Independent, not-for-profit, low carbon technology experts

PROJECT

REPORT

Cardiff Capital Region Ultra Low Emission Vehicle Strategy: 2021 Update

May 2021

Prepared for:

Clare Cameron
Cardiff Council

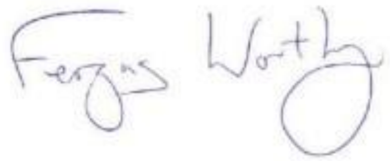
Clare.Cameron@cardiff.gov.uk

03000 040414 ext. 19009

Prepared by:

David Philipson
Technical Specialist

Approved by:



Fergus Worthy
Senior Transport Consultant

Company Details

Cenex
Holywell Building
Holywell Park
Ashby Road
Loughborough
Leicestershire
LE11 3UZ

Registered in England No. 5371158

Tel: 01509 642 500
Email: info@cenex.co.uk
Website: www.cenex.co.uk

Disclaimer

Document Revisions

1	First draft	28-10-19
2	Second draft	13-11-19
3	Draft issued to client	19-11-19
4	Revised draft issued	26-02-20
5	Final version	27-02-20
6	Update (draft)	17-05-21
7	Update (peer reviewed)	18-05-21

Contents

Executive Summary 5
1 Introduction 10
1.1 The Cardiff Capital Region 11
1.2 Aim, Objectives and Outputs 12
1.3 Scope and Definitions 12
1.4 Purpose and Intended Use 14
1.5 Environmental Context 14
1.6 Policy context 15
1.7 Industrial Strategy 17
1.8 Structure 18
2 Technology Overviews 19
2.1 Guide to Technology Overviews 19
2.2 Plug-in Vehicles and Infrastructure 19
2.3 Gas Vehicles and Infrastructure 20
2.4 Hydrogen Vehicles and Infrastructure 21
2.5 Other Fuels 21
3 Methodology 23
3.1 Summary of Methodology 23
3.2 Baselining 23
3.3 Technology Reviews 24
3.4 Scenario Development and Analysis 25
3.5 Infrastructure Sites and Costs 27
3.6 Stakeholder Engagement 28
3.7 Developing Recommendations 28
4 Baseline: Vehicles and Infrastructure 29
4.1 Fleet Composition 29
4.2 Emissions 32
4.3 Infrastructure 33
5 Vehicle Roadmaps 37
5.1 Introduction to Roadmaps 37
5.2 Plug-in Vehicles 37
5.3 Gas Vehicles 39
5.4 Hydrogen Vehicles 40
5.5 Other Fuels 41

6 Infrastructure Roadmaps 42
6.1 Introduction to Roadmaps 42
6.2 Electric Vehicle Recharging 42
6.3 Gas Refuelling 44
6.4 Hydrogen Refuelling 44
7 Vehicle and Infrastructure Forecasting 46
7.1 Vehicles 46
7.2 Infrastructure 50
7.3 Scenario Evaluation 52
8 Infrastructure Sites and Costs 54
8.1 Introduction 54
8.2 Site Types: Electric Vehicle Chargepoints 54
8.3 Site Types: Refuelling Stations for HGVs 55
8.4 Estimated Costs 57
8.5 Infrastructure for PSVs 58
9 Recommendations 60
9.1 Introduction to Recommendations 60
9.2 Cars 61
9.3 PSVs 64
9.4 Vans and HGVs 67
9.5 Public Sector: Leading by Example 72
9.6 Renewable Energy Generation 72
9.7 Economic Growth and Job Creation 73
9.8 Links with Other Policies, Strategies and Activity 74
10 Funding and Delivery 75
10.1 Funding 75
10.2 Delivery 77
11 Conclusions 80
Abbreviations 81

Executive Summary

Introduction

Ultra low emission vehicles can help reduce emissions which contribute to local air pollution and climate change and bring economic benefits through job creation and inward investment. The Cardiff Capital Region (CCR) City Deal Office commissioned Cenex to prepare this Ultra Low Emission Vehicle Strategy to set out how the region can accelerate the shift to cleaner vehicles.

This strategy covers public service vehicles (PSVs), cars, vans and HGVs and considers the period from 2021 to 2030. The fuels and technologies in scope are plug-in vehicles (pure battery electric, plug-in hybrid and extended range electric vehicles), compressed and liquefied gas and biomethane, hydrogen, and other fuels such as biodiesel.

This strategy establishes a framework for public and private sector decision makers to accelerate the transition to ULEVs. It provides recommendations for the City Deal Office to accelerate a transition to ULEVs and provides advice on which fuels and technologies to incentivise and when. The strategy should be used by decision makers within the CCR to guide their strategy development and investment decisions.

- The City Deal Office and other regional policymakers can use it to prioritise actions towards certain technologies and vehicles based on maturity and their expected contribution to achieving environmental objectives.
- Local authorities and private sector organisations can use the report to estimate what recharging and refuelling infrastructure is likely to be required to support a transition to ULEVs, and when and where it needs to be installed.
- The City Deal Office can signpost stakeholders to this report, use it to develop ULEV uptake targets, and an evidence base to support local, national and European funding bids.
- Public service vehicle (PSV) and freight fleet operators can use it to guide their decision making, ensuring they select the right vehicle technology and supporting infrastructure for their needs.

Methodology

The diagram below summarises the steps involved in this work.

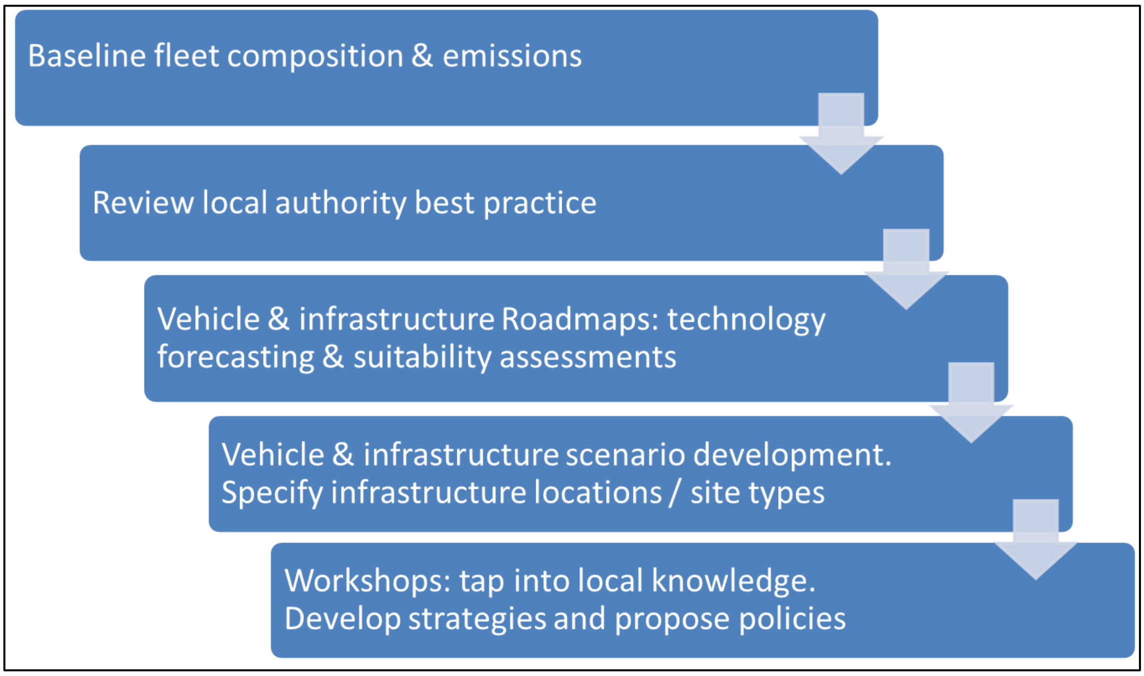


Figure 1. Methodology Flow Diagram.

Our methodology included the following:

- The baseline fleet composition was assessed using DfT registration statics and National Travel Survey data. Baseline infrastructure provision was mapped from a range of publicly available sources.
- Technology reviews involved a broad analysis of vehicle and infrastructure roadmaps.
- A range of ULEV scenarios were developed using forecasts from DfT, the Committee on Climate Change and Ricardo, and evaluated using DfT TAG Data Book damage costs approach. Infrastructure costs were estimated based on information provided by suppliers.
- Proposing site types for recharging and refuelling infrastructure for light duty vehicles.
- Stakeholder engagement, including workshops with PSV and commercial vehicle operators and local authority officers.

Baseline: Vehicles and Infrastructure

This section presents the baseline fleet composition and intrinsic emissions profiles of all vehicle types and the CO_2, NOx and PM emissions from road transport in the CCR. It also includes maps of the baseline network of chargepoints and refuelling stations. Key points:

- Many vehicles operating in the CCR are older, more polluting models.
- The CCR is behind the rest of the UK in rates of plug-in vehicle (PiV) adoption. Only 0.28% of the vehicle parc are PiVs, compared to the UK average of 0.65%.
- Significant investment in recharging and refuelling infrastructure is required to support PiV adoption.

Vehicle Roadmaps

The report includes roadmaps showing the current and forecast maturity and viability of different ULEV technologies that could help reduce emissions in the CCR up to 2030. In summary:

- Plug-in vehicle availability and performance will improve across all vehicle segments, with progress fastest for cars and light duty commercial vehicles.
- Gas vehicle availability may decline between 2025 and 2030 as electric vehicle technology continues to improve.
- Hydrogen is unlikely to reach high maturity and achieve significant market penetration before 2030.
- Renewable biodiesel can be used now to reduce GHG emissions from heavy vehicles.

Infrastructure Roadmaps

The report includes a series of roadmaps showing the current and forecast maturity and viability of recharging and refuelling infrastructure for ULEVs. In summary:

- Chargepoint network coverage will need to increase significantly. and offer more options for drivers without off-street parking.
- Through the 2020s infrastructure will offer faster charging to support longer range vehicles.
- Gas refuelling network coverage will increase steadily in the short term, though the longer term picture is less clear.
- There is uncertainty over the rate of the introduction of hydrogen refuelling; in the short-term small stations may be deployed, but would need to be backed by public subsidies.

Vehicle and Infrastructure Forecasting

The report presents two scenarios for ULEV uptake and deployment of recharging and refuelling infrastructure, showing two possible pathways to reach the target of 100% of new car and van sales being ULEVs in 2030.

- Uptake of ULEVs will remain low in the short-term, and then may increase significantly if sufficient measures are in place. Under the aspirational scenario 38% of cars and vans in the CCR could be ULEVs by 2030. This would require around 170 rapid chargers by 2025, and 1,500 by 2030, at a total estimated cost of £68m.

- There is debate about whether plug-in vehicles or hydrogen will displace diesel for HGVs, and about the timing of this displacement. Uptake of zero emission capable vehicles will be low until the late 2020s. A substantial increase in chargepoint and refuelling station network coverage is required to support the 'aspirational' ULEV uptake scenarios.
- There are significant social cost benefits associated with reducing emissions.

Infrastructure Sites and Costs

A network of chargepoints will be required to support householders who don't have off-street parking, EV drivers who cover relatively high mileages, and commercial vehicle fleets which can't charge at drivers' homes or depots. The network needs to provide good spatial coverage and enough density at key locations. The rate of charging provided should be matched to the likely vehicle downtime at that site, hence a combination of 7kW, 22kW, 50kW and 150kW units will be needed.

- Chargepoints should be located where vehicles are stationary and have time to charge, with the rate of charge provided being matched to the vehicle dwell time.
- Under the aspirational scenario around 170 rapid chargers will be required by 2025, and 1,500 by 2030, at a total estimated cost of £68m.
- Provision of on-street 7kW charging can open up EV ownership to residents without off-street parking, but there are multiple potential drawbacks to consider.
- Site types for HGV refuelling infrastructure can include industrial parks, business parks, ports and docks, sites near the motorway network and the SRN, freight consolidation and distribution centres and rail-road freight interchanges.
- Bus infrastructure will almost entirely be at depots and garages in the short term.

Recommendations

This report presents recommendations for the City Deal Office including a high level assessment of expected impact, cost and ease of implementation. Recommendations include:

Cars

- Workplace Parking Levies: assess the feasibility of implementing workplace parking levies in major urban areas.
- Fleet Reviews: fund independent fleet reviews to identify opportunities for accelerated ULEV uptake.

PSVs

- Engagement with PSV Operators: set up a PSV Working Group to provide structured engagement and collaboration between stakeholders.
- Technology Review and Best Practice Guidance: commission a detailed technology review for PSV operators.
- Lobby for Funding: lobby the Welsh Government and DfT for funding to support operators running low emission buses.

Vans and HGVs

- Engagement with Freight Operators: set up a Freight Working Group to provide structured engagement and collaboration between stakeholders.
- Encourage use of Biofuels: encourage HGV fleets to increase use of biofuels as 'bridging fuels' if other options are not viable.

Other

- Public Sector: Leading by Example: work with local authorities to lead by example and increase ULEV uptake in the public sector.

Charging Infrastructure

- The City Deal Office should work with the CCR local authorities, Western Power Distribution (WPD) and the private sector to facilitate a step-change in the provision of chargepoint infrastructure for plug-in cars and vans.
- Increasing chargepoint network coverage is likely to be the most effective measure to stimulate ULEV uptake by private and business car owners. Costs will be higher than for the recommendations listed above and implementation may be challenging, but without additional infrastructure ULEV uptake will remain low.

Regional Economic Development

Accelerating the transition to ULEVs can help the City Deal Office deliver economic growth through investment and upskilling. The Welsh low carbon economy already consists of 9,000 businesses, employing 13,000 people and generating £2.4 billion turnover in 2016[1]. There is ample potential for these numbers to grow: Innovate UK estimates that for every £1 invested in low and zero emission projects, companies will generate up to £8.40 in revenue over 5 to 10 years[2]. By adopting this ULEV Strategy and aiming to be an exemplar region for ULEV supply and use, the CCR can help attract additional investment to businesses based in the region. The City Deal Office should commission a study to investigate the potential for increased supply and uptake of ULEVs to contribute to regional economic development.

Funding and Delivery

Significant capital funding will be required to deliver the recommendations in this strategy, particularly for recharging and refuelling infrastructure. It is highly unlikely that the full costs can be met by the City Deal Office and the local authorities in the CCR. Funding will need to come from international, national and regional public sector bodies and private sector investors, particularly if the CCR aims for the best practice or exemplar vehicle scenarios. Funding options include:

- European grants and demonstrator funding through Horizon Europe, Interreg and NER 300.
- UK R&D funding from Innovate UK, and deployment funding via OLEV's grant schemes.
- Regional funding including the City Deal Capital Finance funding agreement.
- Private sector investment from investors, local businesses, social enterprise schemes, and Section 106 contributions.

The CCR City Deal Office should set up a ULEV Steering Group to implement this strategy and manage additional projects. It should monitor and report progress against this strategy, commission and manage delivery of further work, coordinate funding bids and lead on engagement with the private sector. In addition to setting up this group, key tasks for the City Deal Office should include:

- Ensuring there is a coherent and consistent approach to ULEVs across the CCR.
- Raising awareness of air quality, climate change and the need for an increase in ULEV uptake in the CCR among senior stakeholders including councillors and business leaders.
- Securing public sector funding for ULEV uptake and supporting infrastructure by lobbying Transport for Wales, the Welsh Government, DfT and OLEV.

Conclusions

This strategy can help the CCR achieve a step-change in uptake of ULEVs for all vehicle types in the region, contributing to objectives around GHG emissions, air quality and economic development. The roadmaps in this report show that in the 2020s there will be a significant improvement in the availability and operational and financial performance of a range of fuels for multiple vehicle types and applications. However, achieving significant increased market take-up and deployment will require additional policy action.

We recommend that the CCR aim for the aspirational scenarios for vehicle and infrastructure uptake. These are realistic and achievable with the right policies and measures in place. Setting lower goals will not put the region on a pathway to achieve net zero carbon emissions by 2050. Stating an ambition to become an exemplar region for ULEVs will help attract investment in recharging and refuelling infrastructure, which will in turn create the conditions for high rates of ULEV uptake.

2021 ULEV Strategy Update

This ULEV Strategy was commissioned in 2019 and first published in February 2020. It has been updated in May 2021 to reflect the latest policy and technology developments. The main changes made to the updated ULEV Strategy in 2021 were as follows:

- **Summary of progress** made by City Deal Office since the strategy was first published, highlighting funding secured for the CCR.
- **Updated definitions** of ULEVs, and new targets for ending the sale of new petrol and diesel cars and vans by 2030 explained.
- Full update of **policy and strategy context**, including European legislation updated with reference to Brexit. Updated summary policy roadmap.
- The **methodology** has been fully revised to reflect the new scenarios that were developed for this update. For cars and vans, replacing the three previous scenarios, the new report is based on two potential pathways from the current baseline to reach 100% ULEV sales in 2030. The methodologies for vehicle scenarios, infrastructure scenarios, costs (Capex and Opex), and damage costs mitigated have all been updated. For HGVs there are smaller updates to the methodology to reflect new scenarios published by the CCC.
- The **vehicle and infrastructure baseline** has been updated with the latest available data on vehicle registrations, travel patterns, and recharging and refuelling infrastructure availability.
- **Vehicle and infrastructure roadmaps** have been updated with new commentary added to reflect improvements in vehicle technology and availability. Key changes include more rapid advancements in plug-in vehicle technology; a reduction in the expected role of gas for buses in the later 2020s; and more commentary on residential, rapid and ultra-rapid charging, and updates on new technology like V2G and inductive charging.
- **Vehicle and infrastructure forecasts** have been fully revised to reflect the new car, van and HGV scenarios as described above, with new figures, tables and charts throughout.
    - In line with the more challenging target from central government, the numbers of ULEVs on the road is expected to increase. For example, in the new aspirational scenario, 38% of all vehicles on the road would be ULEVs in 2030, compared to 17% in the old exemplar scenario.
    - HGVs have changed less, the main updates being slightly accelerated uptake of pure electric vehicles and fuel cell trucks towards 2030.
- Total **infrastructure demand** has increased to reflect these updates.
    - We have revised our model to reflect trends in the industry towards rapid charging hubs rather than on-street residential charging. As a result the number of rapid chargepoints in the aspirational scenario is around 1,500 – compared to just over 500 in the previous exemplar scenario.
    - For HGVs accelerated deployment of zero emission vehicles mean there may be a need for hydrogen refuelling earlier than thought, perhaps soon after 2025, though there is some uncertainty around this.
- The **scenario evaluation** shows a substantial increase in damage costs mitigated, due to increases in the per-tonne figures, and an increase in the tonnes mitigated.
- **Costs** have increased significantly in line with the higher numbers in the scenarios. For example, in the new aspirational scenario, the total cost by 2030 is estimated at just under £60m, compared to £32m in the old exemplar scenario.
- Commentary added in the **recommendations** section on the potential division between providing on-street residential charging, or users being reliant on rapid charge hubs.
- Information on **funding** streams updated to reflect changes to UK government funding and access to European funding.

