reactive, price driven **demand response**. As the deployment of smart metering proceeds an increasing range of market-led devices is expected to become available to assist consumers to manage their energy use, including enhanced energy displays, and smart appliances and,
 - give network operators much **greater visibility** of localised consumption on their infrastructure allowing them to better manage and plan activities and move towards the development of a smart grid.

Smart meters and plug-in vehicles

There are three respects in which smart meters could act as a platform to control plug-in vehicle recharging. First, active load control, via Auxiliary Load Control Switches (ALCS) will allow the Smart Meter Home Area Network to support scheduled control of electric vehicles chargers.

Second, smart meters will facilitate a reactive, price driven demand response. As the deployment of smart metering proceeds an increasing range of market-led devices is expected to become available to assist consumers to manage energy use, including enhanced energy displays, smart appliances and home automation tools. These devices will be able to securely connect to the smart meter, receiving and reacting to gas and electricity consumption and pricing data.

Third, smart meters will give network operators much greater visibility of localised consumption on their infrastructure allowing them to better manage and plan activities and move towards the development of smart grid and demand-side measures: for instance, data showing the highest half-hourly electricity demand and export at a metering point will be available (on request through the central Data and Communications Company). Network companies are assessing the changes to their back office systems needed to accommodate and optimise the availability of this data.

The Smart Metering Equipment Technical Specification (SMETS 2) requires as a minimum that an electricity meter must support at least five HAN-connected ALCS – with manufacturers able to support more at their own discretion to support future flexible use of energy. In addition, one HAN-connected ALC may connect to multiple devices responding at the same time, for example two electric vehicle chargepoints.

Some smart meters could facilitate different models to charge and discharge EV batteries. For example, battery charging could be matched to wind patterns or to available network capacity and reconciled with driver needs. Several trials are ongoing to explore these issues and different ways of controlling electric vehicle charging, such as Low Carbon London, which is running both EV and smart meter trials.⁴⁵ It may be possible to build on this to support more sophisticated techniques as a consensus emerges in the electricity industry about requirements.

Tariffs

- 4.20** Electricity tariffs can also play an important role in influencing charging behaviour. For this to happen it is important that they are: sufficiently differentiated to incentivise behaviour change, simple enough to avoid confusion, and work in concert with some form of automation, which will in most cases be a smart meter. At the end of August, Ofgem brought into force rigorous new standards of conduct that will ensure energy suppliers are treating consumers fairly.

Research into electric vehicles and their interaction with the energy networks

Ofgem has launched the Low Carbon Network Fund to provide up to £500 million support for research projects sponsored by the distribution network operators (DNOs). Funding is available to try out new technology, operating and commercial arrangements. The objective of the projects is to help all DNOs understand what they need to do to provide security of electricity supply at value for money as Great Britain moves to a low carbon economy.

The 2012 competition included several projects of relevance to the electrification of transport, including a project investigating the use of a domestic ‘smart socket’ to manage network constraints caused by electric vehicles, known as ‘My Electric Avenue’.

⁴⁵ <http://www.lowcarbonlondon.info/our-trials/electric-vehicles/> and <http://www.lowcarbonlondon.info/our-trials/smart-meters-edf-energy/>

Similarly, Low Carbon London are holding a trial which involves participants having a simple energy monitor attached to the chargepoint or power outlet that charges their electric vehicle. This data will be used to understand how and when people use electricity to charge their vehicles and to test flexible energy tariffs, alternative energy sources, and other initiatives.

Further details of Low Carbon Network fund projects can be found on the Energy Networks Association website.⁴⁶

Cost of Recharging

There are many variables which affect the cost of charging a plug in vehicle, including the capacity of the battery and the price of the electricity.

The price of electricity varies according to: location, time of recharging, contribution of other energy sources such as solar panels, tariff and how much electricity has been used by a consumer on other devices (e.g. where a tariff charges £x for a particular volume and then £y for subsequent volumes).

So, stating that a single price is the cost of recharging a battery will be misleading. But some things are clear: in particular, that the current running cost of plug-in vehicles are likely to be very attractive compared to alternatives.

We can set out an illustrative case using the DECC-published average variable unit costs and standing charges for standard electricity in 2012. On some Economy 7 tariffs unit prices can vary from 8p at night to 18p during the day. This implies a cost of fully charging a 24kWh battery at night as low as £1.92, compared to a cost of charging during the day of £4.32.

The carbon impact of ULEVs

- 4.21** One of the concerns raised about plug-in vehicles is that claims about their reduced environmental impact, especially carbon, are misplaced because they simply move the point of pollution from a vehicle's tailpipe to the power station. Similarly, fuel cell vehicles, although zero emissions at the point of use, use hydrogen as a fuel source which itself requires energy to be manufactured either through electrolysis or methane reformation.
- 4.22** It is undeniable that all the ULEV technologies considered in this strategy make some form of environmental impact, whether in the manufacture, use or disposal phases of the vehicles. However, there is consistent evidence that the efficiency benefits of electric propulsion outweigh the potential negative impacts of the technologies in the manufacture and disposal phases.
- 4.23** Ultra low emission vehicles already provide a significant environmental advantage over internal combustion engines, due to greater energy efficiency. This advantage will only increase as the Government's plans to increase low carbon energy generation progress. In the coming decades, the extent of the carbon benefits derived from plug-in vehicles will depend on the rate of decarbonisation of the electricity system.

⁴⁶ www.energynetworks.org/electricity/engineering/research-and-development/low-carbon-networks-fund.html

- 4.24** The potential is significant – the average carbon intensity of generation in the UK could drop from around 450g CO₂/kWh in 2010 to a much lower figure by 2030. The Government has decided to take powers to set a 2030 decarbonisation target range for the power sector (following the setting of the 5th Carbon Budget in 2016) and has recently published analysis looking at an average grid intensities of 50g/kWh, 100g/kWh, and 200g/kWh by that year. The Committee on Climate Change has recommended that the grid should be fully decarbonised by 2050.⁴⁷
- 4.25** To give a sense of how reducing grid intensities would impact the carbon emissions from a typical contemporary electric vehicle, a car charged on a 450g/kWh grid would emit an equivalent of 78g/km versus just over 17g/km if grid intensity were around 100g/kwh by 2030.⁴⁸
- 4.26** It is important to remember that the lifecycle emissions will be higher. The Committee on Climate Change have estimated current lifecycle emissions of around 250 – 295 g CO₂e/km for petrol cars, 175 – 235 g CO₂e/km for PHEVs and 140 – 235 g CO₂e/km for BEVs. The range variation depends on individual assumptions for lifetime mileage, carbon intensity, materials and manufacturing processes, and for electric vehicles, need for battery replacement during the vehicle lifetime.⁴⁹
- 4.27** Nevertheless, powering a plug-in vehicle with a less carbon intensive grid means that it will emit less carbon. Indeed, given the same pattern of development we have seen in conventional vehicles, it is likely that the energy consumption of ULEVs will continue to improve. If so, the actual emissions from the vehicle may be even less given equivalent carbon intensities of electricity.

Other environmental impacts

- 4.28** In addition to carbon emissions, all vehicle production has a broader environmental impact beyond the use phase of the vehicle in the production and disposal phases.
- 4.29** There are some issues particular to plug-in vehicles. First, lithium-ion batteries and electric motors can use rare earth elements, elements which are also often used for other manufactured goods, such as wind turbines, and robotic assembly lines. Increasing demand for such goods, in parallel with the expected increase in demand for battery powered vehicles has raised concerns about the potential demand for such metals exceeding the potential supply and about the energy security implications of dependence on metals which are mined in only a few countries.
- 4.30** Vehicle manufacturers and their suppliers are very focused on the need to minimise their reliance on such elements and are working hard to ensure that successive iterations of their vehicles use less and less of these elements.
- 4.31** The second issue relates to battery disposal. The Government will continue to support developments in the second-life use of batteries, which

⁴⁷ For further information see <http://www.theccc.org.uk/wp-content/uploads/2013/04/Power-factsheet.pdf>

⁴⁸ This is based on energy consumption of 0.174 kWh/km by the current Nissan LEAF.

⁴⁹ Reducing the UK's carbon footprint and managing competitiveness risks, Committee on Climate Change, April 2013

maximise their value and alleviate concerns about disposal, as described earlier in the chapter. Over time we expect to see a viable battery reuse and recycling industry develop in the UK as volumes increase.

Summary

4.32 This chapter has:

- Set out the impact which the electrification of road transport might have on the electricity system.
- Explained both the challenge that this presents: keeping the lights on as more vehicles plug-in.
- And the opportunity which it also offers: making a smarter grid work better.
- Explained how smart meters and tariffs could enable the delivery of those benefits.
- Discussed both the carbon impact and other environmental impacts of ULEVs.