1 Introduction

This section outlines the context in which this strategy has been developed, defines the aim, objectives and scope and provides guidance for how it should be used.

Key points:

- Accelerating a shift to ultra low emission vehicles (ULEVs) can help reduce emissions which contribute to local air pollution and climate change.
- European, UK and Welsh policy and regulation has driven down new vehicle emissions. Policymakers should now focus on achieving net zero carbon emissions by 2050 or earlier, and supporting the phase out of new petrol and diesel cars and vans by 2030.
- Increasing the supply and operation of ULEVs can contribute to objectives around economic development and job creation.
- This strategy provides recommendations for the City Deal Office to accelerate a transition to ULEVs and provides advice on which fuels and technologies to incentivise and when.

The UK government aims to phase out the sale of new petrol and diesel cars and vans by 2030, and from 2035 all new cars and vans must be fully zero emission at the tailpipe. These targets will accelerate uptake of plug-in vehicles. For heavier vehicles a range of fuels and technologies have the potential to reduce emissions.

This change in fuel mix will reduce greenhouse gas (GHG) emissions, improve air quality, reduce noise pollution and deliver economic benefits as new jobs are created to build, service and operate these vehicles. This Ultra Low Emission Vehicle Strategy, prepared by Cenex[3], sets out how an accelerated shift to cleaner vehicles can position the CCR as an exemplar region for low emission transport.

This introductory section first defines the aim, objectives and scope of the strategy and provides guidance for how it should be used. It also outlines the context in which this strategy has been developed, covering local and global environmental challenges; international, national and local policy; and industrial strategy.

1.1 The Cardiff Capital Region

Figure 2. The Cardiff Capital Region as shown separated by local authority.

The CCR City Deal is a programme agreed in 2016 between the UK Government, the Welsh Government and ten local authorities in South East Wales (illustrated in the map above) to deliver regional economic growth through investment, upskilling and improved physical and digital infrastructure. The City Deal is funded via the CCR Investment Fund, comprising £500m each from the UK and Welsh governments and at least £120 million over the 20-year duration of the Fund from the ten local authorities. The City Deal Office and the local authorities have a vital role to play in improving the region's environmental, social and economic outcomes. This includes developing and implementing strategies and policies, influencing key stakeholders, and selective investment of public money.

1.1.1 Previous Work

This strategy is part of a broad effort by the CCR to ensure it is best placed to deliver, and benefit from, a transition to ULEVs. In 2018 the City Deal Office commissioned Cenex to assess the impact of zero emission capable vehicles on the recharging infrastructure and energy requirements at 11 metro sites across South East Wales. Cenex's Infrastructure Review[4] provided detailed and robust analysis of likely plug-in car uptake and associated chargepoint requirements, and higher-level estimates of the future demand from plug-in taxis, car clubs, and buses. Cenex has also developed a ULEV Taxi Strategy for the CCR, providing recommendations for changes to vehicle age and emissions licensing policy and a package of supporting measures and incentives to stimulate the uptake of ULEV taxis.

This ULEV Strategy was commissioned in 2019 and first published in February 2020. It has been updated in May 2021 to reflect the latest policy and technology developments. Since the original strategy was published, the CCR City Deal Office has made significant progress in supporting the deployment of ULEVs and associated infrastructure, including:

- Implementing the recommendations of a ULEV Taxi Strategy, also written by Cenex. The City Deal Office has recently procured 50 electric taxis which will be deployed via a 'try before you buy scheme' for regional operators.
- Securing funding for 112 on-street and car park chargers, which will be a combination of 7kW and 22kW units, as recommended by the WG's EV Charging Strategy for Wales[1]. Assets have already been installed in local authorities including Merthyr Tydfil and Caerphilly.
- Securing over £5m, in partnership with Bridgend and Cardiff and local authorities, to invest in sustainable public transport infrastructure.

1.2 Aim, Objectives and Outputs

1.2.1 Aim and Objectives

The aim of this strategy is to establish a framework for public and private sector decision makers to develop action plans to accelerate the transition to ULEVs. It will also inform the design and implementation of strategies and policies to increase supply and uptake of ULEVs, reflecting current and forecast financial, environmental and operational performance of different technologies. Ultimately the transition to ULEVs will help achieve the following objectives:

- Improved air quality, bringing non-compliant areas within limit values and improving public health outcomes.
- Reduced GHG emissions, contributing towards Wales' net zero carbon ambition.
- Increased regional economic development and inward investment.

The key outputs from this strategy are a longlist of recommendations and measures that the City Deal Office should consider implementing, working in partnership with local authorities and other stakeholders in the CCR.

1.3 Scope and Definitions

1.3.1 Vehicle Types

This strategy covers public service vehicles (PSVs), cars, vans, HGVs and, to a lesser extent, motorcycles.

PSVs comprises buses and coaches (more than 16 seats) and minibuses (16 seats or fewer). This strategy focuses primarily on buses, as the City Deal Office and local authorities may have more influence over vehicle procurement and use than for coaches and minibuses. Buses provide vital connectivity for residents and can produce relatively low pollution and GHG emissions on a per passenger kilometre basis. Buses have relatively long lifecycles and therefore older, more polluting vehicles are often still on the road many years after cleaner emissions standards have come into force for new vehicles. They tend to operate in densely populated urban areas where the negative impacts of pollution have the greatest consequences for public health. As a result, even though vehicle numbers are relatively low, helping PSV operators transition to ULEVs will have a substantial impact on local air quality and GHG emissions reduction.

Cars are a significant source of emissions in the CCR because of the number of vehicles on the road, an increase in sales of diesel vehicles over the past 10 years, and variance between official and real world emissions performance. The technology roadmaps in Section 5 illustrate that there is a relatively clear pathway for the UK's car fleet to transition from petrol and diesel to plug-in variants. The UK government intends to end the sale of new petrol and diesel cars and vans by 2030, and for all new cars and vans to be zero emission at the tailpipe from 2035. Cars typically have a shorter lifecycle than HDVs and therefore low emission technology will penetrate the fleet relatively quickly.

[1] https://gov.wales/sites/default/files/publications/2021-03/electric-vehicle-charging-strategy-wales.pdf

Regional action should be taken to reduce car emissions but should not detract from a focus on HDVs, for which emissions cuts are more complex and challenging.

Vans and HGVs deliver the goods and services needed to grow the economy in the CCR. However, HGVs can produce significant emissions, particularly where older vehicles are still in use. Until recently, new vans had much higher real world emissions than their test cycle values. This strategy reflects the contribution that freight vehicles make to emissions in the CCR and the challenges associated with mitigating these emissions. Arguably more focus – and potentially funding – will be required to support the transition to ULEVs for HGVs than for any other vehicle type.

Motorcycles are in scope of the emissions baselining in this strategy but are not addressed in detail because of their small numbers on the road and low intrinsic emissions levels. Motorcycles present some issues, not least noise pollution, but in terms of air quality and GHG emissions they do not require significant focus.

1.3.2 Definitions

For the purposes of this strategy ULEVs are defined as follows:

- For buses we use the Zemo Partnership's definition of an ultra low emission bus as meeting or exceeding Euro VI emissions standards while reducing CO_2 emissions at least 30% compared to a conventional vehicle.
- For light duty vehicles (cars and vans) we use the UK Government definition of a ULEV as a vehicle which emits less than 50g CO_2 per kilometre irrespective of the Euro Standard. For these vehicles, the strategy focus on the uptake of zero emission capable vehicles, which can drive while emitting zero emissions from the tailpipe.
- For HGVs, there is no agreed definition of a ULEV. At the time of writing a definition is being developed by the Zemo Partnership. For simplicity we apply the same definition as for a ULEV bus, i.e. a vehicle that meets or exceeds Euro VI emissions standards while reducing CO_2 emissions at least 30% compared to a conventional vehicle.

1.3.3 Timescale

This strategy covers 2021 to 2030. Up to 2030 we have relatively high confidence in the information presented in this report including the pathways for technology and policy development and the scenarios for potential ULEV uptake. This timescale should provide enough visibility for stakeholders to develop their own strategies and make investment decisions, even for fleet operators with relatively long vehicle lifecycles. Beyond 2030, there are too many uncertainties in technology and policy for us to provide forecasts or recommendations with sufficient confidence.

1.3.1 Fuels and Technologies

The fuels and technologies in scope are plug-in vehicles (pure battery electric, plug-in hybrid and extended range electric vehicles), compressed and liquefied gas and biomethane, hydrogen, and other fuels such as biodiesel. These are explained in detail in Section 3.

As a ULEV strategy, this document focuses on measures to increase uptake of these fuels and technologies when new vehicles are acquired. Significant emissions cuts can also be achieved by removing the oldest, most polluting vehicles from the fleet and this is considered to a lesser extent within this strategy.

1.3.2 Out of Scope

The following topics or technologies are not in scope of this strategy:

- Taxi and private hire vehicles. Cenex has already developed a specific strategy for the CCR for these vehicles.
- Non-motorised road transport, any form of active travel including electrically assisted pedal cycles, or strategies to reduce vehicle ownership and use to tackle congestion.
- Development of a detailed strategic or business case for investing in ULEVs for the CCR or fleet operators.

- Consideration of installing chargepoint infrastructure on private property including domestic and business premises.
- Micro-siting recharging and refuelling infrastructure and site-specific costing for installation. Micro-siting decisions should be taken by public and private sector providers using the information in this document as a guide.

1.4 Purpose and Intended Use

The strategy should be used by decision makers within the CCR to guide their strategy development and investment decisions:

- The City Deal Office and other regional policymakers can use it to prioritise actions towards certain technologies and vehicles based on maturity and their expected contribution to achieving environmental objectives.
- Local authorities and private sector organisations can use the report to estimate what recharging and refuelling infrastructure is likely to be required to support a transition to ULEVs and when it needs to be in place.
- Local authorities can use the strategy to identify sites for recharging and refuelling infrastructure, working with the private sector to develop a comprehensive regional network to support ULEV adoption.
- Infrastructure providers, such as EV chargepoint and gas refuelling station operators can use the technology roadmaps and the scenarios for likely ULEV uptake to help develop business cases for setting up new sites.
- The City Deal Office can use this report as a resource to signpost stakeholders towards, as a framework to develop ULEV uptake targets, and an evidence base to support local, national and European funding bids.
- Organisations in the fleet supply chain, including manufacturers, converters, retrofit suppliers and aftersales support providers, can ensure they are ready to take advantage of growth in new parts of the automotive sector.
- PSV and freight fleets can use the strategy to guide their decision making around selecting the right vehicle technology and supporting infrastructure for their needs. This strategy does not provide detailed implementation plans or propose specific locations for infrastructure for private sector fleet operators, as these decisions should be taken by the operators themselves.

1.5 Environmental Context

This strategy will help tackle local air pollution and climate change caused by GHGs, both of which result from the combustion of fossil fuels. This strategy proposes measures which tackle both areas, with the minimum requirement that any action reduces one type of emission without increasing the other. We do not consider solutions which improve air quality while increasing GHGs or vice versa.

1.5.1 Air Pollution Emissions

Poor air quality is the greatest environmental risk to public health in the UK. Public Health Wales estimates the burden of long-term air pollution exposure to be the equivalent of 1,000 to 1,400 deaths (at typical ages) each year and has been linked to a wide range of conditions including cancer; asthma; and heart, respiratory and cardiovascular disease. The pollutants of most concern are:

- Nitrogen oxides (NOx) which include nitrogen dioxide (NO_2). Long-term exposure to high concentrations can reduce lung function and exacerbate respiratory conditions.
- Particulate matter (PM)[5]. Larger particles can damage the lungs while smaller particles can enter the bloodstream and aggravate cardiovascular conditions.

These pollutants can come from any source of combustion of fossil fuels, including gas boilers and industrial processes. Road transport is a major source of these emissions and the location of the emissions is important; areas with high levels of emissions are often densely populated urban areas where population exposure will be significant. Defra's UK Ambient Air Quality Interactive Map[6] shows that high pollution concentrations are typically recorded close to busy or congested roads. Defra's Clean Air Strategy (2019)[7] estimates that the health and social care costs of air pollution in England could reach £5.3 billion by 2035. As a result, implementing measures to tackle air pollution should be priorities for national and local government.

The area covered by the 10 local authorities in the CCR is mostly rural and therefore has relatively good air quality. However, high levels of NO_2 are consistently recorded at the roadside in urban areas across South Wales, particularly in Cardiff and Newport but in many other urban centres across the region as well.

1.5.2 Greenhouse Gas Emissions

Climate change is one of the greatest challenges facing the world today. The Earth's average surface temperature has risen by 0.7 to 0.9°C since 1901 and most of this warming has occurred recently; the 20 warmest years on record have all been in the past 22 years[8]. There is strong evidence that this is primarily driven by anthropogenic GHG emissions, particularly carbon dioxide (CO_2)[9]. Climate change is strongly associated with a range of negative impacts including rising sea levels, declining sea ice and increased occurrences of extreme weather events[10].

Although UK GHG emissions have dropped 43% in total since 1990, transport has been the largest GHG emitter of any UK economic sector since 2016, accounting for 26% of emissions[11]. The latest Committee on Climate Change (CCC) report shows that transport is the worst-performing sector in the country and emissions have risen in four of the five most recent years[12].

1.6 Policy context

This sub-section outlines the main policies and legislation to reduce pollutant and GHG emissions at European, UK and regional levels.

1.6.1 European Policies and Legislation

Current guidance from the UK government indicates that European Union (EU) vehicle emissions standards and targets will be applied even though the UK is no longer an EU member state[2].

The **European Ambient Air Quality Directive (2008)** places legal obligations on EU (EU) member states to meet air quality limit values. The directive has been ratified by the Air Quality Standards (Wales) Regulations 2010, and therefore Wales is required to meet limit values even though the UK is not an EU member state.

The **Clean Vehicles Directive (2009)** requires public sector organisations to consider vehicles' environmental performance during procurement. It defines a common approach for monetising the lifecycle impacts of vehicles' energy consumption, GHG emissions and pollutant emissions.

The **Euro Emissions Standards** regulate vehicles' intrinsic pollutant emissions. New vehicles must comply with the latest standards (Euro 6 for light duty vehicles and Euro VI for heavy vehicle engines). NOx emissions have fallen less than expected because 'real-world' emissions are often higher than tested values, particularly for light duty diesel vehicles[13]. To address this issue, the EC has introduced the Real Driving Emissions (RDE) test procedure, which better reflects real-world vehicle use and will reduce the discrepancy between test and in-service emissions. Light duty vehicles certified as Euro 6d-TEMP or Euro 6d meet RDE standards.

The EU has set mandatory **CO_2 Emissions Standards** for new cars and vans since 2009 and 2011 respectively. The current targets are 95g CO_2 per kilometre for new cars (since 2021) and 147g CO_2 per km for vans (since 2020). These will be tightened further, with manufacturers required to achieve reductions of 15% from 2025 for cars and vans, and 37.5% and 31% from 2030 for cars and vans respectively.

Intrinsic emissions from HDVs have remained roughly constant over the last 20 years as there has been little incentive and no regulation to improve performance. In 2019 the EU set CO_2 emissions

---

[2] https://www.gov.uk/government/consultations/regulating-co2-emission-standards-for-new-cars-and-vans-after-transition/co2-emission-performance-standards-for-new-passenger-cars-and-light-commercial-vehicles

standards for heavy goods vehicles (HGVs)[14] for the first time. Manufacturers must reduce fleet-wide average CO_2 emissions by 15% by 2025, compared to the EU average from July 2019 to June 2020. They must achieve a 30% reduction from the same baseline by 2030. Manufacturers must ensure that at least 2% of new trucks sold are low or zero emission by 2025. Initially, these standards will only apply to HGVs. The European Commission is expected to review the HDV market in 2022 and will consider extending the scope to cover buses and coaches.UK Policies, Legislation and Strategy.

Air Quality

Local authorities have a statutory duty to monitor air quality. If an authority identifies a location where national and EU objectives are unlikely to be met, it must declare an Air Quality Management Area (AQMA) and develop a local Air Quality Action Plan (AQAP) to show how it will improve air quality. For some cities, the AQAP will include a Clean Air Zone (CAZ). CAZs may not be enough for some cities to comply with air quality limit values or they may not be the most suitable solution. In addition, they do not tackle GHG emissions resulting from fossil fuel combustion. Accelerated uptake of ULEVs is therefore required to help urban areas minimise all road transport emissions.