5. Lessons learnt

The sources

- 5.1** The Government's first strategy document for the ULEV sector (*Making the Connection*, 2011) recognised that successful Government and industry activity would need to draw carefully on a robust evidence base. Much activity in the intervening period has been directed at developing this base.
- 5.2** Foremost in this has been the Plugged-In Places (PIP) programme described in Chapter 3. Coupled with the detailed data generated from the usage of the chargepoints by ULEV drivers, PIP is a key evidential basis for the Government's ULEV strategy.
- 5.3** Our understanding of how ULEVs are used has also been informed from our co-funding of the Ultra Low Carbon Vehicle Demonstrator Programme – Europe's largest co-ordinated trial of ULEVs. This allowed us to understand both the performance of the vehicles under 'real world' conditions and also the perceptions and concerns of consumers with regard to both the vehicles and charging infrastructure.
- 5.4** The Government also has over two years' experience of providing the Plug-in Car Grant and the Plug-in Van Grant, investing in R&D in the ULEV sector and participating in the UKH₂Mobility project (see Chapter 3). Each of these programmes has helped to inform the development of Government's strategic approach.
- 5.5** We have published a number of research outputs alongside this strategy which summarise the key evidence that has emerged from many of these programmes.⁵⁰ These reports include:
- Assessing the role of the Plug-in Car Grant and Plugged-in Places scheme in electric vehicle take-up (Hutchins et al, 2013);
 - Lessons learnt from the Plugged-In Places projects (DfT, 2013);
 - Plugged-In Places data (DfT, 2013); and
 - Ultra Low Carbon Vehicle Demonstrator programme (TSB, 2013).
- 5.6** In addition, this strategy also draws on extensive ongoing dialogue between Government and the ULEV sector.

⁵⁰ Available on the OLEV website at www.gov.uk/olev

- 5.7** The Government has also welcomed the House of Commons Transport Committee's examination of plug-in vehicle policies, which has provided a useful source of evidence and challenge.⁵¹ There have also been useful recent contributions from the IPPR,⁵² RAC Foundation/ UKPIA,⁵³ the Society of Motor Manufacturers and Traders and others.

What we have learnt

- 5.8** The sections that follow break down the key lessons learnt into eight broad themes around which Government action will focus over the coming years.
- 5.9** There are lessons for manufacturers, the supply chain and Government. None of the evidence suggests that the existing policies are fundamentally wrong. While there are challenges, these will inform the actions that we will take in future (outlined in Chapter 6).

Consumer purchasing behaviour

- 5.10** Fundamentally people want vehicles that fit their needs – the type and lengths of journey they want to make and the other demands they have of their vehicle, not least price. Very few people are willing to accept reduced convenience relative to a traditionally fuelled vehicle.
- 5.11** A car is one of the most significant purchases an individual makes. But people go about the consideration and selection of a new vehicle in very different ways. Although some purchase almost on impulse, others undertake considerable research. As ULEVs are a new kind of technology, research tends to be more thorough. For existing ULEV purchasers, two information sources seem to be particularly important:
- Online: Online forums are particularly valued as a means of sharing the experiences of current drivers and demonstrating that these vehicles can be a viable option for 'people like me'.
 - Test drives: People are also particularly keen for the reassurance that a test drive provides. Research shows that test driving these vehicles, usually through a dealership, can often be an important 'tipping point' in their decision to purchase.
- 5.12** These information sources (and others) have the potential to address a range of purchasing barriers. Evidence shows that potential plug-in vehicle buyers can be prevented from moving towards a purchase as a result of insufficient or inaccurate information. Our research with non-ULEV purchasers suggests that many have little, if any, knowledge of ULEVs.⁵⁴ Those that have some knowledge tend to be confused by negative or inaccurate media information, or be hampered by concerns over the 'unknown' (including imagined sub-optimal performance, potential battery degradation or low residual value).⁵⁵

⁵¹ www.publications.parliament.uk/pa/cm201213/cmselect/cmtran/239/239.pdf

⁵² Leading the charge: Can Britain develop a global advantage in ultra-low emission vehicles? (April 2013), IPPR

⁵³ Powering Ahead, the future of low carbon cars and fuels (April 2013), Ricardo-AEA on behalf of RAC Foundation and UKPIA

⁵⁴ DfT (2011)

⁵⁵ Assessing the role of the Plug-in Car Grant and Plugged-in Places scheme in electric vehicle take-up (Hutchins et al, 2013)

- 5.13** Higher upfront purchase prices relative to traditionally fuelled vehicles also act as a purchase barrier. Although early adopters of ULEVs appear to often weigh-up the financial benefits of the technology in detail (comparing lifetime running costs with upfront purchase price), this is not the norm.⁵⁶ Research shows that a ‘total cost of ownership’ approach to purchasing decisions, which seeks to take account of all the relevant cost factors and not just upfront purchase price, tends not to be adopted by many private car purchasers.⁵⁷ Therefore, a key area of benefit for ULEVs – lower running costs – may not be given sufficient weight by the average consumer. This is particularly important given that saving money on fuel over the long-term is the most commonly cited reason for purchasing an ULEV over an internal combustion engine (ICE) vehicle (see Figures 5.1 and 5.2).
- 5.14** ‘Range anxiety’ is also important. Our research with both ULEV-purchasers and non-ULEV purchasers found that the distance a pure electric vehicle can travel on one charge is a consistent concern. This is linked to a limited ability to drive long distances, but also secondary concerns associated with safety and punctuality should an unexpected event result in a loss of charge. High levels of knowledge about and trust in the chargepoint network (which can facilitate longer distances and lower anxiety levels) are therefore critical for drivers of battery electric vehicles.
- 5.15** A key issue for the car industry is ensuring that dealerships are equipped to provide advice to prospective purchasers. ULEVs represent a new technology not only to consumers but also to dealership staff and it can take more time to take a customer through the sales process. Knowledgeable sales and aftercare staff are important to the long-term success of the market.

Fleet and public sector procurement

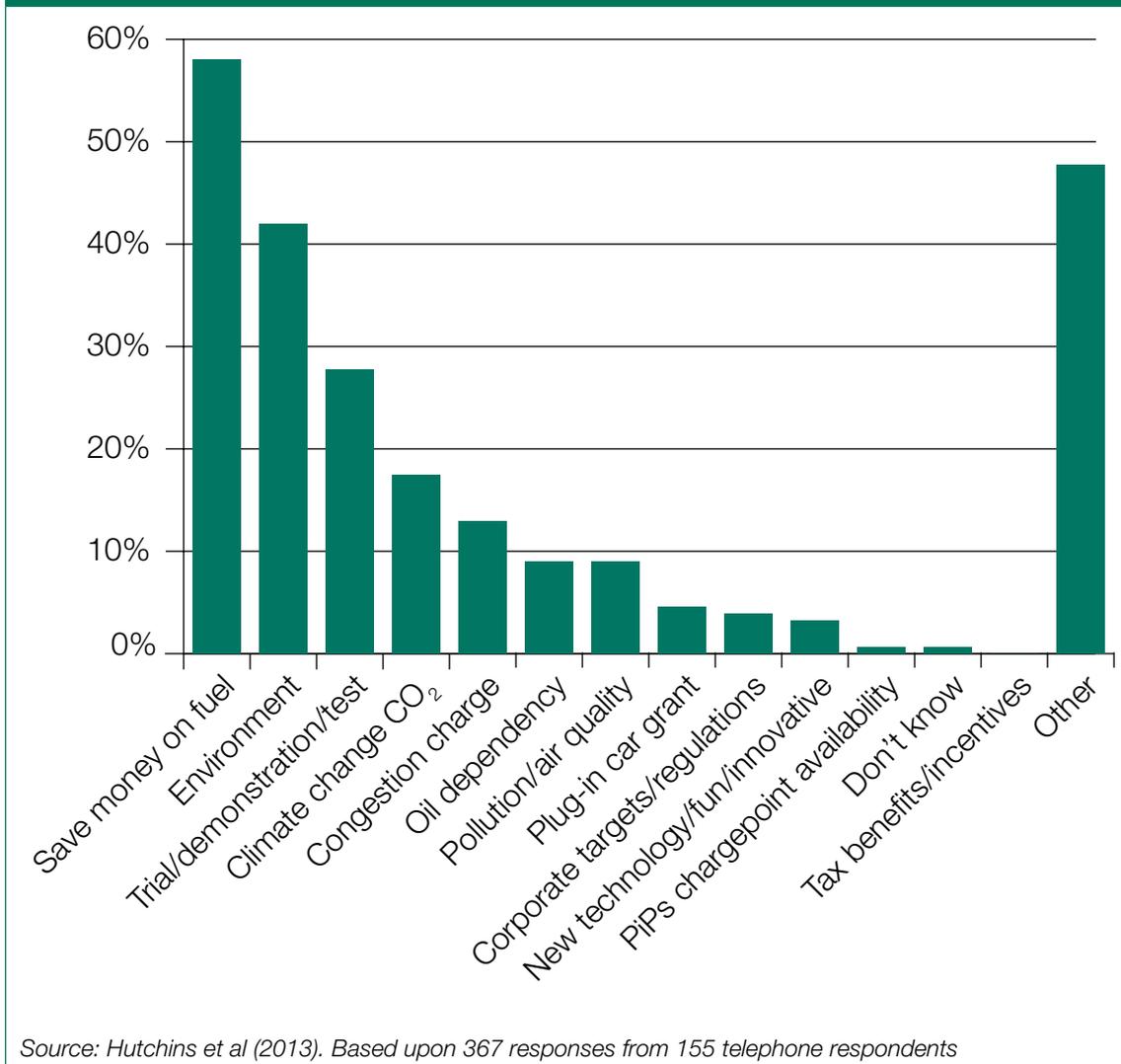
- 5.16** The Energy Saving Trust’s Plugged-in Fleets Initiative has provided valuable insights into how ULEVs can be successfully integrated into fleets.⁵⁸ The overall finding was that ULEVs can provide clear cost and environmental benefits while meeting the operational needs of many organisations if used for appropriate duty cycles. Battery electric vehicles were found to be particularly suited to fleets where drivers had regular, predictable journeys, either of up to 100 miles in length, or longer if there are charging facilities en-route (e.g. a lunchtime stop), while plug-in hybrid and extended range electric vehicles offered more flexibility. Buy-in at a senior level was an important factor, and the final report also showed that there is appetite among fleets in the UK to embrace the technology. Many fleet participants valued the specialist advice and process implemented in the reviews, which helped them to take the first step.

⁵⁶ Assessing the role of the Plug-in Car Grant and Plugged-in Places scheme in electric vehicle take-up (Hutchins et al, 2013)

⁵⁷ Literature review and long-term vehicle users study (Stannard et al, 2010)

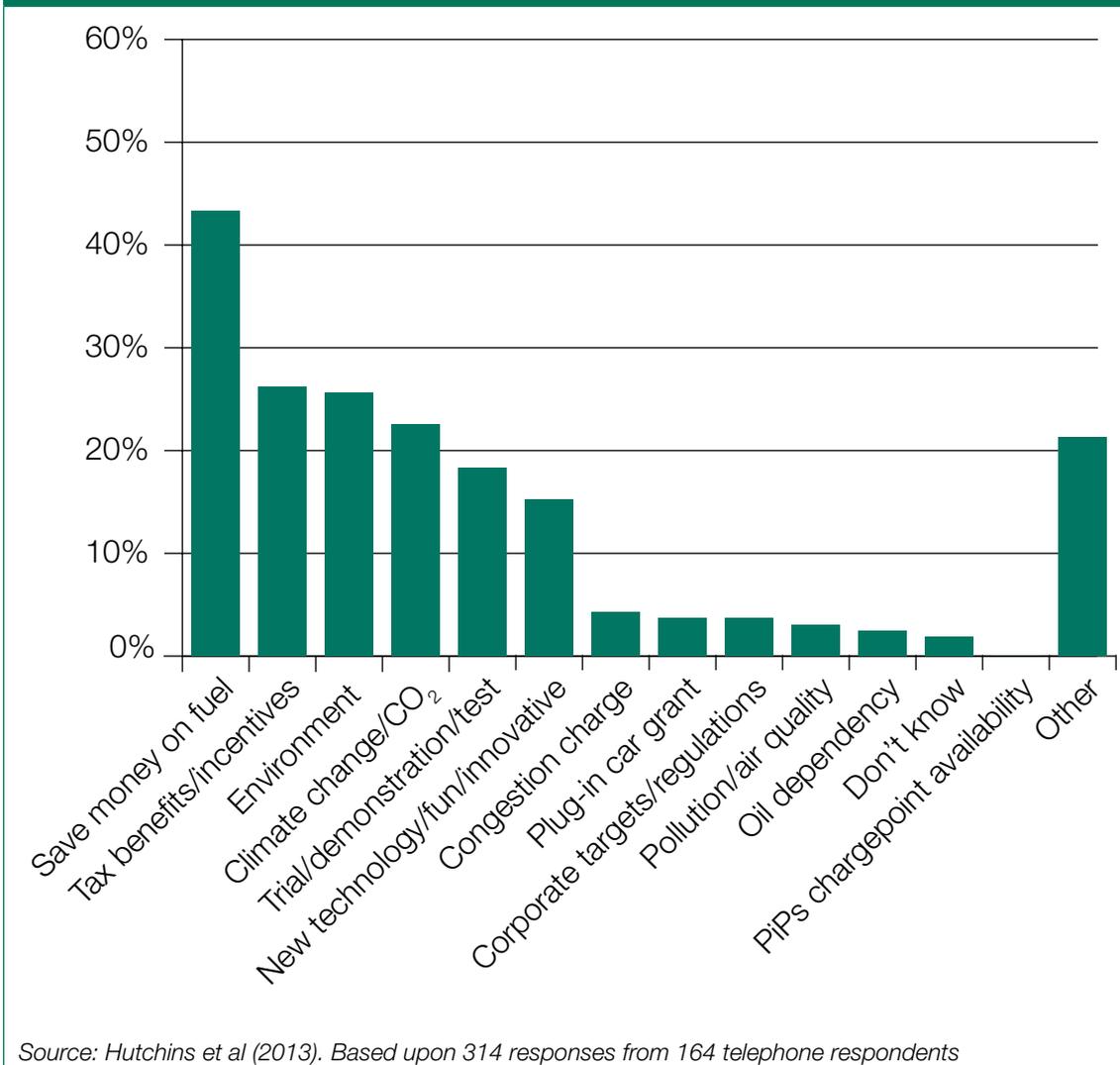
⁵⁸ Plugged-in Fleets Initiative Charging Forward (Energy Saving Trust, 2013)

Figure 5.1 – Private purchaser reasons for choosing an EV rather than an ICE vehicle



5.17 There are some excellent examples of public sector fleet managers embracing the ULEV agenda, but the volumes of ULEVs in public sector fleets are still not high. There are currently barriers and a lack of incentives to procure ULEVs through existing frameworks. The Government Procurement Service manages the purchasing activity of central government departments and also makes its frameworks available to the wider public sector. Through these frameworks it is currently possible to buy ULEVs but they are not included in the regular competitions or e-auctions through which buyers access the most competitive rates for vehicle purchase.

Figure 5.2 – Business purchaser reasons for choosing an EV rather than an ICE vehicle



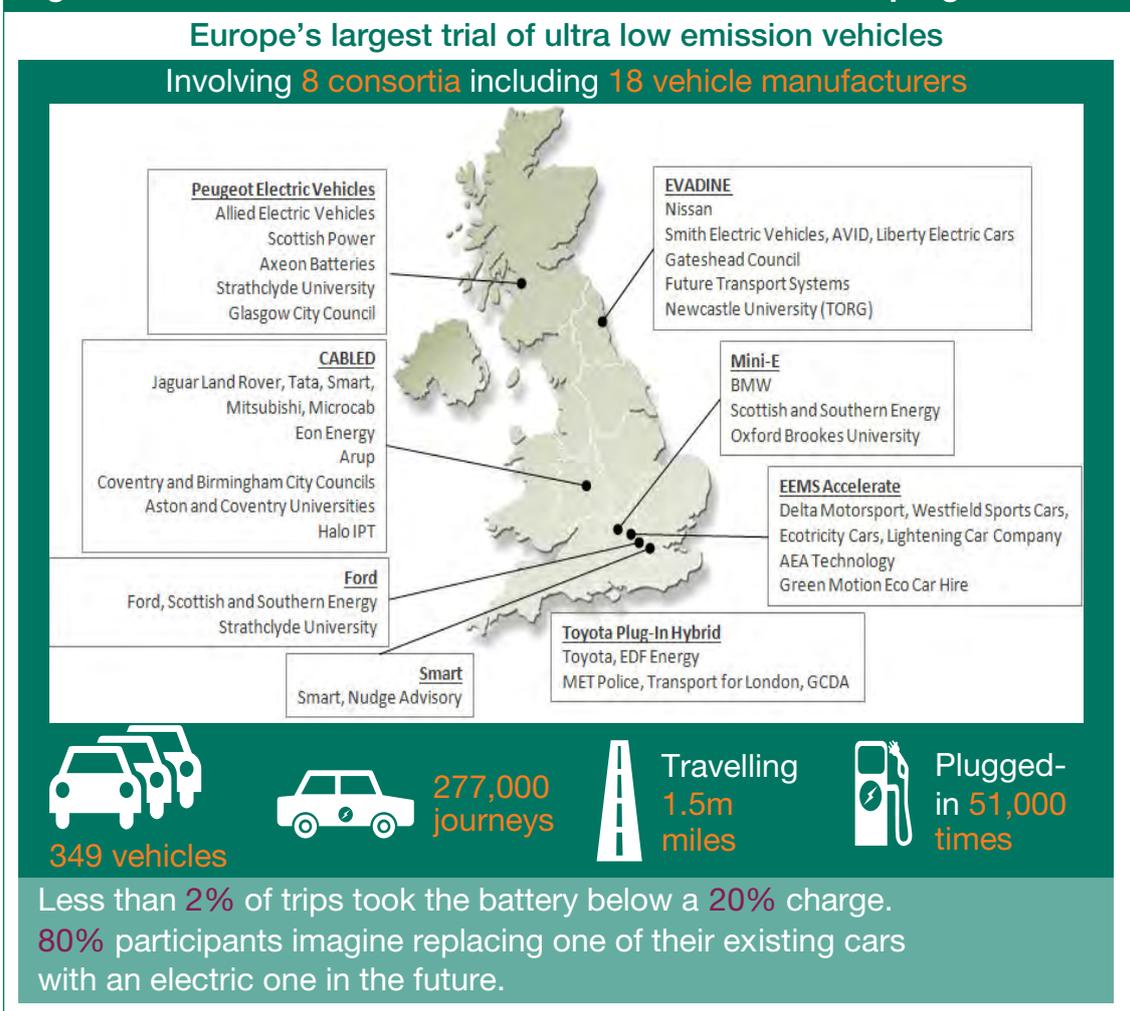
5.18 Similarly, the Government Buying Standard for Transport which outlines the mandatory criteria which the Government's vehicles must meet, and is the best practice standard for the wider public sector, currently provides no incentive to fleet managers to consider whether ULEVs would be appropriate for their fleets. The establishment of frameworks which go some way to reward purchasers for choosing ULEVs, either through inclusion of environmental criteria, or through more competitive prices would likely generate more ULEV sales across the public sector.