Greenhouse Gas Emissions

The Climate Change Act (2008) legislated a national target to cut GHG emissions by 80% by 2050, compared with 1990 levels. In 2019, the UK government amended the Climate Change Act (2008) with a commitment to reach net zero carbon emissions by 2050[15].

1.6.2 Welsh Policies and Legislation

Air Quality

The Wales Environment Act (2015) requires local authorities to designate an AQMA when national air quality objectives are not being achieved or are unlikely to be achieved. 45 AQMAs are in place across the CCR (an increase from 30 when this ULEV Strategy was first prepared in 2019), with all local authorities except Blaenau Gwent and Torfaen having at least one within their jurisdiction. More action is needed to shift to ULEVs to bring air pollution in these areas below legal limits.

The Well-being of Future Generations (Wales) Act (2015) requires public bodies to take a proactive and joined-up approach to sustainability. As such it underpins all policy developed in Wales and ensure emissions reductions are considered during planning decisions.

GHG Emissions

In April 2019 the Welsh Government published *Prosperity for All, A Low Carbon Wales*, which outlines the benefits of moving towards a low carbon economy and makes commitments including:

- Developing a low carbon public transport system, and an ambition for a zero emission bus, taxi and private hire vehicle fleet by 2028.
- Investing £2m in the short-term to facilitate a network of rapid EV chargepoints.
- Working to achieve a modal shift from car dependency to sustainable forms of transport.
- Requiring new non-residential developments with at least 10 car parking spaces to install chargepoints in at least 10% of these spaces.

In March 2021, Senedd Cymru approved a net zero target for 2050. It also set an interim carbon budget for 2021-2025, during which time a 37% reduction in GHG emissions must be achieved. A detailed plan for achieving this budget will be published later in 2021. Strategic guidance is contained in the Wales Transport Strategy 2021. The Welsh Government has also stated an aim to achieve a zero emission bus and taxi/private hire vehicle fleet by 2028.

1.6.3 Summary of Policy Context

The main policies likely to affect road transport and encourage a shift to ULEVs are illustrated in the roadmap below.

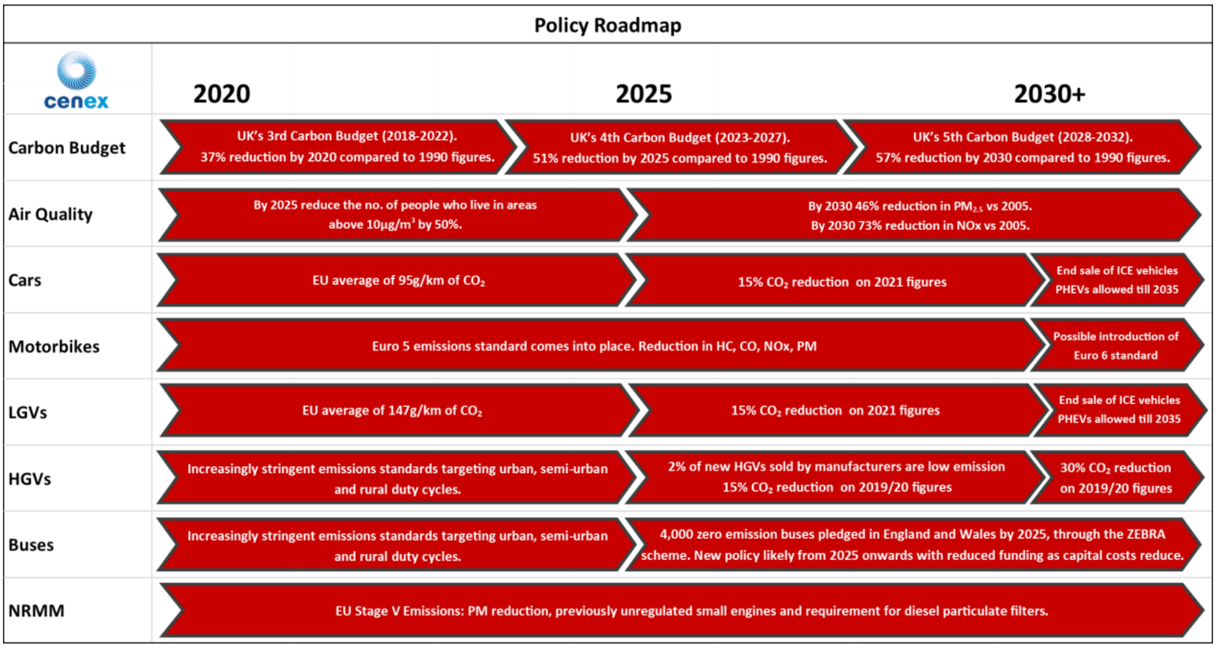


Figure 3. Policy Roadmap

1.7 Industrial Strategy

Accelerating the transition to ULEVs can help deliver clean economic growth, create high value jobs and attract inward investment. Implementing measures to reduce road transport emissions form part of the UK Government's Industrial Strategy[16], which aims to increase the country's competitiveness in the context of global economic trends. The strategy aims to boost productivity by helping businesses invest in skills, industries and infrastructure. It recognises the importance of increasing supply and uptake of EVs for the environmental and economic benefits they can deliver.

The UK already has significant expertise in areas including EV manufacturing, renewable energy generation and smart energy systems and can develop these areas further by stimulated increased demand for EVs. This can also be broadened to encompass the supply and uptake of alternative fuels and infrastructure and development of the supply chain for these products.

The Department for Transport (DfT) has committed to a range of measures to stimulate ULEV uptake, including:

- A £400 million charging infrastructure investment fund to help companies that produce and install chargepoints.
- The Electric Vehicle Homecharge Scheme (EVHS) provides grant funding of up to 75% towards the cost of installing electric vehicle chargepoints at domestic properties across the UK.
- The continuation of the plug-in car and van grants:the grant scheme was renewed in 2020, with £582 million of funding intended to last until at least 2022.
- The launch of an EV energy taskforce to bring together the energy and automotive industries to plan for the increase in demand on energy infrastructure that will result from a rise in the use of EVs.
- New powers through the Automated and Electric Vehicles Bill to ensure chargepoints are easily accessed and used across the UK, available at motorway service areas and large fuel retailers.

With the right policies in place the UK can continue to be at the forefront of the design and manufacturing of ULEVs for domestic and global markets. There are already more than 350,000 ULEVs and over 23,000 public chargepoints in the UK and demand for these products will increase significantly as we work towards achieving net zero emissions by 2050. Within the UK, there will be regional competition to attract government support and private sector investment in these markets.

Regions which take an ambitious approach to stimulating uptake of ULEVs and facilitating the development of the ULEV supply chain will be well placed to attract this funding.

1.8 Structure

The structure of the remainder of this document is as follows. Section 2 summarises the approach and methodology used to develop this strategy. Section 3 introduces the different ULEV fuels and technologies discussed in the strategy. Section 4 shows the baseline for the region in terms of the current fleet composition and associate emissions. Sections 5 and 6 present technology roadmaps for vehicles and infrastructure respectively. Section 7 contains the forecasts and scenarios for ULEV uptake for all vehicle types. Section 8 outlines the potential site types for recharging and refuelling infrastructure and the costs associated with developing this network. Section 9 presents a longlist of potential recommendations and measures that the CCR City Deal Office could take or facilitate. Section 10 discusses how these recommendations might be funded and delivered, and Section 11 concludes the strategy.

2 Technology Overviews

This section describes the alternative fuels and technologies which could meet the ULEV definitions provided in the previous section.

Key points:

- Plug-in vehicles are a mature technology with good availability for light duty vehicles and buses
- Gas vehicles are a mature technology with good availability for HGVs and buses.
- Hydrogen is a developing technology with limited availability.
- Other fuels such as biodiesel can be used in conventional vehicles in the short term to reduce GHG emissions.

2.1 Guide to Technology Overviews

This section provides a high level overview of current operational, environmental and financial performance for each fuel or technology in a range of vehicle types, plus infrastructure requirements and vehicle availability. This information is intended to be a summary to support understanding of later parts of this document, rather than detailed technical guidance. In the vehicle availability sub-sections we outline the general state of the market, highlighting specific vehicles where applicable and signpost sources of more detailed information.

2.2 Plug-in Vehicles and Infrastructure

2.2.1 Operational, Environmental and Financial Performance

Plug-in vehicles include pure battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs) and extended range electric vehicles (E-REVs). BEVs store energy in a battery (usually lithium-ion) and deliver power to the wheels through an electric motor. Braking energy is captured by the electric motor and stored as electrical energy in the battery. PHEVs and E-REVs both have an internal combustion engine as well as a battery and electric motor. PHEVs are parallel hybrids, which means the wheels can be driven by either the combustion engine or the electric motor. E-REVs are series hybrids, so the wheels are always powered by the electric motor and the battery is recharged by the combustion engine.

- **Operational**: Plug-in vehicles are a mature technology with good availability for light duty vehicles and single deck buses. Key considerations include range, charging requirements and, for commercial vehicles, payload. Modern BEVs provide a range of around 150 to 250 miles on a single charge depending on the vehicle type and model.
- **Environmental**: Plug-in vehicles have zero tailpipe emissions when operating in electric power. BEVs therefore have no tailpipe emissions, while emissions from PHEVs and E-REVs depend on the proportion of miles driven on electric power. Well-to-wheel (WTW) GHG emissions are significantly lower for electricity than for petrol and diesel vehicles, even when standard UK grid electricity is used.
- **Financial**: Plug-in vehicles typically have an upfront cost premium compared to conventional vehicles but offer significantly lower running costs (fuel and maintenance). Payback can be achieved under a wide range of conditions for light duty vehicles. For HDVs, relatively high mileage and long vehicle lifecycles may be required to achieve a cost benefit.

2.2.2 Infrastructure

The key considerations for chargepoint infrastructure are speed (rate of charging) and connector type.

- **Speed**: For this strategy we have concentrated on three commonly supplied rates of charging: standard (7kW) which can supply a full charge in five to eight hours, fast (22kW) which typically provides an 80% charge in 1.5 to two hours, and rapid or ultra-rapid (50kW+) which provides an 80% charge in around 20 minutes to one hour depending on the battery capacity[17].
- **Connector type**: Standard charging is supplied by a Type 1 or Type 2 alternating current (AC) connector. Vehicles will be supplied with the appropriate lead for connecting to the relevant chargepoint. Units are typically installed at residential or workplace sites and on the kerbside. Fast and rapid charging can be supplied by either AC or direct current (DC). AC rapid charging is always supplied via a Type 2 connector. Rapid and ultra-rapid chargepoints have tethered cables for AC and DC charging.

2.2.3 Vehicle Availability

- **Buses**: Single deck and double deck BEVs are available from several manufacturers including Optare, BYD and Alexander Dennis.
- **Cars**: Most major manufacturers now offer BEVs and PHEVs in segments ranging from small cars to SUVs. Refer to the OZEV website[18] for a regularly updated list of cars eligible for the Plug-in Car Grant.
- **Vans and HGVs**: The plug-in commercial vehicle market is growing, with an increasing range of BEV and PHEV vans and a small number of plug-in HGVs. Refer to the OZEV website[19] for a regularly updated list of vehicles eligible for the Plug-in Van Grant including vehicles over 3.5t gross vehicle weight (GVW).

2.3 Gas Vehicles and Infrastructure

2.3.1 Operational, Environmental and Financial Performance

Natural gas is predominantly methane and is the same fuel used by central heating boilers and cookers in the UK. It is a clean burning fuel, with lower levels of pollutant and GHG emissions than conventional mineral fuels. Compressed Natural Gas (CNG) is stored on vehicles in pressurised cylinders at 200 to 250 bar and combusted in a dedicated gas engine. Liquefied natural gas (LNG) has been cooled to -160 degrees centigrade and can be stored as a liquid. LNG has a higher energy density than CNG which means more fuel can be stored in the same space, extending range and reducing refuelling frequency.

Biomethane is a renewable fuel that is chemically identical to fossil fuel natural gas. Biomethane can be used as a direct replacement for natural gas in compressed (bio-CNG) or liquefied (bio-LNG) form. Gas vehicles only offer a significant environmental advantage compared to diesel if they are fuelled with biomethane.

- **Operational**: Gas vehicles are a mature technology with good availability for HGVs and buses. Range is similar to a conventionally fuelled vehicle. Vehicles can be run on natural gas or biomethane interchangeably with no impact on fuel consumption, maintenance costs or warranty considerations. The key consideration is refuelling requirements as there is little infrastructure available in or near the CCR.
- **Environmental**: CNG and LNG vehicles typically produce similar GHG and pollutant emissions than petrol or diesel vehicles. Bio variants of these fuels can reduce GHG emissions by around 85% compared to diesel.
- **Financial**: Gas vehicles cost more than a conventional diesel but offer running cost savings as the fuel is usually cheaper than diesel on a pence per mile. The additional vehicle capital cost can be repaid if lifecycle mileage is high enough.

2.3.2 Infrastructure

Refuelling a gas vehicle takes around the same length of time as a conventional diesel vehicle. CNG stations can have a direct national grid connection or have CNG delivered by tanker (a so-called mother and daughter arrangement). Both options can be used to supply CNG and bio-CNG. Gas from grid-connected stations is compressed on-site for dispensing into vehicles. The local gas main must have enough pressure and capacity to supply the required demand. Connecting to a relatively high-pressure part of the gas network reduces the compression needed and therefore lowers costs and slightly reduces WTW GHG emissions. Installation costs increase with distance from the network to the dispensing unit. A lower pressure connection will require additional compression and supply fewer vehicles. However, it may be suitable if vehicles are stationary for several hours, allowing gas to be compressed into tanks gradually. Mother and daughter stations refuelled by tanker offer flexibility as the location and capacity can easily be adapted.

2.3.3 Vehicle Availability

- **Buses**: Gas vehicles are widely available from manufacturers including Scania and MAN.
- **Cars**: There are no gas powered cars available on the market in the UK.
- **Vans and HGVs**: Most major manufacturers offer gas vehicles at the heavier end of the commercial vehicle market.

Refer to the Gas Vehicle Hub[20] for details of available gas vehicles.

2.4 Hydrogen Vehicles and Infrastructure

2.4.1 Operational, Environmental and Financial Performance

Hydrogen is a safe, clean burning energy source which can offer significant GHG emissions benefits. It is stored on vehicles in compressed hydrogen cylinders and can be used to power a vehicle in one of two ways. Fuel cell vehicles use hydrogen in conjunction with a battery which powers an electric motor. Dual fuel systems mix and combust hydrogen and diesel in a compression ignition engine. Hydrogen can be derived from processes including water electrolysis and gasification of biomass or petroleum fuels. It requires high pressure storage on vehicles to provide sufficient range. Refuelling stations typically provide hydrogen at either 350 or 700 bar.

- **Operational**: Hydrogen vehicles are a medium maturity or developing technology. Hydrogen powered buses can provide a range of up to 200 miles making them well suited to longer routes. For HGVs, challenges include lack of vehicle availability and refuelling requirements as there is no station network in the CCR.
- **Environmental**: Hydrogen combustion produces only water as an emission. Fuel cell vehicles have zero tailpipe emissions and dual fuel systems offer a reduction in tailpipe emissions in proportion to the volume of diesel displaced by hydrogen. WTW GHG emissions vary depending on whether grid or renewable electricity is used to make the hydrogen.
- **Financial**: Hydrogen vehicles cost more upfront than conventionally fuelled equivalents and running costs are also higher than petrol or diesel.

2.4.2 Infrastructure

Refuelling a hydrogen vehicle takes around the same length of time as a conventional diesel vehicle. A hydrogen refuelling station (HRS) consists of a high pressure storage system and one or more dispensers. It can also include a production unit if hydrogen is made on site. Alternatively, hydrogen can be delivered to the station and compressed on site. There is currently no refuelling network in the CCR making deployment of hydrogen vehicles challenging.

2.4.3 Vehicle availability

There are no hydrogen fuel cell or dual fuel vans available from major manufacturers. Retrofit suppliers include ULEMCo for dual fuel systems. Resources for finding out about future vehicle availability include Hydrogen Mobility Europe[21].

2.5 Other Fuels

2.5.1 Operational, Environmental and Financial Performance

This category includes hydrotreated vegetable oil (HVO) and high blend biodiesel (B100 or FAME).

HVO

HVO is a renewable fuel primarily produced from waste pressings from vegetable oils. It is chemically identical to conventional fossil fuel diesel.

- **Operational**: Range is the same as for conventional diesel vehicles. HVO is a 'drop-in' fuel, which means it can be substituted for conventional diesel with no impact on operational requirements. It is approved by a growing number of vehicle manufacturers for use at blend levels up to 100% under standard maintenance and warranty conditions.
- **Environmental**: HVO combustion is similar to conventional diesel so tailpipe emissions will not be impacted. It can reduce GHG emissions by around 90% compared to diesel.
- **Financial**: There is no cost premium for the vehicle and the fuel is slightly more expensive per litre than conventional diesel so there are no TCO savings.

High Blend Biodiesel

High blend biodiesel is derived from a variety of vegetable oils and is typically used as a blend such as B30 (30% biodiesel and 70% conventional diesel) or B70 (70% biodiesel and 30% conventional diesel).

- **Operational**: Range is the same as for conventional diesel vehicles. High-blend biodiesel storage may require additional equipment and management compared to conventional diesel.
- **Environmental**: Biodiesel combustion is similar to conventional diesel, so tailpipe emissions will not be impacted. GHG emissions savings depend on the blend of biodiesel used. For example, B30 from used cooking oil can reduce WTW GHG emissions by around 28%.
- **Financial**: There is usually no cost premium for the vehicle. High biodiesel blends are slightly more expensive per litre than conventional diesel so there are no TCO savings.

2.5.2 Infrastructure

There is no public refuelling for HVO or high blend biodiesel in the UK so fleets would need to have depot based bunkered fuel.