User experience of plug-in vehicles

5.19 The Ultra Low Carbon Vehicle Demonstrator programme was set up to expose demonstration vehicles to multiple drivers and real world scenarios and to understand customer perception about the vehicles and charging infrastructure. The project was valued at £52 million with £25 million of Government funding being match funded by industry. It collected data from 349 vehicles driving over 1.5 million miles. Of the demonstrator vehicles 314 were pure battery electric, with the remainder plug-in hybrids and fuel cell electric.

- 5.20 The programme identified that drivers adapt almost immediately to the vehicles (usually within the first journey), finding them easy to use, smooth and fun to drive with impressive acceleration. Drivers quickly learnt how driving style, on-vehicle energy recuperation, route selection, state of charge and information from the vehicle impacted on overall vehicle range. The energy consumption per mile was higher for shorter distances as drivers only drove more efficiently when they had to, adopting a different style for longer trips.
- 5.21 There was very little experience of range anxiety as the majority of drivers kept well within the capability of the vehicles. Only one in five trips took the vehicle's battery charge below 50% and less than two in 100 went below a 20% charge. The average daily mileage was 21 miles.

Figure 5.3 – The Ultra Low Carbon Vehicle Demonstrator programme



- 5.22 Drivers with recharging infrastructure installed at home used it for 97% of charging, with smart infrastructure proving effective in transferring charging to outside of the peak electricity demand periods. Even though most trips were completed without using the public charging infrastructure, a high proportion remained convinced that public charging sites were essential, especially as drivers began to use their vehicles for longer journeys. Over the course of the demonstration users increased the distance travelled

between charging, although some users considered they would benefit from greater vehicle range.

- 5.23** The trial's findings challenge the perception that electric vehicles are only for those with environmental motivations. Drivers wanted to experience the financial benefit from lower running costs, but without the increased purchase price or compromising on looks and design. Four out of five participants could imagine replacing one of their existing cars with an electric one in the future.

Figure 5.4 – Quotes from ULEV owners



Installing and operating infrastructure

- 5.24** As well as the PIPs, a wide range of public and private sector organisations, often working in consortia, have entered the electric vehicle infrastructure industry over the last few years. Installing chargepoints can be a complex process given the nature of the early market, the broad range of partners it is necessary to recruit and align, and the potential for new and emerging technologies to be a future part of the offer.
- 5.25** Installers and operators are employing different business models and no single dominant approach has emerged – different models work in different contexts depending on local factors and business objectives. As anticipated, during the early development period of this industry there have been challenges for the emergence of sustainable business models. That is changing – and will continue to do so – as vehicle uptake grows.
- 5.26** In terms of operating chargepoint networks, we are seeing viable membership and pay-as-you-go schemes emerging, often in parallel. There is increasing maturity and healthy competition in the development and supply of the systems to manage chargepoint operations.

User experience of the charging infrastructure

- 5.27** It remains the case that most charging occurs at home and overnight, with some charging at the workplace. The current usage of on-street chargepoints can sometimes be limited, but they serve an important purpose in reassuring prospective and actual ULEV drivers that they will be able to charge their vehicle away from home or workplace should they need to. This remains an important factor for many prospective ULEV drivers who often anticipate higher usage of chargepoints away from their home than actually transpires.
- 5.28** We have begun to see the development of different recharging technologies, such as rapid chargepoints and pay-as-you-go capability. Whilst such developments are welcome, this can pose a confusing picture for drivers. For example, in the case of rapid chargepoints, it is important that the right type of infrastructure is in the right location and that drivers are made aware of it being there.
- 5.29** The availability and quality of information about chargepoints is not only important for drivers, but is important to assure potential purchasers of plug-in vehicles that their recharging needs, perceived or actual, will be met. Basic accurate information such as chargepoint location and connector type is not currently available in one central place for drivers to access, yet is valued by drivers and by vehicle manufacturers. Information about the location and accessibility of chargepoints needs to be readily available and up to date. Opportunities exist for improving information provision to ensure that the process for users is as easy as possible, such as building on the basic chargepoint information contained within the National Chargepoint Registry.
- 5.30** The evidence we have from market analysis and DfT surveying work is that the associated benefits of being a member of a local chargepoint scheme or schemes, such as reduced or free parking whilst charging, or the integration with passenger transport ticketing systems, are highly valued. However, drivers have expressed frustration at the range of different membership schemes that exist for accessing chargepoints and the lack of a single national scheme. Our research shows that this frustration stems from uncertainty about whether drivers will be able to access a given chargepoint upon arrival coupled with the need to carry several membership cards to access different schemes.⁵⁹
- 5.31** We have given the industry freedom to develop its own innovative solutions to the issue of interoperability between membership schemes, supporting them as they do so. This has resulted in membership schemes, such as Source East and Source London, agreeing roaming between networks for their members. Similarly, private sector scheme operators such as Ecotricity are working with PIP schemes to deliver rapid chargepoints at motorway service stations and some IKEA stores which Source London, Source East, Plugged in Midlands, Milton Keynes and Ecotricity members can all access.

⁵⁹ Assessing the role of the Plug-in Car Grant and Plugged-in Places scheme in electric vehicle take-up (Hutchins et al, 2013)

Lessons from other countries

- 5.32** The rate of uptake of ULEVs in the UK is broadly comparable with some other major European markets, but lags behind France, Germany and the Netherlands in total cars sold. Other countries have adopted measures which have enabled the barriers to ULEV uptake to be overcome much more rapidly. However, these come at significant cost to taxpayers, or involve policy developments which would be challenging to replicate in the UK.
- 5.33** Norway is the stand-out example where electric vehicles already make up 3% of new car sales. Purchase taxes on traditionally fuelled vehicles have been used to close, and even reverse, the cost differential with ULEVs. Coupled with other measures, such as access for ULEVs to bus lanes in Oslo, Norway has become a leading market for ULEVs.
- 5.34** The lesson for the UK from Norway's experience is that there are no insurmountable barriers to ULEV adoption. The policy challenge for Government and for industry here is to ensure that the objective of promoting ULEV uptake is balanced appropriately with other considerations, not least affordability.
- 5.35** Our engagement with governments across the world has also reinforced our understanding of the importance of constructive cooperation between national and local government. A strong policy framework from national government is most effective when matched by ambition at the regional and local level.

Communications

- 5.36** A degree of scepticism towards the ULEV agenda exists in elements of the mainstream media. This situation can be an inevitable part of the introduction of a new technology but there is a role for Government, and for industry, to engage with opinion formers and provide accurate information for the car-buying public. Some media reporting has been based on outdated misconceptions about the technology, its implications and its potential.
- 5.37** Consumers require clear and consistent messages from Government which must be joined-up with industry activity, so that consumers are able to develop a clear understanding of the issues.
- 5.38** We have also seen that awareness amongst the public of Government support for ULEVs, including through the Plug-in Grants and funding for infrastructure, is low. The wider and so more effective dissemination of information could be expected to further support ULEV up-take in the UK. Indeed, the social research being published alongside this document demonstrates the very positive impact of the consumer incentive in consumer purchase decisions where those consumers were aware of it.

The role of regulation and targets

- 5.39** Over the last decade more and more vehicle manufacturers have responded positively to the challenge of reducing in-use CO₂ emissions. Industry's technological innovations have been appreciated by motorists keen to benefit from the reduced running costs that more efficient vehicles deliver.

- 5.40** A key to the success of the current targets is that they are based in large part on close joint working between regulators and industry. That must continue. By setting ambitious but realistic targets along the way, agreed in good time to allow stability for future product planning, we can play our part in ensuring industry is able to deliver its obligations cost-effectively. We fully expect vehicle manufacturers to be able to deliver further reductions in CO₂ emissions to meet more demanding EU level targets.
- 5.41** Current targets are also output-based, focusing solely on tailpipe emissions. They do not mandate particular technologies. This needs to continue – governments should not tell industry how to determine the optimal approach to delivering emissions improvements.

Summary

- 5.42** This chapter has:
- Presented some of the key findings from recent UK research in the ULEV sector.
 - Reviewed the key lessons that the Government has drawn from these and its other activities in the ULEV sector in recent years.
 - Looked across the entire ULEV sector, from consumer purchasing behaviour, to experiences of installing and using infrastructure.

6. The way forward

Strategic approach

Government's vision

- 6.1** Government and industry now have a good understanding of the challenges and opportunities presented by the global shift to ULEVs. It is not something that will happen immediately, and it is clear that Government and industry must work together if the opportunities for the UK are to be fully capitalised upon. The Government is wholly committed to this agenda and its overall vision for ULEVs in the UK remains ambitious:
- buoyant domestic fleet and private markets for ULEVs with every new car an ULEV from 2040 and an effectively decarbonised fleet by 2050 to meet our Carbon Plan targets;
 - a network of supporting infrastructure that ensures ULEVs are an attractive customer proposition;
 - world class skills and facilities for the development and manufacture of ULEV technologies, exporting vehicles globally;
 - a smarter electricity grid that maximises the benefits to vehicle owners and the electricity system from the shift to ULEVs; and
 - all of the above combining to make the UK the best place in Europe for the automotive sector and associated ULEV industries to invest.

Overarching principles

- 6.2** In delivering this vision for the ULEV sector in the UK, Government's activities will be consistent with the following principles:
- a. Focusing on inward investment and the supply chain** – The Government will continue to pursue the wider prize of securing the maximum possible benefits to the UK economy from the mass market adoption of ULEVs. This means focusing on enabling the UK supply chain to become pre-eminent in low carbon technologies.
 - b. Technological neutrality** – The Government will not seek to 'pick winners' in terms of emerging technologies at this early stage. Instead we will support activities that are backed by industry consensus, allowing the market to ultimately determine which technologies win through. We will generally specify the bulk of our policies in output rather than technology terms.

- c. **Working with the EU on ambitious but realistic regulation** – The Government will work to agree regulations that are ambitious, consistent with our statutory carbon budgets and target for 2050, and which encourage innovation but which are also realistic, deliverable and neither penalise the ordinary motorist nor overburden industry.
- d. **Addressing market failure** – Government can speed the transition to ULEVs by addressing areas where the market alone might not deliver the best outcomes in the shortest possible timescale. The ‘chicken and egg’ problem of ULEV uptake and the provision of refuelling infrastructure is a good example of this.
- e. **Consistent communications** – The Government will engage early, openly and proactively with industry on all aspects of the developing ULEV sector, and we will support clear and consistent communications with consumers.

Key commitments

Long term investment

- 6.3 The UK is seen as one of the most open automotive markets in Europe, which is both a strength and a weakness. Because many UK manufacturers are foreign-owned, with a global choice of manufacturing and development sites, the UK has to be particularly attractive to stimulate investments in advanced technologies.
- 6.4 The Government recognises this. In July 2013, it set out its long-term ambition for roads⁶⁰ including a significant funding commitment of **over £500 million from 2015 until 2020** to continue to support the growing market for ULEVs. This, combined with the existing **£400 million support to 2015** and the recent **advanced propulsion centre announcement**, constitutes one of the longest and most comprehensive packages of support for ULEVs anywhere in the world.

Support to 2020 – call for evidence

- 6.5 It is important that Government’s support for the transition to ULEVs is appropriately targeted in the period 2015-2020. Different sectors will have different views about the balance between various options for support. It is important that the final shape of any support package (likely to require State Aid clearance in due course), reflects these views and also retains sufficient flexibility to respond to changing circumstances.
- 6.6 Following the publication of this strategy the Government will, therefore, open a dialogue with interested stakeholders to help shape the support package for the 2015-2020 period.

60 <https://www.gov.uk/government/publications/action-for-roads-a-network-for-the-21st-century>

We will launch a call for evidence later in 2013 to inform the development of the 2015-2020 package of support for ULEVs, including consumer incentives. This will consider the balance of support between the workstreams below and plot the path to Government's exit from subsidy.

Delivering the vision

- 6.7** Government will take forward the ULEV agenda in the immediate term through a number of practical actions and commitments. These activities are aimed at normalising the technology, addressing current barriers to adoption (such as price, the infrastructure 'offer', and the availability of accurate consumer information), preparing the ground for increased adoption and new technologies (such as hydrogen), stimulating the UK supply chain to make the most of the coming industrial opportunities, and working to ensure that future regulatory structures are consistent with the UK's strategic aims.
- 6.8** The following sections set out other specific commitments that the Government will take forward now to deliver its vision. These are organised under five workstreams.

Workstream 1 – Supporting the early market

- 6.9** Continued efficiency improvements to petrol and diesel engine vehicles will provide the biggest carbon savings in the short term. But it is clear that the UK market for ULEVs will need to continue to grow year-on-year if we are to both secure the wider benefits of the transition and meet our long term Carbon Plan targets.
- 6.10** The Government is confident that this will happen – both global and national trends on this are positive. Rising uptake of ULEVs will lead to the technology being 'normalised' as people see growing numbers of drivers happily using these vehicles and a greater number of models on the market (pictured, the BMW i3, on sale in the UK from November 2013).



Source: BMW

Consumer incentives

- 6.11** The need for Government to support the early market will continue over the near term. As the market develops we expect increasing global sales to drive down costs through economies of scale. While the ULEV market in the UK has grown significantly, doubling in size between 2011 and 2012, it is still nascent. We expect that a material, although declining, cost gap between traditionally fuelled vehicles and ULEVs will remain for some years to come. Until that point, the market is likely to require continuing support to alleviate a portion of the extra cost of ULEVs.

6.12 Government incentives cannot be maintained indefinitely, however, and we will need to consider how and when support should end. This decision will need to be taken following engagement with industry. We also need to ensure that the consumer incentives are technology neutral and able to actively support the introduction of new technologies such as hydrogen fuel cell electric vehicles when they begin to enter the market in increasing numbers from 2015.

6.13 Our key consumer incentive commitments are as follows:

- a) To provide certainty for investors and consumers the existing plug-in vehicle grants will remain unchanged to May 2015, and consumer incentives will remain in place beyond this date.
- b) We will ensure that the guidelines for the Plug-in Grants include appropriate technology neutral performance criteria so as not to exclude emerging technologies like FCEVs – by May 2014.
- c) We will simplify the registration of hydrogen FCEVs when they become commercially available from 2015 by removing the requirement for vehicles using hydrogen fuel to be issued with a Vehicle Special Order.

Incentives for electric powered two wheelers and quadricycles

6.14 Changing patterns of mobility point towards an increasing variation in the size and type of vehicles used to meet people's mobility needs. With increased urbanisation, we expect to see a buoyant future for electric powered two wheelers and other small ULEVs.

6.15 Given the relatively low contribution of motorcycles and scooters to road transport emissions in the UK (only 0.5% in 2011), the case for support in this market is less strong. We will continue to work with the industry, and in particular the eMCI, to monitor progress as the market develops. The Government recognises that the 'electric powered two wheeler' sector is working hard to address issues unique to their market, for instance on insurance, sales and distribution and recharging infrastructure.

6.16 We will keep this position under review when considering changes in scope to current consumer incentives. We are keen to encourage reductions in emissions across all sectors and would welcome input from these important sectors when we launch a call for evidence later in 2013 to inform the development of the next phase of the Plug-in Vehicle Grants.

Incentives for heavy goods vehicles (HGVs)

6.17 Often the greatest barrier to the uptake of new technologies is uncertainty around the fuel cost savings they will achieve in use. An independent test and accreditation scheme could provide reassurance and an indication of likely percentage fuel savings. We will work with the Low Carbon Vehicle

Partnership⁶¹ and others to consider how we might facilitate an industry-led scheme for the UK.

- d) We will review the opportunities available to promote uptake of low emission HGV technologies by May 2014, in particular considering the use of incentives that could improve the business case for operators.

Enabling informed decision-making by consumers

- 6.18** There is evidence that persistent misconceptions remain amongst prospective buyers about ULEVs. These include issues around performance, daily use, the availability of charging infrastructure and the environmental credentials of ULEVs. A key priority for the Government will be to address these misconceptions head-on and to provide the public with consistent, well-evidenced information.

- e) We will work with a consortium of major ULEV manufacturers to explore the case for a national consumer communications campaign. Subject to agreement from all those involved, during 2014 we will launch a platform for providing robust and authoritative consumer information on ULEVs, supported by awareness raising activity.

Supporting uptake in public and private sector fleets

- 6.19** We will work with industry and wider partners to ensure potential consumers, including fleets, have easy access to useful, comprehensive and accurate information about ULEVs, to inform purchasing decisions and to support vehicle uptake and use.
- 6.20** We will also ensure that public sector organisations play a leading role in the early market for ULEVs, securing for themselves and demonstrating to others the benefits that these vehicles can bring.

- f) We will provide funding to the Energy Saving Trust to continue the Plugged-in Fleets Initiative through to March 2014, helping 100 fleets to identify where plug-in vehicles can support their business needs.
- g) We will update the Government Buying Standard for Transport by summer 2014 to encourage higher ULEV uptake in the public sector. In addition, we will work to remove unintended administrative barriers to public sector purchase of ULEVs.
- h) We will develop a procurement specification for ULEVs by February 2014 as a basis for future mass public sector procurement exercises, bringing down the cost per vehicle of ULEVs for public sector organisations.

⁶¹ The Low Carbon Vehicle Partnership (www.lowcvp.org.uk/) is a public-private partnership that exists to accelerate a sustainable shift to lower carbon vehicles and fuels and create opportunities for UK business. Nearly 200 organisations are engaged including automotive and fuel supply chains, vehicle users, academics, environment groups and others.

Workstream 2 – Shaping the required infrastructure

- 6.21** Drivers of traditionally fuelled vehicles have the confidence to be able to drive anywhere in the UK, and beyond, knowing that they will be able to refuel when they need to. Our goal is that drivers have the same confidence in ULEVs and their supporting infrastructure as quickly as possible.
- 6.22** Much of the UK is already well served by chargepoints and drivers of plug-in hybrids and range-extended electric vehicles can already undertake longer journeys with confidence. Building on the network that already exists, we are continuing to provide funding to increase the reach and scope of the chargepoint network across the UK. Working with the private sector and other partners we will monitor the need for additional chargepoints and other refuelling infrastructure as vehicle uptake grows and as new technologies such as hydrogen are introduced.
- 6.23** With the increasing sales of vehicles and a steady succession of planned new model launches, now is the right time to move away from pilot schemes to a compelling national ‘offer’ on recharging infrastructure.

Plugged-in Places infrastructure

- 6.24** The Plugged-in Places (PIP) programme has provided real insight into the challenges and opportunities of rolling out infrastructure but also into the way motorists use their plug-in vehicles.
- 6.25** We will provide targeted match funding for the eight Plugged-in Places schemes during 2013/14 to enable them to transition to long-term sustainable models of operation and to increase pay-as-you-go access to their chargepoints. This will help to reduce the need for drivers to carry multiple infrastructure membership cards.

National infrastructure

- 6.26** Building on the experience for the eight regional PIP schemes, in February 2013 the Government announced a £37 million national package of support for the rollout of chargepoint infrastructure through to May 2015.