2.5.3 Vehicle Availability

HVO and high blend biodiesel can be used in conventional diesel compression engines, though fleets must check with the manufacturer first to ensure the vehicle warranty will not be invalidated.

3 Methodology

This section summarises the methodology used to develop this strategy.

Key points:

- The baseline fleet composition was assessed using DfT registration statics and national Travel Survey data. Baseline infrastructure provision was mapped from a range of publicly available sources.
- Technology reviews involved a broad analysis of vehicle and infrastructure roadmaps.
- A range of ULEV scenarios were developed using forecasts from DfT, the Committee on Climate Change and Ricardo, and evaluated using DfT TAG Data Book damage costs approach.
- Infrastructure unit costs were requested from suppliers and will be used later in the report to estimate total infrastructure capital costs.
- We also engaged with local stakeholders including via bus and freight workshops.

3.1 Summary of Methodology

The diagram below summarises the key steps involved in this work. These are explained in more detail below.

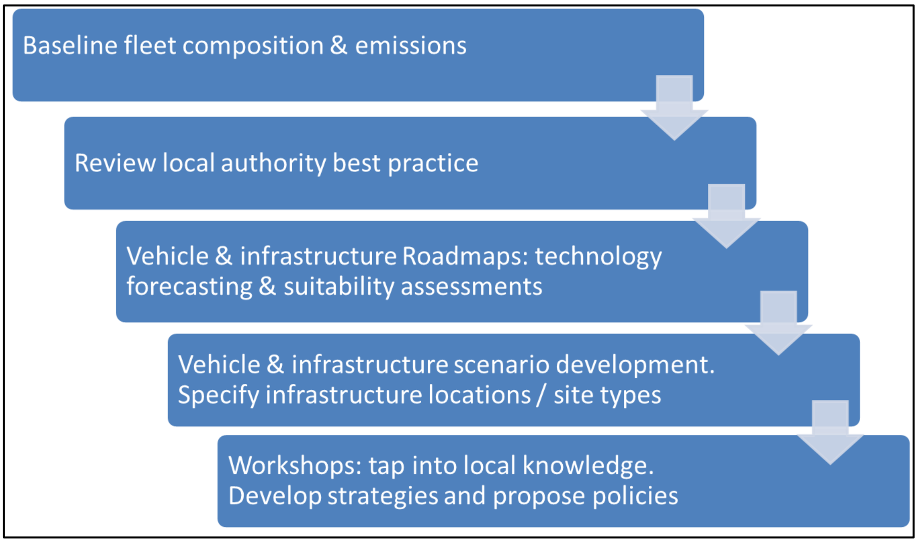


Figure 4. Methodology Flow Diagram.

3.2 Baselining

3.2.1 Fleet Composition and Emissions

We used a range of UK[3] government reports and datasets to build up a picture of the various fleet types in the region and estimate their contribution to GHG and pollutant emissions. This was carried out via the following steps.

Fleet Composition

[3] Local authority or Welsh data was used where available. UK datasets were used when this was the best available.

- Details of vehicles registered in the CCR region were taken from DfT vehicle registrations data[22],[23]. This provides a breakdown of vehicles by year of registration, fuel type, Euro emissions standards and, for some vehicles, tailpipe CO_2 emissions[4].
- Similar regional datasets were collected for the CCR for all vehicle types[24,25]. Transport for Wales (TfW) provided additional region-specific data for PSVs[5].
- These datasets allowed us to develop a model of the fleet composition in the CCR based on the estimated number of each vehicle type in the region.

Emissions

- Emissions were calculated using a 'bottom up' approach. We calculated emissions for individual vehicles within each category based on estimated mileage and known official tailpipe emissions factors and then multiplied the results by the number of vehicles of that type registered in the CCR.
- We collated a range of UK government sources to obtain estimated annual mileage for each vehicle type[26]. Additional duty cycle data was taken from a range of sources to support this analysis[27],[28],[29].
- We combined the fleet composition data, annual mileage estimates and DEFRA emissions conversion factors[30] to estimate annual GHG and pollutant emissions for individual vehicles within each vehicle category and for each category overall.

3.2.2 Infrastructure

We assessed current provision of ULEV recharging and refuelling infrastructure using the following sources:

- **Plug-in vehicle charging infrastructure**: We mapped chargepoint locations from the National Chargepoint Registry (NCR)[31], which Cenex manages on behalf of OLEV.
- **Gas refuelling infrastructure**: Gas refuelling station locations were taken from the Gas Vehicle Hub (GVH)[32]. The GVH, managed by Cenex, provides impartial information about the costs and benefits of operating natural gas trucks within the UK, supported by case studies from fleets already using the technology. The Hub also hosts an up-to-date, searchable, map of the UK's natural gas refuelling infrastructure.
- **Hydrogen refuelling infrastructure**: Hydrogen refuelling station locations were drawn from Zap-Map and the H_2Stations.org website[33].

The outputs from the baseline analysis are in section 4.

3.3 Technology Reviews

Next, we reviewed current and forecast ULEV technologies for each vehicle type in scope. Different fuels and technologies are at different levels of technical and economic maturity; some are ready for uptake and can deliver environmental and economic benefits, while others are either not cost effective or their benefits are not yet proven.

For each vehicle type and fuel, we assessed current and forecast technology maturity and product availability, cost performance and tailpipe and WTW emissions performance. The review covered vehicles and the recharging or refuelling infrastructure that would be required to support their deployment. For the infrastructure we reviewed types and compatibility, current and forecast technology maturity and product availability, hardware and installation costs and installation process.

[4] DfT vehicle registration data is published annually, usually in April. This updated report was prepared in early May 2021, at which time 2020 data had not yet been released. We have used 2019 data – this will not have a significant impact on the outputs as the scenarios for 2025 and 2030 are the primary drivers behind the analysis and recommendations.

[5] DfT data for the CCR indicated there were 4,051 PSVs registered in the region when the data was accessed in 2019. TfW report that 1,920 of these are buses and coaches with more than 16 seats. The remainder (2,131) are assumed to be minibuses with 16 seats or fewer.

The review used Cenex's in-house knowledge repository built up from delivering a range of ULEV projects for public and private sector clients, and desk-based research to update this information with details of new or planned vehicle releases and developments in vehicle and infrastructure technology. Finally, we undertook telephone interviews with a selection of vehicle and infrastructure manufacturers and suppliers to check our understanding of the market and fill in any remaining knowledge gaps.

The output from this review was a series of roadmaps which illustrate the expected introduction of different technologies for different applications. Organisations such as the Advanced Propulsion Centre (APC) and the Automotive Council already produce similar roadmaps to show likely trends in technology development, the legislative environment, or end user requirements. We analysed roadmaps produced by multiple organisations, so the results presented in this report represent a broad consensus across the market.

Our roadmaps add value to those already available as they illustrate the expected implementation phases of each technology based on when each option is expected to reach operational maturity and commercial readiness for different vehicle types. The outputs are specifically geared towards helping local authorities and fleet decision makers decide which fuel or technology to deploy and when. The roadmaps are in Sections 5 and 6.

3.4 Scenario Development and Analysis

Next we developed a set of scenarios for ULEV and infrastructure uptake in the CCR, starting from the measured baseline and based on the likely technology pathways for each fuel and vehicle type as shown in the roadmaps.

3.4.1 Scenario Development: Vehicles

We developed two scenarios for ULEV uptake for cars, vans and HGVs as defined below[34].

Cars and Vans

- Low Uptake: this scenario assumes that 100% of new car and van sales will be ULEVs in 2030, in line with the UK government target for ending the sale of new petrol and diesel vehicles. It assumes that few or no measures will be implemented to encourage voluntary uptake of ULEVs in the 2020s, such that only 24% of new car sales will be ULEVs in 2025, based on extrapolation of current uptake rates.
- Aspirational: this scenario also assumes that 100% of new car and van sales will be ULEVs by 2030, and also assumes that significant investment will be made to encourage earlier adoption. We assume that 60%[6] of new car sales will be ULEVs in 2025.

These scenarios are shown in the chart below.

[6] This figure is based on the date at which price parity for electric vehicles is expected to be reached for low to mid-range electric vehicles, and on a survey conducted by Cenex which found that around 60% of drivers expect to buy an EV by 2025

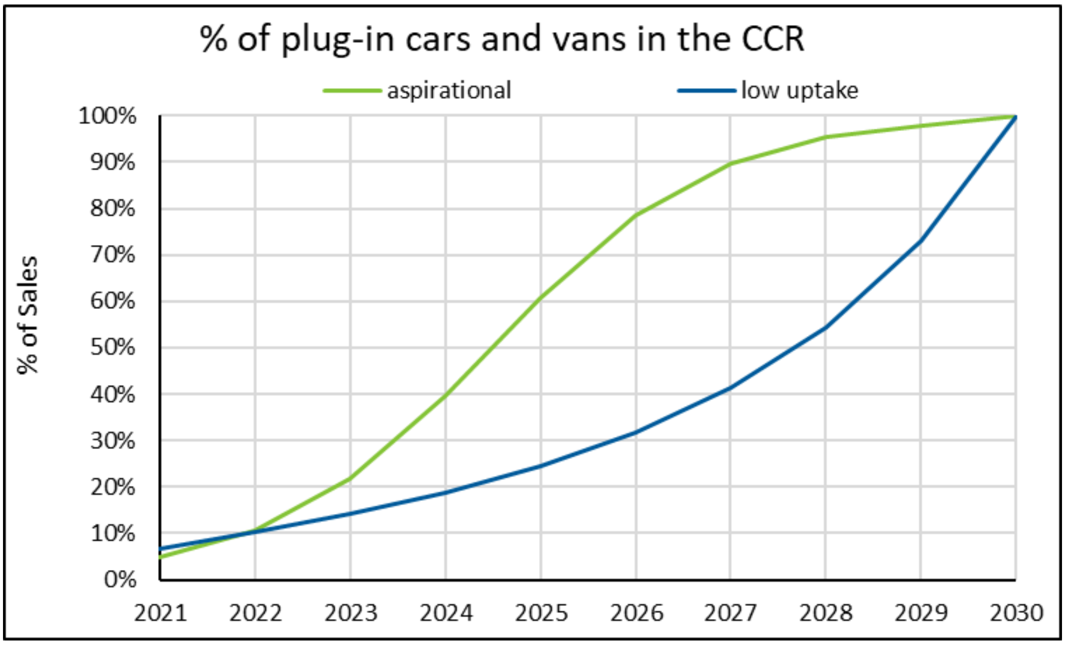


Figure 5. The two market scenarios for plug-in vehicle uptake in the CCR.

HGVs

We developed two scenarios as follows:

- ULEV Uptake (EV and hydrogen): This assumes that zero emission capable vehicles will make up 96% of new sales of HGVs by 2035 (42% battery electric, 54% hydrogen fuel-cell) and almost 100% by 2040, in line with the CCC 6th Carbon Budget[7].
- ULEV Uptake (gas): This assumes a more diverse mix, with 14% of the HGV fleet being gas powered in 2030, slightly increased use of plug-in vehicles and only 1% of vehicles fuelled by hydrogen, based on a report by Element Energy for the Zemo Partnership[35].

For each scenario we established the total number of HGVs registered in the UK and CCR using DfT vehicle registration data[36]. We then used forecasts for the total number of HGV vehicles for the whole UK and applied these to the current CCR fleet to establish the total forecast HGV fleet in the region. We then applied the market shares described above to estimate the number of vehicles of each fuel type in the CCR in 2030.

3.4.2 Scenario Development: Infrastructure

Next we estimated the recharging and refuelling infrastructure network (electric chargepoints, gas refuelling stations which supply biomethane, and hydrogen refuelling stations) needed for each ULEV uptake scenario. Estimates were developed as follows:

Chargepoints for Cars and Vans

- Vehicle mileage and ULEV forecasts were developed as outlined above.
- We estimated energy demand using the calculated vehicle mileage and assumptions around off-street parking availability[37], current and forecast battery capacity[38] and real-world plug-in vehicle efficiency data[39].

We estimated the number of chargepoints required to meet this energy demand as follows:

- The energy demand was split out across four charging rates: 7kW, 22kW, 50kW, and 150kW.
- The baseline split for 2021 is 25% 7kW units, 45% 22kW units and 30% for 50kW+ units[40]. The model accounts for a gradual transition to increased use of higher power chargers between now and 2030.

---

[7] https://www.theccc.org.uk/wp-content/uploads/2020/12/The-Sixth-Carbon-Budget-The-UKs-path-to-Net-Zero.pdf

HGV Chargepoints and Refuelling Stations

- Vehicle mileages up to 2030 were calculated using UK Government road traffic forecasts[41].
- We estimated energy demand using the calculated vehicle mileage and assumptions around fuel consumption[42] and energy density[43].
- This energy demand could then be used to estimate volumes of gas and hydrogen that will be required, using the same data for energy density of different fuels and Cenex's database of vehicle real world energy consumption. This provides estimates of the daily and annual quantities of electricity, gas and hydrogen that would need to be supplied to the HGV fleet in each scenario.
- Finally, we converted this energy demand into forecasts for numbers of stations based on a series of assumptions around station capacity and utilisation.

3.4.3 Scenario Evaluation

Next, we analysed the likely impacts of each scenario by estimating the social cost benefit of mitigating emissions using damage costs. Damage costs allow the negative impacts of emissions to be converted into economic impacts using a set of impact values defined per mass of emission by pollutant. Damage costs for each scenario were estimated using data from the DfT TAG Data[44] for CO_2, NOx and PM emissions. For more detail on the damage cost methodology please refer to Defra's Air Quality Damage Cost Guidance[45]. The results from the scenario development work and analysis are in Section 7.

3.5 Infrastructure Sites and Costs

3.5.1 Infrastructure Site Types

Example site types for installing recharging and refuelling infrastructure were established via stakeholder working groups and desk-based analysis of the CCR. Further work will be required to refine these suggestions and determine their viability; this should be led by private sector fleet operators and infrastructure providers as they are likely to make investment decisions. Proposed site types are in Section 8.

3.5.2 Infrastructure Costs

Section 3.3 outlined how we estimated the number of chargepoints, gas (biomethane) and hydrogen refuelling stations that will be required across the CCR. The total cost of developing this network was estimated by applying the following factors:

Chargepoints

Once the number of chargers was known, the costs associated with each type of charger was coupled with this data to estimate total cost of infrastructure. We estimated total capital and annual operating costs for the proposed EV chargepoints from an average of three quotations provided by industry contacts. Costs include equipment, electrical connection costs, enabling works and miscellaneous installation costs. A summary of costs is presented in the table below.

Table 1. Charger cost by charger type.

	7kW Standard Charger	22kW Fast Charger	50kW Rapid Charger	150kW Ultra-Rapid Charger
Capital Costs[46]				
Total Capital Cost	£6,100	£6,300	£23,950	£84,200
Operating Costs (per chargepoint, per year)				
Total Baseline Operating Cost	£750	£750	£500	£500
Other Costs				
Electricity Cost (wholesale per kWh)	£0.15	£0.15	£0.15	£0.15

Gas (Biomethane) Refuelling Stations

CNG station costs were supplied by CNG Fuels. Equivalent LNG station costs were calculated using the ratio of 45% to CNG station costs as reported in Biomethane for Transport: HGV cost modelling (TTR for the Zemo Partnership)[47]. The total cost of installing a medium capacity CNG station is around £3m. An equivalent capacity LNG station would cost around £1.3m.

Hydrogen Refuelling Stations

Station costs were taken from Zero Emission HGV Infrastructure Requirements (Ricardo Energy and Environment)[48]. The total cost of installing a medium capacity hydrogen station is around £3.7m.

3.6 Stakeholder Engagement

Engagement with stakeholders in the CCR was critical to the development of this strategy. This included:

- A project steering group, chaired by Cenex, with representatives from the CCR City Deal Office and local authorities in the region. This group met at the beginning of the project to direct work and provide insights.
- A freight stakeholder workshop, chaired by Cenex, with representatives from van and HGV fleet operators, trade associations, local authorities and other key organisations.
- A PSV stakeholder workshop, chaired by Cenex, with representatives from operators, vehicle manufacturers, local authorities and other key organisations.

3.7 Developing Recommendations

The final part of the methodology involved assimilating all the information gathered from the desk-based modelling analysis, industry engagement and stakeholder activity to develop recommendations for accelerated ULEV adoption in the CCR. The recommendations reflect the likely technology pathways and scenarios developed. They are primarily targeted towards the City Deal Office. It should then work with the local authorities in the CCR and other key stakeholders such as PSV and freight operators to implement the best options. This is also likely to involve lobbying organisations such as the Welsh Government UK government departments to ensure funding is in place to support the planned activity. Recommendations are in Section 9 of this report.

4 Baseline: Vehicles and Infrastructure

This section first presents the baseline fleet composition and intrinsic emissions profiles of all vehicle types and the CO_2, NOx and PM emissions from road transport in the CCR. It also includes maps of the baseline network of chargepoints and refuelling stations.

Key points:

- Many vehicles operating in the CCR are older, more polluting models.
- The CCR lags behind the rest of the UK in rates of plug-in vehicle (PiV) adoption. Only 0.28% of the vehicle parc are PiVs, compared to the UK average of 0.65%.
- Cars have low emissions on a per vehicle basis but as a vehicle category are the highest emitter.
- Activity needs to focus on removing the oldest, most polluting vehicles from the fleet as well as encouraging uptake of new PiVs.
- Significant investment in recharging and refuelling infrastructure is required to support PiV adoption.

4.1 Fleet Composition

The two charts below illustrate the current fleet composition by vehicle type across the CCR.