Domestic chargepoint grant

- 6.27** The majority of people charge their vehicles at home, usually overnight, and the installation of a dedicated domestic charging unit can help vehicle owners to do this more safely and quickly than using conventional three pin domestic sockets. But we recognise that for many people there is a cost barrier to the uptake of a domestic charging unit. That is why the £37 million package includes the domestic chargepoint grant. Under this scheme homeowners are able to claim up to 75% (capped at £1,000 including VAT) off the total capital costs of the chargepoint and associated installation costs. We have seen that a number of vehicle manufacturers and chargepoint suppliers are willing to contribute the remaining 25%, so that the chargepoint can be installed without cost to the homeowner.

Support for local authorities

- 6.28** Local authorities can play a key role in the future delivery of recharging infrastructure in the UK, and we will help them prepare for the growth in the

number of ULEVs on the roads. We have published a lessons learnt document, informed by the PIP programme, to help local authorities deliver a growing network of infrastructure. The £37 million package also includes a specific grant scheme for local authorities that will support:

- on-street chargepoints in residential streets where off-street parking is not available; and
- rapid chargepoints in locations where they will support uptake of plug-in vehicles.

6.29 In July 2013, we announced that 26 rapid charging schemes were successful, sharing an £8 million pot of funding. A viable national network of rapid chargepoints is seen as critical to the successful adoption of plug-in ULEVs by many. This grant, together with the rapid chargepoints installed under PIP, those recently announced under Trans European Network Transport (TEN-T)⁶² programme, and those being installed by other providers will give the UK an expanded network of potentially around 500 rapid chargepoints (see Figure 6.1).

6.30 The Government will continue to work with stakeholders to consider the best way of implementing a sustainable network of rapid chargepoints to meet the needs of current and prospective ULEV owners. Japan, for example, already has over 1,000 rapid chargepoints and recently announced plans for a further 4,000.

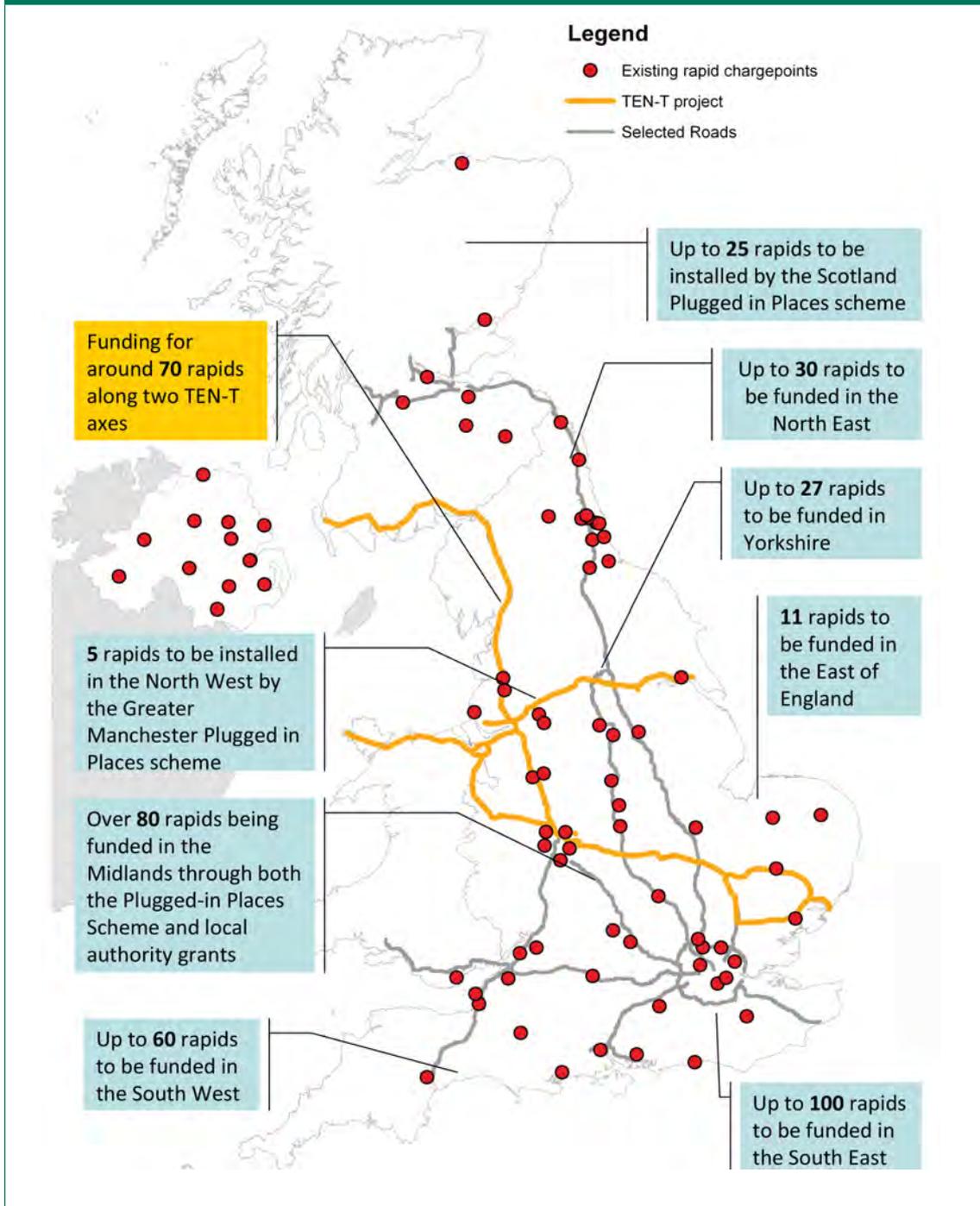
Train station car parks

6.31 Train station car parks are ideal locations for charging electric vehicles because vehicles are often parked there for several hours at a time. We have made available funding to train operating companies (TOCs) in England to cover a proportion of the costs of obtaining and installing plug-in vehicle charging infrastructure at train stations.

6.32 In the first round of bids, five projects involving seven TOCs have been successful: Southern, Southeastern, Greater Anglia, East Coast, Merseyrail, Northern Rail and Virgin Trains. These projects will deliver around 110 chargepoints along their franchise routes. We will work with the TOCs to encourage further applications for grants with a view to a steadily increasing number of chargepoints in station car parks.

⁶² The Trans European Network – Transport (TEN-T) programme exists to support the development of the single market by providing funding for transport infrastructure projects on a set of defined networks.

Figure 6.1 – The UK’s emerging rapid charger network



Public sector workplace grant

6.33 We are also providing a grant to support the installation of recharging infrastructure in public sector workplace car parks. This will help public sector bodies and their employees integrate plug-in vehicles into fleets and demonstrate leadership.

6.34 Over 43 public sector organisations have been successful in the first round of bidding for these funds, and we expect that up to 380 chargepoints at 150 public sector locations will be delivered by these organisations by the end of 2014/15.

- a) We will continue to provide a national package of up to £37 million through to May 2015 to support the installation of chargepoints in homes, residential streets, railway station and public sector car parks and rapid chargepoints to facilitate longer journeys, inviting a second round of bids from train operators, local authorities and the wider public sector by 31 October 2013.

Meeting driver requirements

- 6.35** The Government's vision for plug-in vehicle charging infrastructure is focused on meeting driver requirements. We are keen that infrastructure should be easy to locate, use and pay for, and recognise that this is not always the case today.

Easy to locate

- b) We will continue to support the creation of a single definitive database of all publicly accessible charging infrastructure. We will build on the existing National Chargepoint Registry (NCR) and work with industry during 2013 and 2014 to develop it to allow greater flexibility and functionality.
- c) We will work with the recharging industry and network operators to take account of driver needs when installing infrastructure, developing best practice guidance on signage and information on chargepoint functionality – by summer 2014.

Figure 6.2 – Example of best practice – Manchester PIP signage and chargepoint location information.



Source: Greater Manchester Electric Vehicle Scheme

Easy to use

- 6.36** We have responded to requests from vehicle manufacturers and now only fund public chargepoints with 'Type 2' sockets or tethered cables, a move that was welcomed by the industry, in order to reduce confusion and uncertainty. For rapid chargers we will support the provision of infrastructure standards that best meet the mix of vehicles on the UK's roads. As part of this process we will also continue to work to ensure that the needs of

drivers in the UK are fully represented in legislative and other developments at European and international levels.

- d) We will work with industry, standardisation bodies and global partners to get the best deal for plug-in vehicle drivers on the move to standardise charging infrastructure (including plugs and connectors) – ongoing.
- e) We will work with local authorities to ensure that parking regulations for ULEVs are fit for purpose and plug-in vehicle drivers are able to use publicly accessible infrastructure – by May 2015.

Easy to pay

6.37 A number of the chargepoint schemes already operating in the UK, including the Plugged-in Places, have, or are developing, mechanisms to open up their networks to non-members. This has included roaming agreements and the development of ‘pay-as-you-go’ functionality, allowing anyone with a credit or debit card to access chargepoints.

- f) We will include a requirement that every publicly accessible chargepoint that the Government funds has ‘pay-as-you-go’ functionality. We will also encourage the integration of payment systems with other services, such as transport ticketing systems or car parking charges, for ease of use.

Horizon scanning

6.38 We will continue to monitor future recharging technologies, such as inductive charging, and target our policies to create the right conditions for those technologies to come to market where they meet our policy aims.