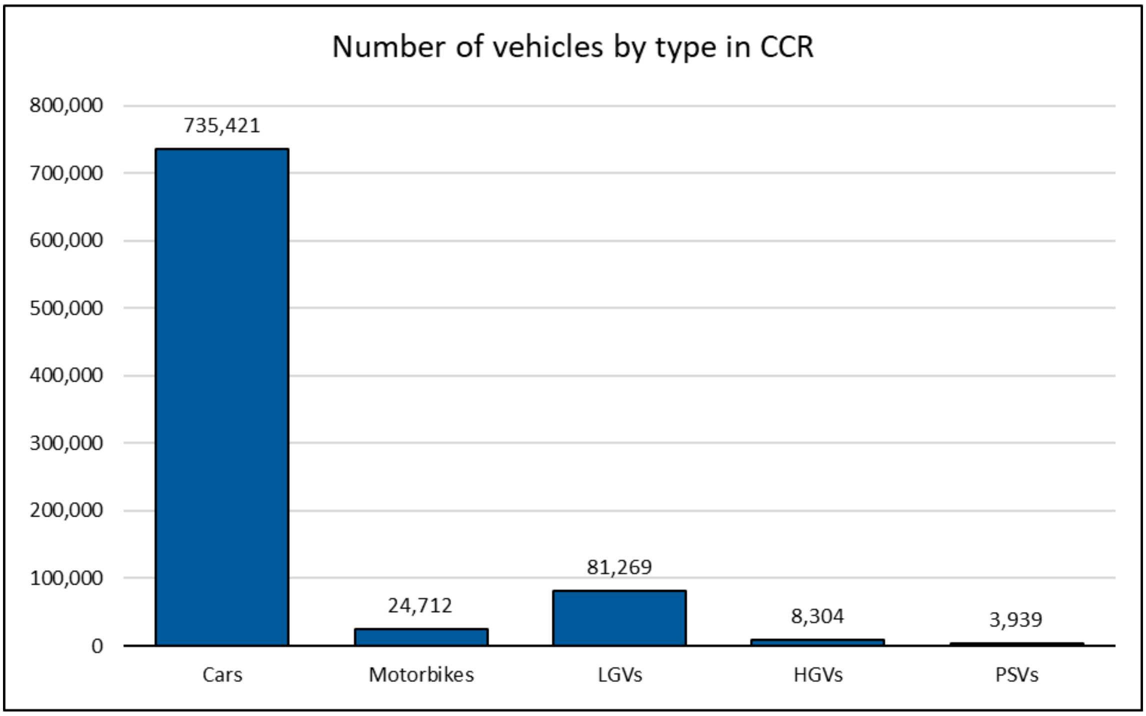


Figure 6. CCR fleet composition by vehicle type.

This chart above illustrates that cars are by far the most common vehicle type in the region.

The second chart (below) breaks the fleet down further by vehicle and fuel type, revealing that there are slightly more petrol cars than diesel on the roads.

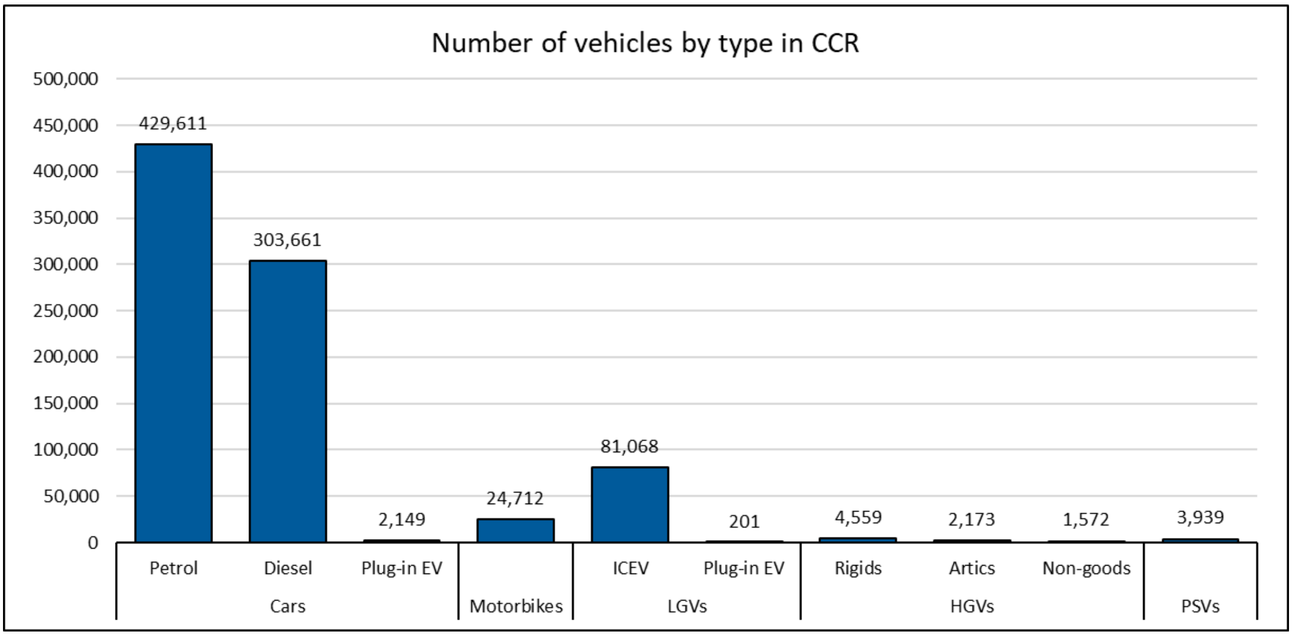


Figure 7. CCR fleet composition by vehicle type - expanded.

The chart above shows the latest DfT data on PSV registrations. Based on data provided by the CCR City Deal Office, we estimate that 2,072 of the PSVs have more than 16 seats and 1,867 have 16 seats or fewer (i.e. minibuses). Around 1,000 vehicles with more than 16 seats are deployed on a scheduled service.

The next chart breaks down the vehicle parc by Euro emissions standards. The cleanest vehicles – those which meet the Euro 6/VI standard – are only the second most common type of vehicle in the CCR. The fleet has large numbers of Euro 5/V vehicles which have relatively high pollutant emissions, particularly of NOx. The share of Euro 6/VI vehicles on the road has increased significantly since this strategy was first published in 2019.

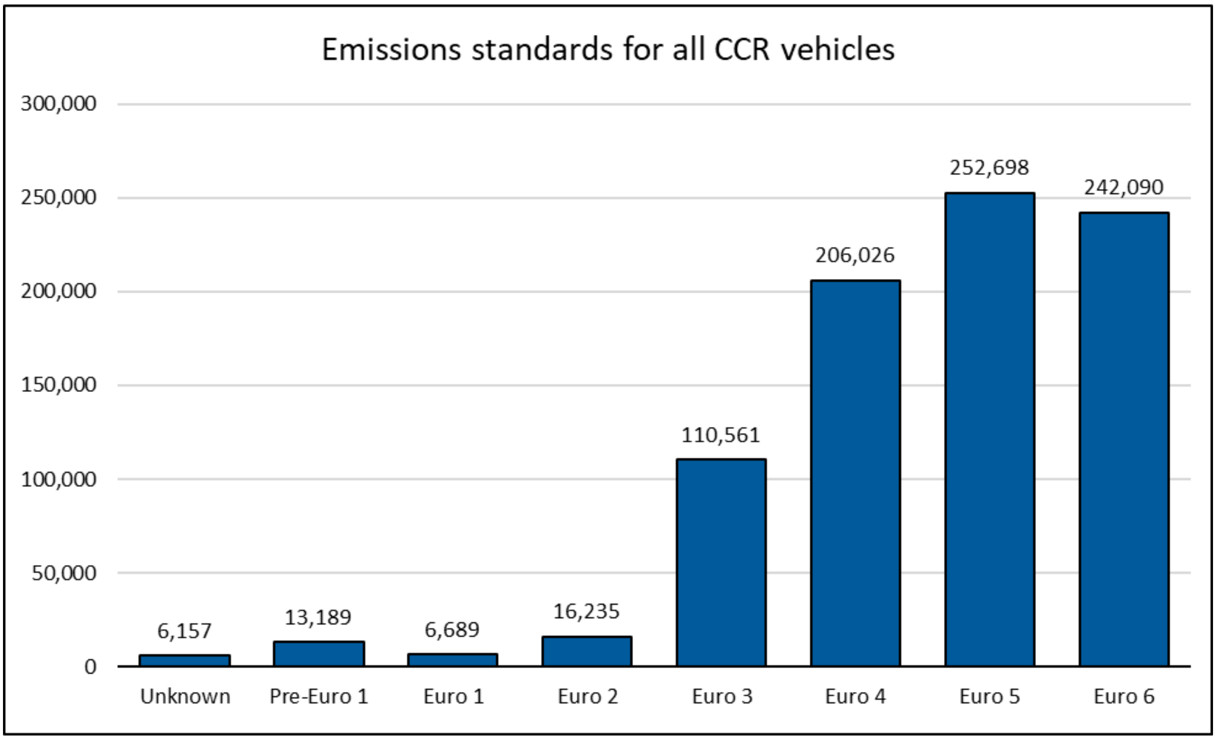


Figure 8. CCR fleet by emissions standard.

The chart below splits the parc into vehicle type and emissions standard. This shows that there are a relatively high proportion of Euro VI HGVs and buses in the CCR. Conversely for cars and vans there is a more even distribution of Euro 4, 5 and 6 vehicles. The other key point to note is that the number of pre-Euro 4/IV vehicles is a concern. These vehicles will have substantially higher PM and NOx emissions than newer vehicles and, unless very well maintained, will have even higher emissions than official data would suggest. Accelerating the rate at which these older vehicles are removed from the fleet should be a priority.

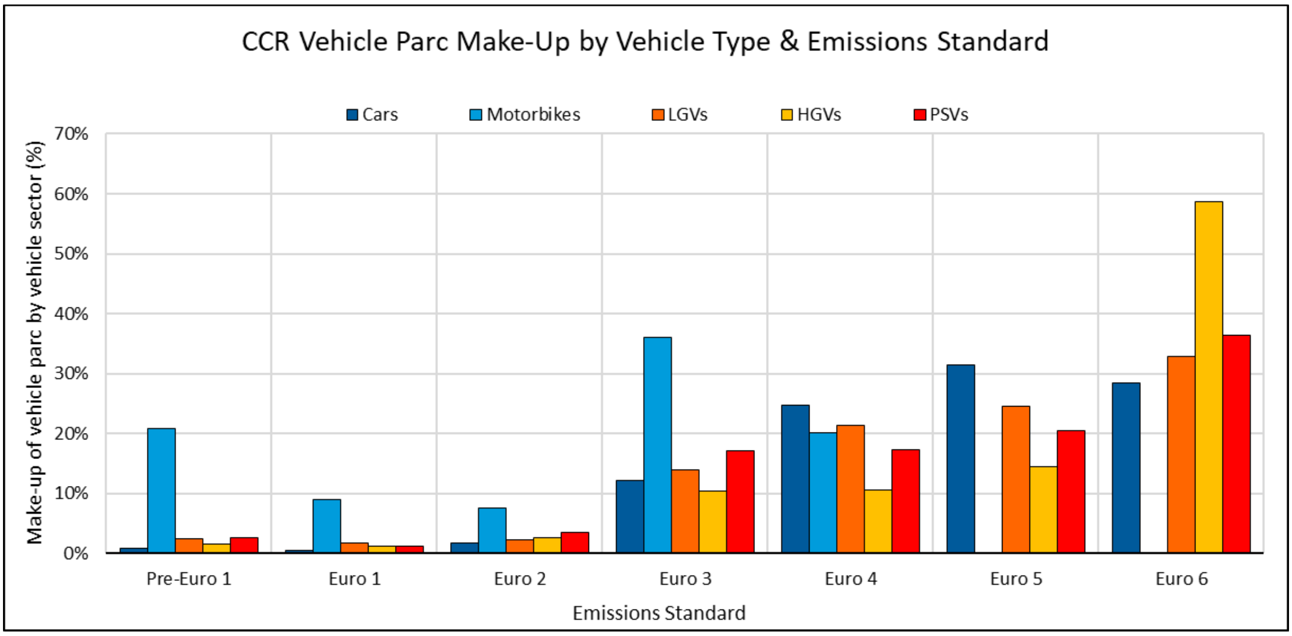


Figure 9. CCR vehicle parc by emissions standard and vehicle type.

The figure below provides a breakdown of the age profile of PSVs. This is important as it illustrates the significant differences in vehicle average age for different the use cases. For example, non-scheduled services and school buses have a higher average age than other buses and coaches in the CCR. The implications of this on options to reduce emissions are discussed in Section 9.

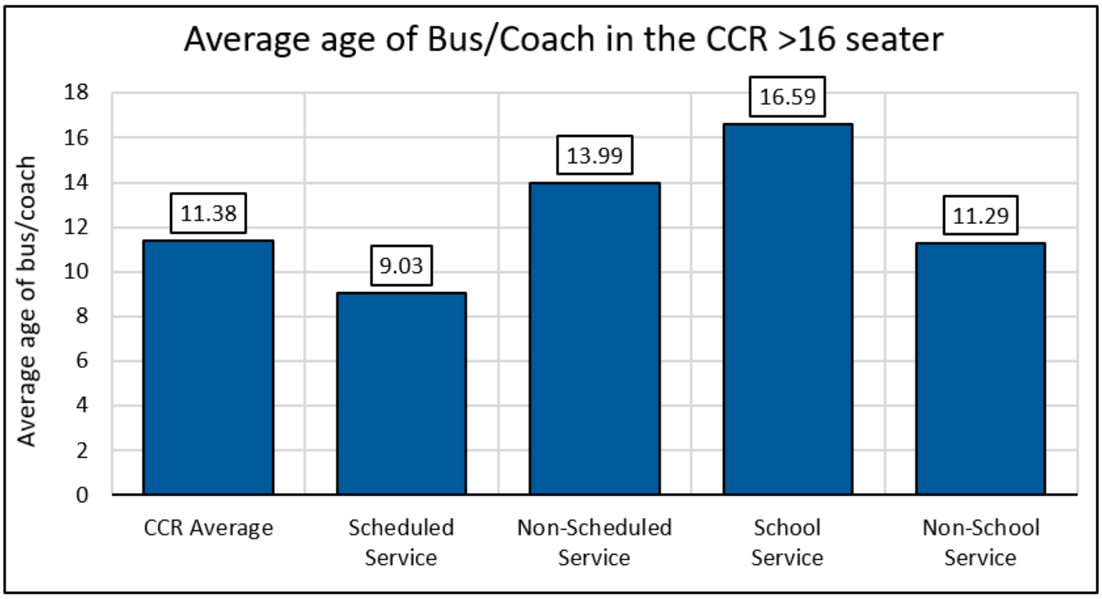


Figure 10. Average age of PSVs in the CCR for >16 seater vehicles

Our emissions model accounts for the breakdown of vehicle age and mileage by duty cycle within the PSV sector. This reflects nuances such as the relatively low mileage covered by some very highly polluting vehicles.

4.1.1 Plug-in vehicle Penetration

The table below shows plug-in vehicle (PiV) penetration (all vehicle types) in each of the 10 local authorities in the CCR and for comparison the whole UK.

Table 2. CCR ULEV penetration by local authority.

	Total Vehicles	PiVs	PiVs (%)
Bridgend	89,539	368	0.41%
The Vale of Glamorgan	79,773	338	0.42%
Cardiff	164,186	573	0.35%
Rhondda Cynon Taf	136,767	198	0.14%
Merthyr Tydfil	34,457	43	0.14%
Caerphilly	103,962	174	0.17%
Blaenau Gwent	39,098	38	0.10%
Torfaen	56,833	94	0.17%
Monmouthshire	66,490	295	0.44%
Newport	85,540	229	0.27%
UK	**39,087,267**	**253,957**	**0.65%**

The column showing PiVs as a proportion of all vehicle types illustrates that the CCR lags behind the rest of the UK in rates of PiV adoption. In total only 0.28% of the vehicle parc are PiVs, compared to the UK average of 0.65%. Significant additional action will be required to ensure the region does not get left further behind the rest of the UK as the PiV market develops. There is also substantial divergence with the CCR, with only one PiV for every 700 vehicles registered in Rhondda Cynon Taf, Merthyr Tydfil and Blaenau Gwent.

4.2 Emissions

The chart below shows the estimated air pollutant and GHG emissions from all vehicles in the CCR, disaggregated by vehicle type.