Hydrogen infrastructure

6.39 A key element of Phase 2 of UKH₂Mobility is to identify mechanisms by which investment in the initial network of hydrogen refuelling stations can be secured. This will enable Government and industry to agree what actions are required by whom to support the creation of a co-ordinated, national network of hydrogen refuelling stations to support the commercial roll-out of hydrogen FCEVs in the UK from 2015.

- g) Subject to further work in Phase 2 of UKH₂Mobility, we will explore the options for Government grant funding to support industry’s investments in the initial network of around 65 hydrogen refuelling stations estimated to be required to support the introduction of hydrogen FCEVs in the UK – by May 2014.
- h) We will work with industry to identify and resolve outstanding practical issues around the refuelling and use of hydrogen FCEVs, including the hydrogen quality assurance process, integration of hydrogen refuelling into conventional fuel retail forecourts and ensuring an optimal consumer experience – by December 2014.

Workstream 3 – Securing the right regulatory and fiscal measures

Tax regime

6.40 Tax has an important part to play in supporting the uptake of ULEVs. As outlined in Chapter 3, in his 2013 Budget the Chancellor committed to maintaining a stable and meaningful set of taxation benefits for ULEV drivers relative to traditionally fuelled vehicles.

- a) We will maintain a strong, clear and lasting set of tax incentives for ULEVs until at least 2020. We will involve industry and wider partners in the process for subsequent development of the tax regime.
- b) OLEV will work with HMRC to clarify the tax position for ULEVs and publish this as a factsheet on the OLEV website by May 2014. This will enable fleet managers to better understand the likely costs of ULEVs for their fleets.

Support ambitious but realistic emissions targets for new vehicles beyond 2020

6.41 Ever tighter emissions regulations are one of the main drivers of the transition to ULEVs. For cars and light vans it is clear that some form of mandatory and progressively tighter emission standards will continue to be an effective way to deliver carbon reductions beyond 2020. It is also highly likely that a similar approach could deliver cost effective emissions reductions from HGVs, buses and coaches.

6.42 The new technology required to meet these tougher standards will have cost implications, especially while volumes are low. If regulations run too far ahead of the technical capabilities of industry then this could be reflected in higher new car prices. There is, therefore, a balance to be struck between stretching regulatory targets and overambitious ones which could risk penalising the ordinary motorist – although lower CO₂ emissions can also equate to lower running costs, offsetting higher purchase prices.

6.43 We will, therefore, work with the industry and other partners to develop and promote a UK position on both light and heavy duty vehicle emissions to influence the EU regulatory framework to deliver our ambitions. The Government wants to see regulations that are ambitious enough to be consistent with our Carbon Plan targets but which are deliverable and open up the possibility of lower running cost ULEV motoring for as many people as possible.

Clean Power for Transport

6.44 We recognise that there are still barriers and challenges around infrastructure. The draft proposals in the recent Clean Power for Transport package from the European Commission seek to address the slower than desired deployment of alternative fuels infrastructure across Europe. The proposed directive would set binding targets for the build up of electric chargepoints and gas refuelling equipment and set common standards for their design, operation and use. We support efforts to agree technical standards and are now working with the Commission and other Member States on the detail of these proposals, including the need to reflect the technologies already in the market.

- 6.45** These discussions could be an important step towards improving the infrastructure provision across the EU and providing confidence to those looking to invest in the future of low carbon transport.

c) We will work with industry and international partners to support ambitious but realistic and cost effective emissions targets in EU regulations for new vehicles beyond 2020 and to deliver UK ambitions on the Commission's Clean Power for Transport proposals.

Workstream 4 – Investing in UK automotive capability

- 6.46** The Automotive Sector Strategy published in July 2013 sets out how the Government and the automotive industry are working together to ensure the long-term future of the UK automotive sector. Enabling the development and commercialisation of new automotive technologies in the UK is critical to the medium to long term future of the sector and is at the heart of improving the UK supply chain.

- 6.47** Government and industry's investment of around £1 billion over 10 years in a new Advanced Propulsion Centre represents a step change in the scale of support for advanced propulsion technologies, and will enable these products to be commercialised and produced in the UK.

- 6.48** The 2013 Spending Round included new and dedicated funding to develop long-life battery technology for the next generation of electric vehicles. This will be offered as a 'challenge prize' of up to £10 million for those individuals or organisations able to transform the range and affordability of currently available ultra low emission cars. The challenge will encourage innovation from science and engineering experts, business and commercial investment, and stimulate academic thought and further development of technology for next generation ULEVs.

- 6.49** The specific challenge to be met and the competition guidelines will be unveiled later in 2013.

- a) We will continue to work through the Automotive Council to identify specific activities to develop and strengthen the UK ULEV supply chain and, by December 2013, will discuss with industry how best to target ULEV R&D funding out to 2020.
- b) OLEV will continue to co-ordinate ULEV R&D and supply chain activity across Government, with industry and with the Technology Strategy Board to maximise economic benefits for the UK. This will include working with all stakeholders to ensure appropriate alignment of activities at the Advanced Propulsion Centre and the Energy Storage Centre with other ULEV programmes to maximise benefits for the UK from the move to ULEVs.
- c) We will offer a prize of up to £10 million to develop long-life battery technology for the next generation of electric vehicles. We will work with NESTA (the UK's centre of excellence for challenge prizes) and the Technology Strategy Board to develop the competition scope and criteria. The specific challenge to be met and the competition guidelines will be unveiled later in 2013.

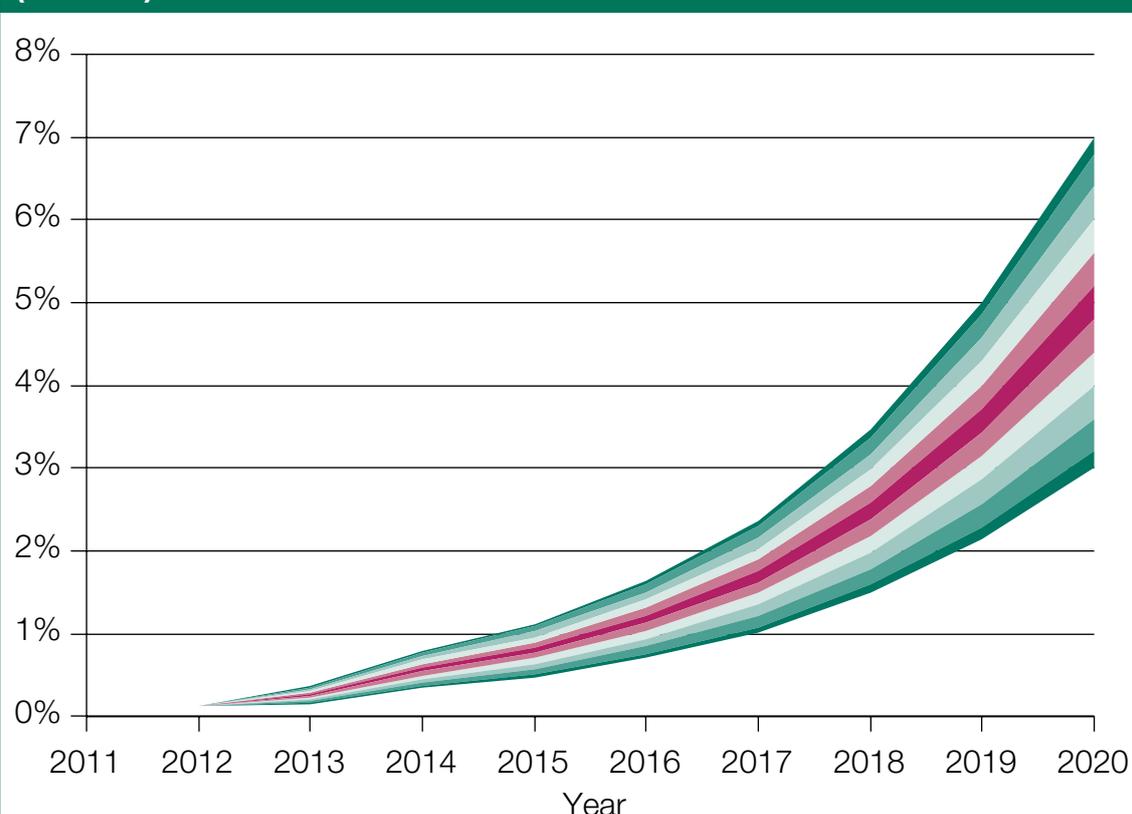
Workstream 5 – Preparing the energy sector

Projections for uptake

- a) We will make available UK ULEV uptake scenarios to the Smart Grid Forum, and update these regularly, to provide strategic direction to the energy industry – ongoing.

- 6.50** The uptake of ULEVs remains difficult to predict, particularly beyond 2020. It will be determined by a number of factors, many of which are outside Government's control – most critically the speed with which manufacturers bring ULEVs to market and the price they charge for them. Figure 6.3 outlines our latest projections of ULEV uptake to 2020 as a proportion of all new car sales. It estimates that by 2020 between 3% and 7% of all new car sales will be ULEVs. We estimate that this trajectory of uptake will lead to an annual reduction in domestic transport CO₂ emissions of approximately 10MtCO₂, from 66.8MtCO₂ to 56.6MtCO₂, over the period 2010 to 2020.
- 6.51** In addition to the factors quoted above, the range in Figure 6.3 reflects the uncertainty over some of the key drivers of future uptake of ULEVs. These include: battery prices, fuel costs, residual values, purchasing models (e.g. battery leasing), and accessible rapid charging. Combining a range of values for these variables through multiple modelling exercises enables us to build up a picture of the likely range of ULEV uptake in 2020.