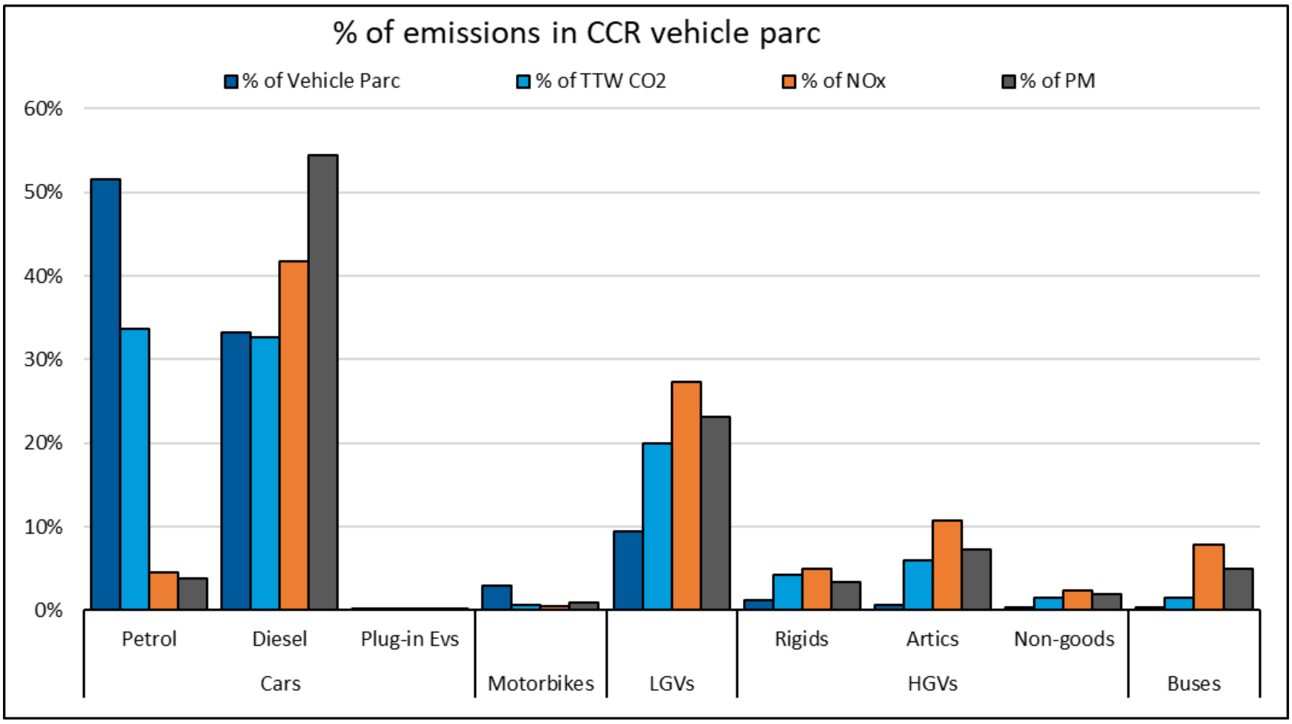


Figure 11. Percentage of emissions by vehicle type across entire CCR vehicle parc.

Cars produce the largest quantities of all three emissions when considered across the whole parc. However, on an individual vehicle basis, cars have much lower emissions than other vehicle types, particularly CO_2.

Vans, HGVs and PSVs have disproportionate levels of emissions in comparison to the number of vehicles on the road. This results primarily from higher usage – the annual mileages of vans, HGVs and PSVs are much larger than of cars. As these vehicles are operated on economic principles, having newer vehicles results in cost advantages. We see that LGVs, HGVs and PSVs have a higher share of Euro VI vehicles compared to cars. Despite newer technology, larger vehicles have higher individual CO_2 emissions than cars due to increased size and mass. There are relatively clear technology and policy pathways for cars to shift to plug-in alternatives, which means car emissions should reduce relatively quickly over the next two decades. However, cutting emissions from freight and buses will be more challenging because of uncertainty over technology pathways, lack of clear policy guidance and the slow rate of churn of these vehicles.

4.3 Infrastructure

This sub-section covers the baseline provision of recharging and refuelling infrastructure for plug-in, gas and hydrogen vehicles in the CCR.

4.3.1 Plug-in Vehicle Infrastructure

The coverage of the UK's chargepoint network has increased steadily in recent years, through provision of slow, fast and rapid chargepoints by local authorities and the private sector. The chart below shows the growth in numbers of charging connectors from 2016 to 2020 according to Zap-Map[49].

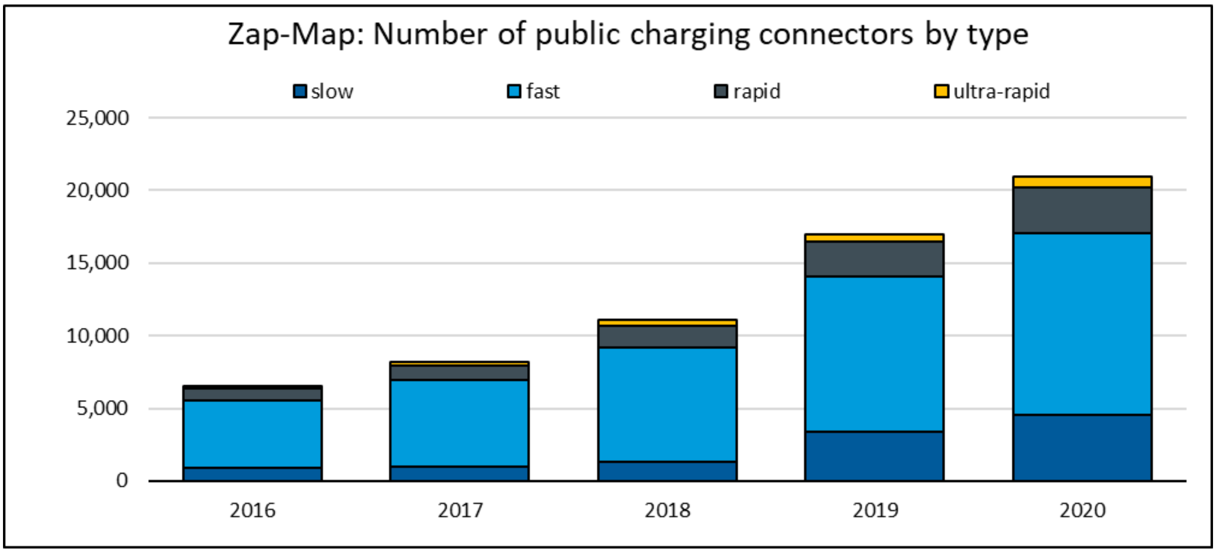


Figure 12. UK installed charging connectors by type.

Rapid chargepoints will be crucial to facilitating widespread plug-in vehicle adoption, particularly for high mileage users such as taxi and van fleets or for households without access to off-street parking. The chart below illustrates the acceleration in the rate of deployment of rapid chargepoints in the UK, also using Zap-Map data.

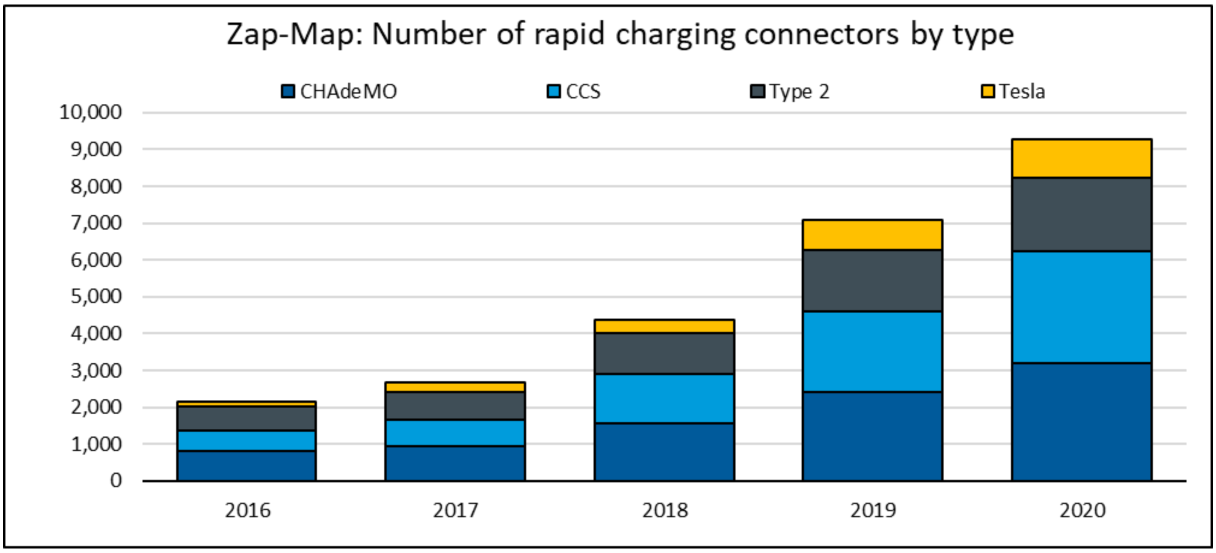


Figure 13. UK rapid charging connectors by type.

4.3.2 Infrastructure in the CCR

The figure below shows the coverage of recharging and refuelling infrastructure in the CCR. This shows the spread of chargepoint provision (using data gathered from the NCR), and the location of a single hydrogen refuelling station in Abergavenny, though this station is not available for public use at this time.

The majority of chargepoint provision is centered around the major cities of Cardiff and Newport along with a rapid chargepoint network along the M4 corridor. In the rural region of the CCR there is generally poor coverage, especially in Merthyr Tydfil, Rhondda Cynon Taf and Blaenau Gwent.

There are no gas refuelling stations in the CCR region, though there are four stations in Bristol.

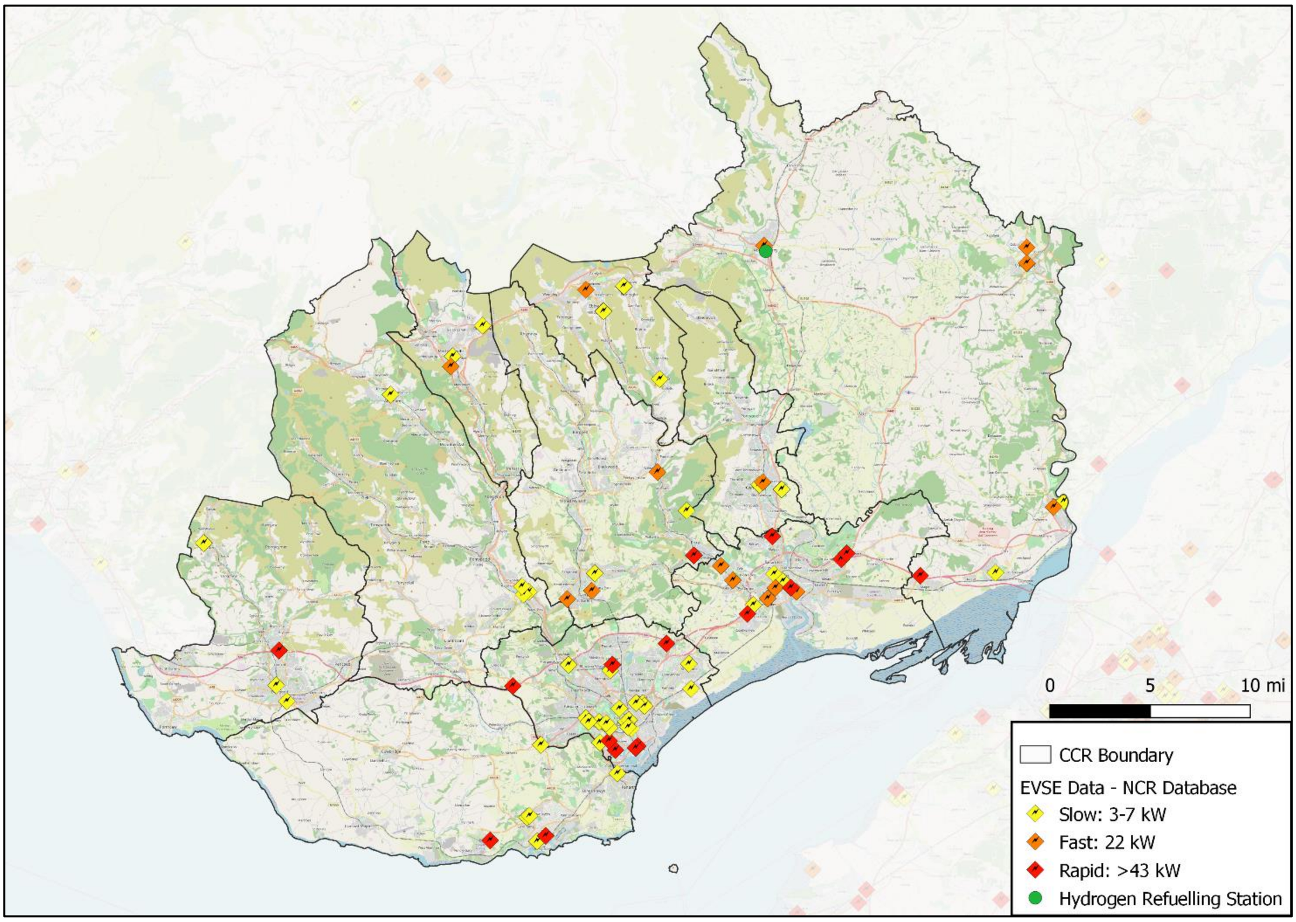


Figure 14. Chargepoint and Hydrogen Refuelling Station provision in the CCR

4.3.3 Summary of Current Status

The tables below summarise the current baseline of infrastructure provision in the CCR and compare this to the rest of the UK. The first table shows the number of publically available chargepoints (of all types and speeds registered on the NCR database) and benchmarks this against the population, number of plug-in vehicles and total number of all cars and vans in the CCR, Wales and the UK. This illustrates that by all three metrics the CCR (and Wales generally) has poor chargepoint provision compared to the rest of the UK. It should be noted that the NCR database does not include all public chargepoints e.g. Zap-map quotes 20,964 devices, as of 2020, in the UK compared to 17,400 quoted by the NCR.

Table 3. CCR, Wales and UK EV infrastructure comparison.

	Chargepoint Devices[50]	People per chargepoint[51]	Plug-in vehicles per chargepoint	Cars and vans per chargepoint
CCR	125	12,346	18.8	6,534
Wales	351	8,983	14.6	5,143
UK	17,401	3,839	14.6	2,134

A breakdown from the NCR database is given in the below table showing the total number of devices for each local authority within the CCR.

NCR Database	
Local Authority	**Total Devices**
Blaenau Gwent	7
Bridgend	8
Caerphilly	11
Cardiff	36
Merthyr Tydfil	5
Monmouthshire	10
Newport	18
Rhondda Cynon Taf	6
The Vale of Glamorgan	13
Torfaen	11
Total CCR	***125***

Additionally, the total number of sockets for the CCR region has been broken down into the relative speed. This shows that the majority of sockets are slow (3-7 kW), though a large proportion of the network are rapid chargers (29%).

CCR Region	
Socket Rating	**Total Sockets**
Slow: 3-7 kW	140
Fast: 22 kW	45
Rapid: >43 kW	75
Total Sockets	***260***
Total Devices	***125***

The table below considers the provision of gas and hydrogen refuelling stations for HGVs in the CCR and the rest of the UK. While the CCR is leading vs the rest of the UK for hydrogen station provision per vehicle it is behind on the provision of gas stations with none present in the region, though it should be noted that there are 4 gas stations present in Bristol, close by.

Table 4. CCR, Wales and UK other low carbon fuel infrastructure.

	H_2 stations[52]	HGVs per H_2 Station	Gas stations[3]	HGVs per gas station
CCR	1	8,304	0	-
Wales	1	22,451	0	-
UK	17	30,927	29	18,129

Significant investment is required in recharging and refuelling infrastructure to support ULEV adoption in the CCR.

5 Vehicle Roadmaps

This section presents the market status of different ULEV technologies that could help reduce emissions in the CCR up to 2030.

Key points:

- Plug-in vehicle availability and performance will improve across all vehicle segments, with progress fastest for cars and light duty commercial vehicles.
- Gas vehicle availability may decline between 2025 and 2030 as electric vehicle technology continues to improve.
- Hydrogen is unlikely to reach maturity and achieve significant uptake before 2030.
- Renewable biodiesel can be used now to reduce GHG emissions from heavy vehicles.

5.1 Introduction to Roadmaps

Technologies are split into four categories: plug-in vehicles, natural gas and biomethane, hydrogen, and other fuels (such as biodiesel). For each technology, the roadmap illustrates forecasts up to 2030[53]. The roadmaps show when the technology is expected to reach operational maturity and commercial readiness for different vehicle types. The roadmaps use arrows to illustrate technology development. A single arrow shows that we have a high degree of confidence in the likely time this transition will happen. Two short arrows together represent more uncertainty around when this transition is going to happen. Brief commentary is provided under each roadmap to highlight the key points. The vehicle roadmaps use a colour code scheme to indicate technology maturity, as shown in the key below.

	Trial & early stage demonstration
	Transition to main-stream technology
	Commercial/large-scale deployment

Figure 15. Key to Vehicle Roadmaps.

5.2 Plug-in Vehicles

	Trial & early stage demonstration
	Transition to main-stream technology
	Commercial/large-scale deployment

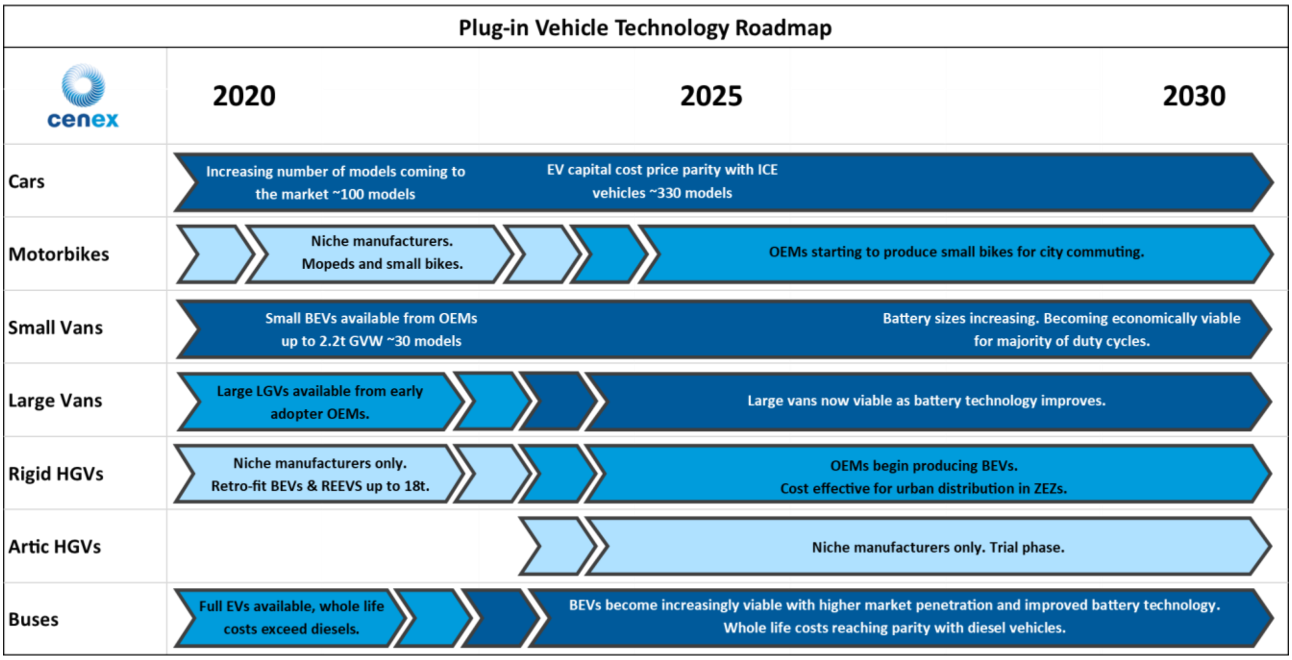


Figure 16. Plug-in Vehicle Roadmap.