Figure 6.3 – Projected ULEV car sales as proportion of all car sales (2011-20)



Source: Department for Transport modelling

6.52 Future CO₂ targets will drive technological change, encouraging manufacturers to introduce ULEVs across their ranges to comply with their targets. Our modelling suggests that, set appropriately, new car CO₂ targets can lead to ULEV uptake consistent with the Government's aspiration that by 2040 almost every new car bought in the UK will be an ULEV. The modelling also suggests that this would be a cost-effective means of helping to achieve the UK's 2050 CO₂ targets. By contrast, without such targets and other supporting policy measures, the modelling suggests that the market is unlikely by itself to deliver these very high ULEV uptake rates.

Maximise the energy benefits of ULEVs

6.53 The electrification of road transport over the coming decades presents a range of challenges and opportunities for the energy sector. Government will work with agencies, regulators and industry to ensure that the challenges are met, risks are mitigated and that opportunities are appropriately exploited to bring the maximum benefits to the UK.

- b) We will continue to require the national rollout of smart meters into homes by 2020. We will ensure that this new technology acts as a platform which can support plug-in vehicle charging.
- c) We will take an active role in the Smart Grid Forum to prepare for the increasing adoption of ULEVs – ongoing.
- d) We will begin a dialogue with the plug-in vehicle and house building industries about the most cost effective way to promote the inclusion of wiring and the installation of dedicated chargepoints in appropriate new housing stock – by May 2014.

Management of the grid

6.54 The electrification of road transport will place novel demands on the national grid and increased demand for electricity and new spatial and temporal patterns of demand are likely effects. It will become increasingly important that distribution network operators have timely and accurate information about the installation of new chargepoints, even when that does not require a new connection to the local electricity grid.

- e) We will review how to ensure that appropriate information is flowing from chargepoint installers to notify distribution network operators about chargepoint installations. We will work to ensure that notification processes are capable of dealing with higher numbers of installations as uptake increases – by May 2014.

Production of hydrogen

6.55 While hydrogen fuel cell electric vehicles (FCEVs) themselves emit no CO₂, some processes for hydrogen production do. It is important that the introduction of FCEVs is consistent with delivering our long term carbon ambitions. A key part of this rests on minimising the carbon emissions associated with the production of hydrogen as far as possible while still

ensuring that hydrogen is available at a price that is attractive to consumers. This is a key piece of work being undertaken by the UKH₂Mobility project.

- f) We will work with industry to identify mechanisms to ensure that as the uptake of hydrogen FCEVs grows, they can increasingly be fuelled by 'green' hydrogen – ongoing.

Conclusion

- 6.56** The move to ultra low emission vehicles is inevitable. There are hugely significant benefits for the UK from this transition in terms of energy security, air quality and carbon reduction. But, beyond this, the transition also represents a potentially once in a lifetime industrial opportunity for the UK automotive sector if it successfully positions itself in the vanguard of this new technology – delivering jobs and growth for decades to come.
- 6.57** The UK Government is wholly committed to this agenda, and recognises that it will take time. This strategy has set out why this policy is so important and the comprehensive and compelling set of commitments that the Government is already making to make its vision a reality as fast as possible.
- 6.58** The Government looks forward to working with the automotive industry, its wider supply chain, and the energy, infrastructure and technology sectors to deliver this transition.

Annex: Full list of commitments

Support to 2020 – call for evidence

We will make provision for over £500 million from 2015 until 2020 to support the growing market for ultra low emission vehicles.

We will launch a call for evidence later in 2013 to inform the development of this package of support, including consumer incentives. This will consider the balance of support between the following workstreams and plot the path to Government's exit from subsidy.

Workstream 1 – Supporting the early market

- a) To provide certainty for investors and consumers the existing plug-in vehicle grants will remain unchanged to May 2015 and consumer incentives will remain in place beyond this date.
- b) We will ensure that the guidelines for the Plug-in Grants include appropriate technology neutral performance criteria so as not to exclude emerging technologies like FCEVs – by May 2014.
- c) We will simplify the registration of hydrogen FCEVs when they become commercially available from 2015 by removing the requirement for vehicles using hydrogen fuel to be issued with a Vehicle Special Order.
- d) We will review the opportunities available to promote uptake of low emission HGV technologies by May 2014, in particular considering the use of incentives that could improve the business case for operators.
- e) We will work with a consortium of major ULEV manufacturers to explore the case for a national consumer communications campaign. Subject to agreement from all those involved, during 2014 we will launch a platform for providing robust and authoritative consumer information on ULEVs, supported by awareness raising activity.
- f) We will provide funding to the Energy Saving Trust (EST) to continue the Plugged-in Fleets Initiative through to March 2014, helping 100 fleets to identify where plug-in vehicles can support their business needs.
- g) We will update the Government Buying Standard for Transport by summer 2014 to encourage higher ULEV uptake in the public sector. In addition, we will work to remove unintended administrative barriers to public sector purchase of ULEVs.
- h) We will develop a procurement specification for ULEVs by February 2014 as a basis for future mass public sector procurement exercises, bringing down the cost per vehicle of ULEVs for public sector organisations.

Workstream 2 – Shaping the required infrastructure

- a) We will continue to provide a national package of up to £37 million through to May 2015 to support the installation of chargepoints in homes, residential streets, railway station and public sector car parks and rapid chargepoints to facilitate longer journeys, inviting a second round of bids from train operators, local authorities and the wider public sector by 31 October 2013.
- b) We will continue to support the creation of a single definitive database of all publicly accessible charging infrastructure. We will build on the existing National Chargepoint Registry (NCR) and work with industry during 2013 and 2014 to develop it to allow greater flexibility and functionality.
- c) We will work with the recharging industry and network operators to take account of driver needs when installing infrastructure, developing best practice guidance on signage and information on chargepoint functionality – by summer 2014.
- d) We will work with industry, standardisation bodies and global partners to get the best deal for plug-in vehicle drivers on the move to standardise charging infrastructure (including plugs and connectors) – ongoing.
- e) We will work with local authorities to ensure that parking regulations for ULEVs are fit for purpose and plug-in vehicle drivers are able to use publicly accessible infrastructure – by May 2015.
- f) We will include a requirement that every publicly accessible chargepoint that the Government funds has ‘pay-as-you-go’ functionality. We will also encourage the integration of payment systems with other services, such as transport ticketing systems or car parking charges, for ease of use.
- g) Subject to further work in Phase 2 of UKH₂Mobility, we will explore the options for Government grant funding to support industry’s investments in the initial network of around 65 hydrogen refuelling stations estimated to be required to support the introduction of hydrogen fuel cell electric vehicles in the UK – by May 2014.
- h) We will work with industry to identify and resolve outstanding practical issues around the refuelling and use of hydrogen FCEVs, including the hydrogen quality assurance process, integration of hydrogen refuelling into conventional fuel retail forecourts and ensuring an optimal consumer experience – by December 2014.

Workstream 3 – Securing the right regulatory and fiscal measures

- a) We will maintain a strong, clear and lasting set of tax incentives for ULEVs until at least 2020. We will involve industry and wider partners in the process for subsequent development of the tax regime.
- b) OLEV will work with HMRC to clarify the tax position for ULEVs and publish this as a factsheet on the OLEV website by May 2014. This will enable fleet managers to better understand the likely costs of ULEVs for their fleets.

- c) We will work with industry and international partners to support ambitious but realistic and cost effective emissions targets in EU regulations for new vehicles beyond 2020 and to deliver UK ambitions on the Commission's Clean Power for Transport proposals.

Workstream 4 – Investing in UK automotive capability

- a) We will continue to work through the Automotive Council to identify specific activities to develop and strengthen the UK ULEV supply chain and, by December 2013, will discuss with industry how best to target ULEV R&D funding out to 2020.
- b) OLEV will continue to co-ordinate ULEV R&D and supply chain activity across Government, with industry and with the Technology Strategy Board to maximise economic benefits for the UK. This will include working with all stakeholders to ensure appropriate alignment of activities at the Advanced Propulsion Centre and the Energy Storage Centre with other ULEV programmes to maximise benefits for the UK from the move to ULEVs.
- c) We will offer a prize of up to £10 million to develop long-life battery technology for the next generation of electric vehicles. We will work with NESTA (the UK's centre of excellence for challenge prizes) and the Technology Strategy Board to develop the competition scope and criteria. The specific challenge to be met and the competition guidelines will be unveiled later in 2013.

Workstream 5 – Preparing the energy sector

- a) We will make available UK ULEV uptake scenarios to the Smart Grid Forum, and update these regularly, to provide strategic direction to the energy industry – ongoing.
- b) We will continue to require the national rollout of smart meters into homes by 2020. We will ensure that this new technology acts as a platform which can support plug-in vehicle charging.
- c) We will take an active role in the Smart Grid Forum to prepare for the increasing adoption of ULEVs – ongoing.
- d) We will begin a dialogue with the plug-in vehicle and house building industries about the most cost effective way to promote the inclusion of wiring and the installation of dedicated chargepoints in appropriate new housing stock – by May 2014.
- e) We will review how to ensure that appropriate information is flowing from chargepoint installers to notify distribution network operators about chargepoint installations. We will work to ensure that notification processes are capable of dealing with higher numbers of installations as uptake increases – by May 2014.
- f) We will work with industry to identify mechanisms to ensure that as the uptake of hydrogen FCEVs grows, they can increasingly be fuelled by 'green' hydrogen – ongoing.