5.2.1 2020 – 2025

Cars: Between 2020 and 2025 EV sales will increase relatively quickly from a low baseline. Product choice on the market will continue to grow in all vehicle segments, with range on a single charge also increasing significantly. There is already a strong economic case for electric cars on many duty cycles. Around the middle of the decade cost parity with conventional vehicles is expected to be reached for cars with a range of around 150 to 200 miles Vehicles with a longer range will still have a cost premium compared to petrol and diesel models.

Buses: Stop-start and mild hybrid systems, which offer relatively short term payback, are appearing in increasing numbers of city buses. Electric buses are available but their total cost of ownership (TCO) is higher than for diesel models. Deployment of BEV buses will be concentrated where they are supported by public funding and targeted policy such as the ultra-low emission bus grant and the all-electric bus town initiatives in the UK.

Vans and HGVs: Battery capacities in light duty vehicles will increase over this period, providing range on a single charge of up to 300 miles. This is expected to support a rapid growth in model availability in this market segment. Large plug-in vans will become more widely available from mainstream manufacturers towards the end of this period. Some medium sized rigid trucks will appear as early market offerings from niche manufacturers in low production volumes. Single charge ranges of around 150 miles are expected. There will be a business case for operating plug-in vans on a TCO basis in many cases, but the upfront price premium for large vans and rigid trucks may mean high mileage duty cycles or long ownership periods are required. At this stage it is unclear what role electric vehicles will play in decarbonising articulated HGVs.

Emissions: WTW emissions will continue to drop as the UK electricity grid is decarbonised. Emissions intensity is predicted to fall from 136g CO_2e per kWh in 2020 to 108g CO_2e per kWh by 2025, providing a reduction compared to diesel of 68%[54].

5.2.2 2025 – 2030

Cars: In the second half of the decade increased vehicle choice, longer ranges, falling prices and the approach of the UK’s 2030 deadline for ending the sale of new petrol and diesel cars will significantly increase the supply and uptake of EVs. Price parity will be reached for all comparable car types, so cost will no longer be a barrier to EV adoption. Rates of EV uptake will depend on infrastructure availability and cost of use, and consumers’ desire to keep using familiar technology.

Buses: By 2025 hybridisation is likely to be standard on most new diesel and gas buses. Advances in battery technology will incrementally improve the range and cost performance of EV buses. Some deployments will be subsidised while non-subsidised breakeven may be reached on higher mileage duty cycles.

Vans and HGVs: Vans of all sizes will be widely available with ranges of up to around 300 miles. The approach of the UK’s 2030 deadline for ending the sale of new petrol and diesel vans will significantly increase the supply and uptake of EVs. Access to charging infrastructure may be the greatest barrier to widespread uptake. Mainstream manufacturers will launch rigid electric trucks, primarily for use in urban areas where access restrictions on diesel vehicles are in place.

These may provide cost savings over diesel vehicles if deployed in cities where zero emission zones (ZEZs) are in place and charge a few for polluting vehicles to travel through them. Small scale development of Arctic HGVs will be in trial phase for niche applications with hydrogen vehicles likely to dominate the market for these vehicles unless significant advances in battery power density are developed.

Emissions: WTW emissions are forecast to drop further, from 108g CO_2e per kWh in 2020 to 85g CO_2e per kWh by 2030, providing a reduction compared to diesel of 76%[55].

5.3 Gas Vehicles

	Trial & early stage demonstration
	Transition to main-stream technology
	Commercial/large-scale deployment

Natural Gas & Biomethane Technology Roadmap		
cenex	2020	2025 — 2030
Cars		
Motorbikes		
LGVs Small		
LGVs Large	CNG vans available and economically viable.	CNG use in vans phased out as adoption of Large LGV BEVs accelerates
Rigid HGVs	Growing availability for CNG & LNG. OEMs investing in gas powered vehicles. Economically viable but limited vehicles deployed due to lack of infrastructure.	
Artic HGVs	Growing availability for CNG & LNG. OEMs investing in gas powered vehicles. Economically viable but limited vehicles deployed due to lack of infrastructure.	
Buses	CNG buses available and economically viable.	CNG becoming niche as EV and Hydrogen technologies develop further

Figure 17. Gas Vehicle Roadmap.

5.3.1 2020 – 2025

Cars: Gas is not currently used in passenger cars in the UK and this is not forecast to change.

Buses: Although natural gas buses are available, the market will rapidly move to electric buses as local authorities seek to reach net zero emissions targets. Current UK government low emission bus funding is for zero tailpipe emission vehicles only, and the market will respond accordingly.

Vans and HGVs: Gas vehicles are already available in all segments of the commercial vehicle market, with product range forecast to increase for rigid and articulated trucks. A limited number of LNG vehicles will be available in the articulated truck segment. Vehicles will continue to have an upfront price premium compared to diesel but can be economically viable at relatively high annual mileages. The increased focus by local authorities and some businesses on reaching net zero by encouraging use of zero tailpipe emission vehicles means the case for gas is less strong.

Emissions: Natural gas vehicles have similar GHG emissions to diesel vehicles. Biomethane can provide GHG emissions savings of around 80% compared to diesel. Gas vehicles need to be powered by biomethane to offer an environmental benefit compared to diesel.

5.3.2 2025 – 2030

Cars: Gas is not currently used in passenger cars in the UK and this is not forecast to change.

Buses: Gas buses are likely to disappear from the UK market as zero emission capable vehicles increasingly displace diesel models.

Vans and HGVs: Supply and use of gas vans is likely to decline and be replaced by EVs which will provide increasing range and cost performance. Major manufacturers may increase investment in and production of rigid and articulated CNG and LNG vehicles, though this will depend on the availability of a gas refuelling infrastructure network, and progress in developing zero emission tailpipe (electric or hydrogen) HGVs.

Emissions: The difference in GHG emissions compared to diesel is likely to remain constant.

5.4 Hydrogen Vehicles

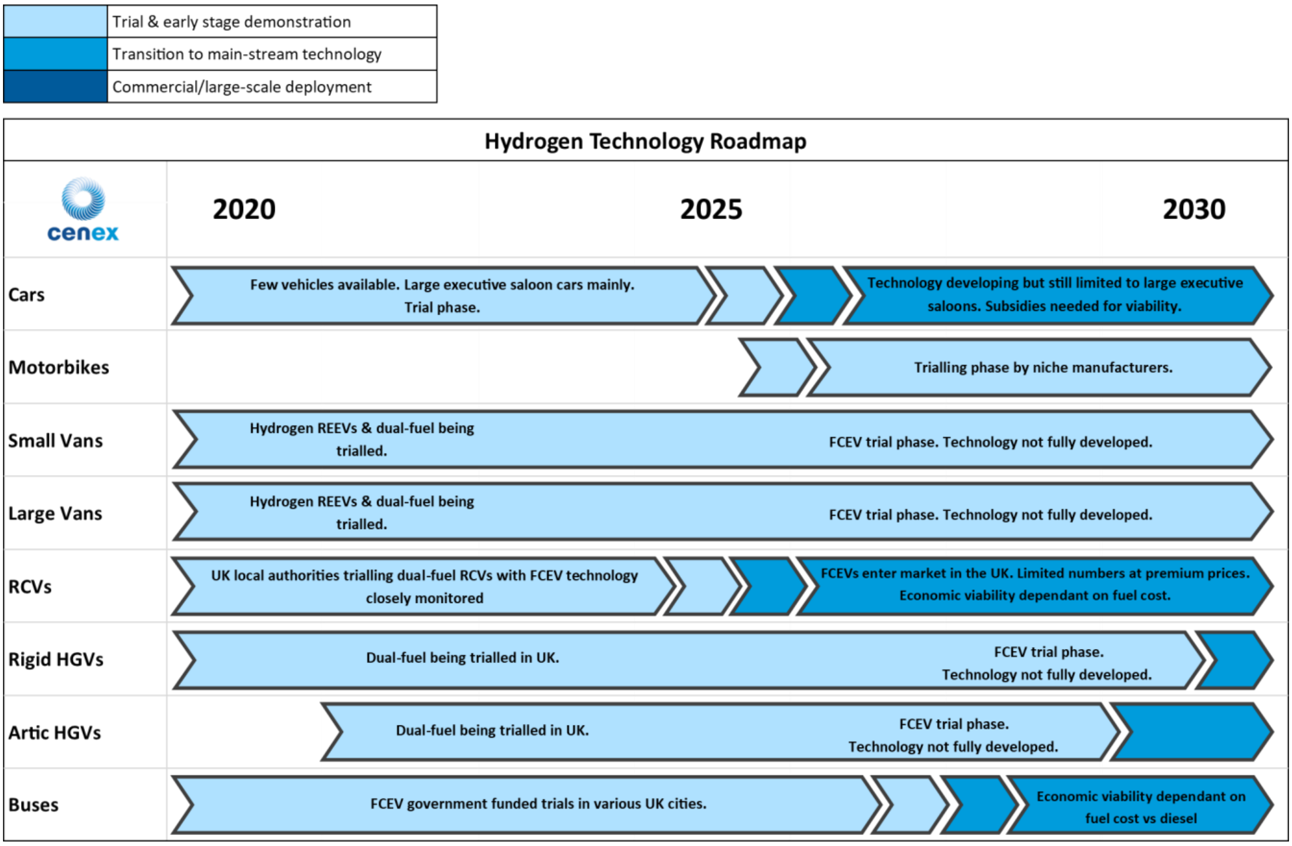


Figure 18. Hydrogen Vehicle Roadmap.

5.4.1 2020 – 2025

Cars: A small number of fuel cell cars are currently available in upper market segments, primarily for funded trials and demonstration. Significant price premiums over conventional vehicles will constrain uptake. Electric vehicles are improving rapidly in range and cost performance, meaning there is no economic case for fuel cell cars, which are more expensive to acquire and operate.

Buses: Fuel cell bus trials are taking place in the UK: trials will require external funding until the cost of vehicles and fuel reduces. Price premiums over conventional vehicles will constrain uptake.

Vans and HGVs: There is currently no business case for fleets to switch to hydrogen; deployments will rely on grant funding. There are no hydrogen HGVs available from mainstream manufacturers in the UK, and near-term supply increases are constrained by the UK being a right hand drive market.

Emissions: WTW GHG emissions can be near-zero if hydrogen is made on-site using an electrolyser powered by renewable electricity. Currently most hydrogen is produced from fossil fuels and this provides little or no emissions benefits.

5.4.2 2025 – 2030

Cars: Fuel cell technology is likely to improve, with vehicles delivering longer range and better efficiency. However, competition from improved EVs will mean uptake remains low.

Buses: Additional trials and demonstrators will take place and a small number of economically viable deployments may go ahead towards the end of the decade. We forecast that hydrogen costs will decrease and therefore the economic viability of hydrogen buses will improve. Hydrogen fuel cell technology will compete with electric vehicles; hydrogen may appear more attractive for longer and more demanding routes, but electric vehicles with ultra-rapid or on-route charging may be operationally suitable and more cost effective.

Vans and HGVs: Vans are likely to switch to electric vehicles rather than fuel cell models. Dual fuel hydrogen and diesel technology is unlikely to develop significant market share. Fuel cell hydrogen

HGVs may reach prototype and demonstration phase, with articulated trucks the primary target due to their lack of suitability for replacement by electric vehicles. This will still be a development phase with widespread availability and uptake not expected until late in the 2020s.

Emissions: GHG emissions will be almost 100% lower than for diesel if hydrogen is made on-site using an electrolyser powered by renewable electricity. Hydrogen made from grid electricity may also offer emissions benefits as the UK electricity grid is decarbonised.

5.5 Other Fuels

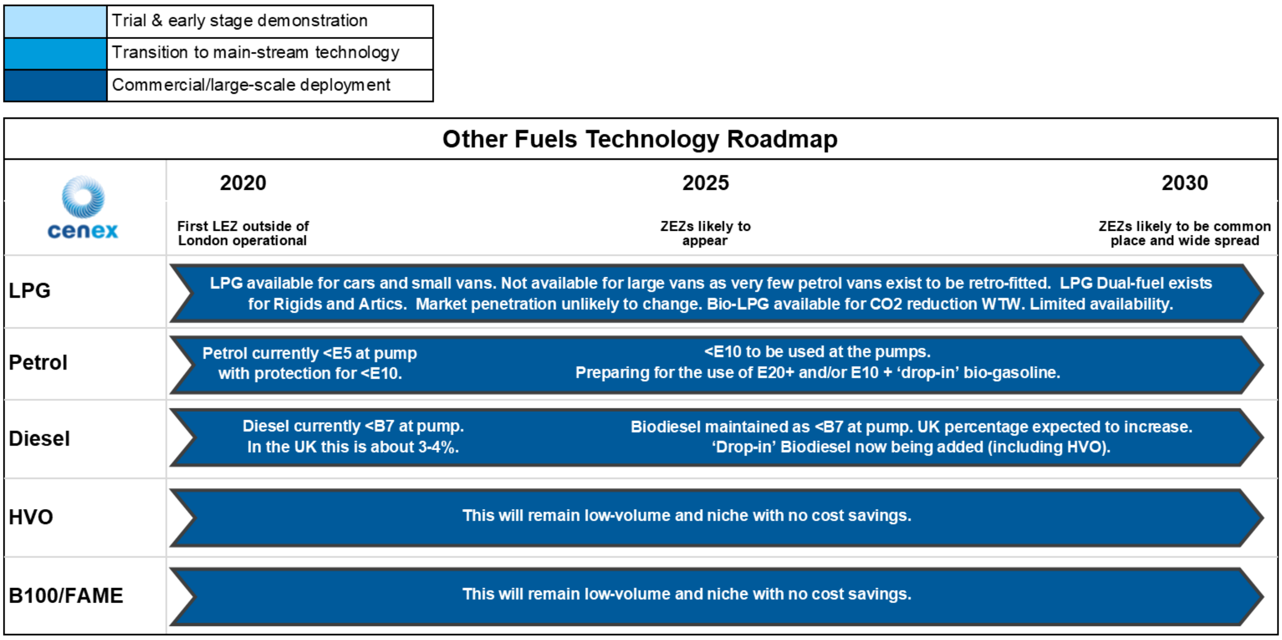


Figure 19. Other Fuels Roadmap.

5.5.1 2020 – 2025

Cars: HVO and B100 will not be used in cars as they are dispensed from fuel bunkers rather than conventional forecourts.

Buses: Biofuels will increase in use primarily in blends with standard diesel. Some operators with bunkered fuel may use strong biodiesel blends or HVO, subject to vehicle warranties.

Vans and HGVs: B100 and HVO deployment may increase for HGV fleets which have bunkered fuel. Both fuels cost slightly more per litre than conventional diesel but are a cost effective way to reduce GHG emissions.

Emissions: HVO and biodiesel can offer WTW GHG emissions savings of up to 90% depending on the feedstock used.

5.5.2 2025 – 2030

Cars: HVO and B100 will not be used in cars.

Buses: Increased policy focus on low and zero emissions and improved performance of EVs and gas vehicles means HVO and biodiesel may primarily be 'bridging fuels' which do not go on to reach mass market adoption.

Vans and HGVs: Higher blends of biodiesel may be widely available on pump forecourts and increasingly used by fleets with depot refuelling as a means of cutting carbon emissions.

Emissions: GHG emissions benefits will remain relatively constant.

6 Infrastructure Roadmaps

This section complements the vehicle roadmaps by illustrating the market status of recharging and refuelling infrastructure technologies to support ULEV adoption.

Key points:

- Chargepoint network coverage will need to increase significantly. and offer more options for drivers without off-street parking.
- Infrastructure will offer faster rates of charging to support longer range vehicles.
- Gas refuelling network coverage will increase steadily in the short term, though the longer term picture is less clear.
- There is uncertainty over the rate of the introduction of hydrogen refuelling; in the short-term small stations may be deployed, but would need to be backed by public subsidies.

6.1 Introduction to Roadmaps

Technologies are split into three categories: electric vehicle recharging, natural gas and biomethane refuelling, and hydrogen refuelling[56]. For each technology, a summary roadmap is provided which illustrates how the technology is expected to develop from 2020 to 2030. The roadmaps show when the technology is likely to reach operational maturity and commercial readiness for different vehicle types. Brief commentary is provided under each roadmap to highlight the key points.

The roadmaps use arrows to represent a transition to the next development within each category. A single arrow shows that we have a high confidence of the likely time this transition will happen. Two arrows represent more uncertainty of when this transition is going to happen. Unlike the vehicle roadmaps, we have not used colour coding to illustrate expected technology maturity. This is because for the majority of the categories (such as coverage and economics) there is insufficient evidence available to enable us to specify an associated maturity level.

6.2 Electric Vehicle Recharging

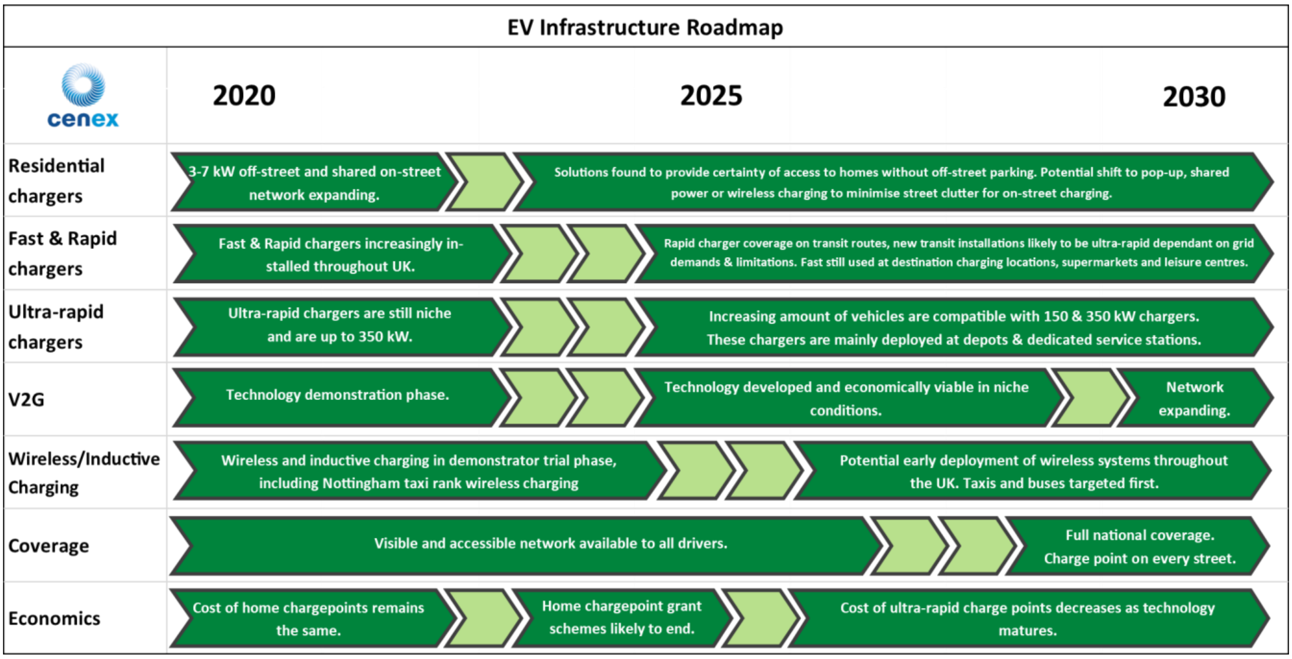


Figure 20. EV Infrastructure Roadmap.

Residential Charging

In the early part of the decade there will be a steady growth of 3-7 kW chargers as the number of electric vehicles increase. Up to 2025 residential charging, and thus EV ownership, will be largely restricted to households with off-street parking where a dedicated chargepoint can be installed. Those without off-street parking will rely on on-street public charging, which is often more expensive than using their own private electricity source at home. On-street charging development, from 2025 onwards, will focus on solutions to minimising street clutter. It is unlikely that a suitable solution, that can be rolled out at scale, will be found for a few years; however, likely solutions that minimise street clutter include pop-up chargepoints and wireless charging.

Fast and Rapid Charging

The fast and rapid chargepoint network of 22 kW and 50kW units respectively will continue to grow. Fast charger deployment will likely concentrate on destination charging, where users are likely to park for up to 3 hours, at locations such as park & ride, retail, tourist hotspots. The coverage of rapid chargers will increase at motorway service stations and on the strategic road network (SRN) in the short-term. Further into the 2020s this may be replaced by ultra-rapid chargers, as long as sufficient capacity in the electricity grid is available at the site.

Ultra-rapid Charging

Ultra-rapid chargers (>50 kW) are being deployed in the UK but from a low baseline, so their coverage will be relatively limited in the first half of the 2020s. Later in the decade deployment is likely to increase in pace, with chargers up to 350 kW being installed. These will be mainly at dedicated service stations on the SRN with sufficient grid capacity and at private depots where limiting vehicle downtime is important and/or HGVs with large batteries require quick charging. More vehicles are expected to be compatible with these chargepoints as their roll-out increases and the demand for ultra-rapid charging increases.

V2G

Vehicle-to-Grid (V2G) can reduce the impact of mass EV adoption on the electricity grid via bi-directional flows of electricity between EVs and chargepoints. V2G will be a trial and demonstration technology through to around 2025. Trials will focus on proving the use case for fleet and private customers. As the technology develops through the latter part of the decade the technology will be rolled out from demonstration to commercial applications, though limited in deployment.

Wireless/Inductive Charging

Wireless/inductive charging will be a trial and demonstration technology through to around 2025. The Wireless Charging for Electric Taxis (WiCET) project led by Cenex, researching wireless charging in real world applications, is one of many key demonstrators in this field that will determine future technology developments and how the technology is deployed. From 2025 potential early deployment of wireless systems will be present in the UK targeting taxis and buses first with a potential use case of on-street residential charging, as discussed previously. However, there is significant uncertainty over the role of wireless and inductive charging, as it is currently less efficient and more expensive than conventional charging.

6.3 Gas Refuelling

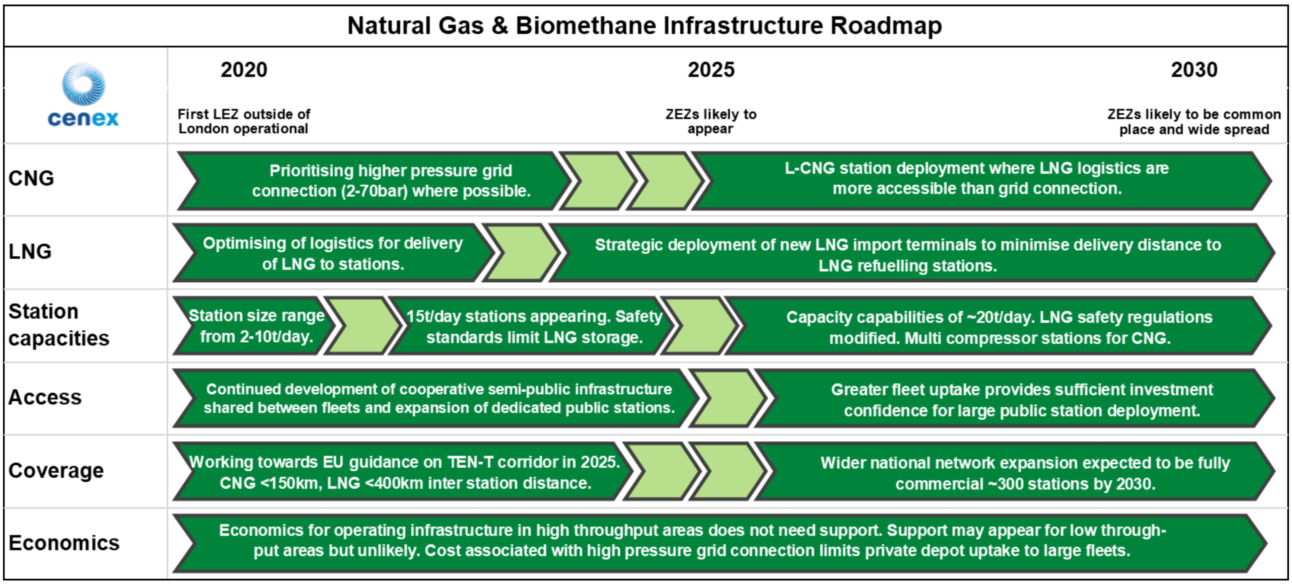


Figure 21. Gas Refuelling Infrastructure Roadmap.

In the first half of the 2020s the main trend for gas refuelling will be a gradual roll-out of infrastructure connected to the medium pressure gas grid, primarily aimed at HGV fleets. Station sizes may increase as the number of vehicles on the road increases. To help overcome challenges around securing fleet demand and land availability, infrastructure providers may seek to install semi-public sites, shared between two or more fleets. The business case for installing infrastructure will improve as more vehicles come to market, though uncertainties over competition from other fuels (EV and hydrogen), payback periods and the high upfront capital cost may deter investors.

Further ahead, LNG refuelling may increase in use in the second half of the 2020s, possibly co-located with CNG refuelling. Depending on the scenario for changes to fleet composition, increased demand will mean increased station sizes. A positive feedback loop should be created with more vehicles on the road benefitting the economics of providing infrastructure, and the increase in infrastructure provision allowing fleets to deploy more vehicles. However, the acceleration of activity to deploy zero emission capable vehicles may mean gas is pushed out in favour of electric and hydrogen vehicles.

6.4 Hydrogen Refuelling

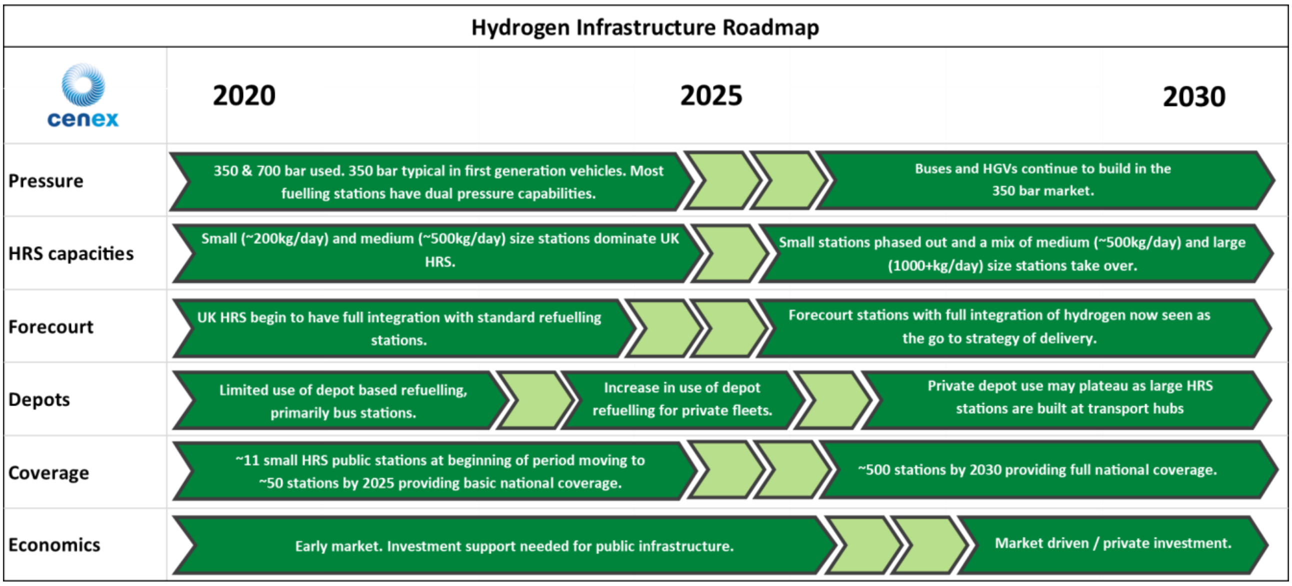


Figure 22. Hydrogen Refuelling Infrastructure Roadmap.

Pressure

A mixture of 350 and 700 bar pressure will continue to be used at hydrogen refuelling stations with most capable of delivering both pressures. 700 bar pressure will primarily serve cars and vans whereas 350 bar pressure will serve buses and HGVs. As the bus and HGV market grows it is expected that 350 bar provision will as well with 700 bar becoming less of a priority though still available at the majority of stations.

HRS Capabilities

Small and medium size stations will continue to dominate throughout the UK having the capacity to deliver up to 500 kg/day. As the uptake of hydrogen vehicles increases over the decade smaller stations will be phased out and larger stations of 1000 kg+/day will become economically feasible as demand grows, increasing the utilisation of such stations.

Forecourt

At present the majority of HRS in the UK are located at dedicated hydrogen sites with a few integrated at existing forecourts that already deliver standard diesel and petrol. Throughout the decade this trend towards integration into existing forecourts is likely to become the go to strategy for distributers, utilising the existing infrastructure that drivers are already familiar with and negating potentially high site development costs alongside major hauling roads.

Depots

Due to the high cost of installing dedicated hydrogen refuelling at present depot based refuellers will be limited to fully converted hydrogen fleets where the cost can be offset through high usage. In the UK this will most likely be limited to bus stations through to the middle of the decade. During the middle of the decade early adopters of hydrogen vehicles may find it more economically viable to install their own refuelling at depot, while coverage is still relatively poor across the UK. However, as coverage improves the business case for privately owned infrastructure will begin to disappear as larger public refuelling stations become available.

Coverage

The coverage in the UK is currently spread out with 12 small public stations currently in place. By 2025 it is expected that up to 50 stations could provide a basic national coverage of the UK. As vehicle technology develops there is likely to be a significant rise in demand for hydrogen refuelling towards the end of the decade with up to 500 stations deployed in the UK providing full national coverage.

7 Vehicle and Infrastructure Forecasting

This section presents scenarios for ULEVs and recharging and refuelling infrastructure developed using the methodologies described in Section 3.

Key points:

- Cars and vans: uptake of ULEVs will remain low in the short-term, and then may increase significantly if sufficient measures are in place.
- HGVs: there is debate about whether plug-in vehicles or hydrogen will displace diesel and the timing of this displacement.
- A significant increase in chargepoint and refuelling station network coverage is required to support the 'aspirational' ULEV uptake scenarios.
- There are significant social cost benefits associated with reducing emissions.

7.1 Vehicles

7.1.1 Cars and Vans

The following table shows the forecast for PiV passenger car and van uptake in the CCR under the two scenarios: low uptake and aspirational. For 2025 and 2030 the table shows the number of PiVs forecast to be on the road in the CCR and the proportion of cars and vans which will be PiV as a percentage.

Table 5. On the road PiV car forecast by scenario and target year.

	PiV Car and Van Uptake			
	2025		2030	
	Number	%	Number	%
Low uptake	27,500	3.1%	231,000	24.0%
Aspirational	67,400	7.6%	363,900	37.9%

These estimates are illustrated in the chart below.

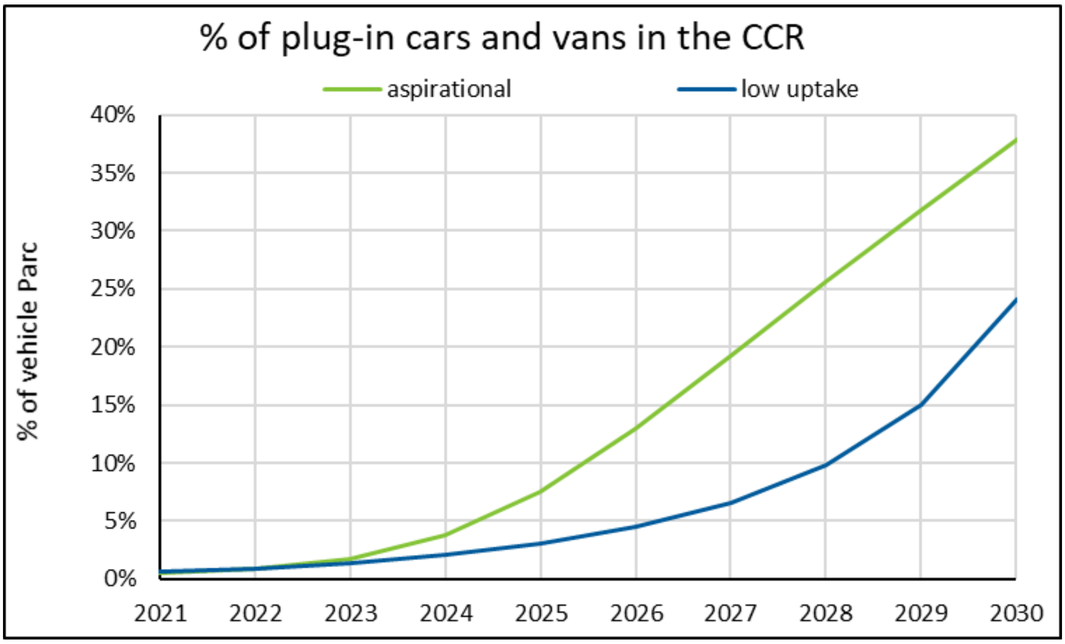


Figure 23. On the road ULEV car forecast by scenario and target year.

It is likely that uptake will remain relatively low in both scenarios until around 2023 for several reasons. First, the availability of new ULEVs is still developing; currently there is a lack of affordable products in the mini, small and medium categories. Second, prices of new ULEVs are expected to fall over the next few years as battery prices reduce but for now high upfront cost is constraining uptake. Finally, additional chargepoint infrastructure is required to achieve an uplift in ULEV adoption.

From 2023 onwards, there is a clear divergence between the two scenarios. The pathway followed will depend on the implementation of policy by the UK government and implementation of the recommendations in this report, particularly provision of a suitable chargepoint network. Given the low ULEV adoption in the CCR and the current gaps in chargepoint provision, we do not expect the region to be able to achieve the aspirational scenario without additional regional action.

7.1.2 HGVs

As discussed in Section 3, there are two likely pathways for alternative fuel adoption in the HGV fleet. The CCC[57] expect hydrogen to displace significant quantities of diesel, while the Zemo Partnership[58] predicts a more diverse mix of fuels to displace diesel with biomethane having the largest market share. We have used these two pathways to develop two possible scenarios for high uptake of alternative fuels. These scenarios are illustrated in the following sub-sections.

HGV Scenario 1: High Hydrogen Uptake

The chart below shows the CCC scenario through to 2040.

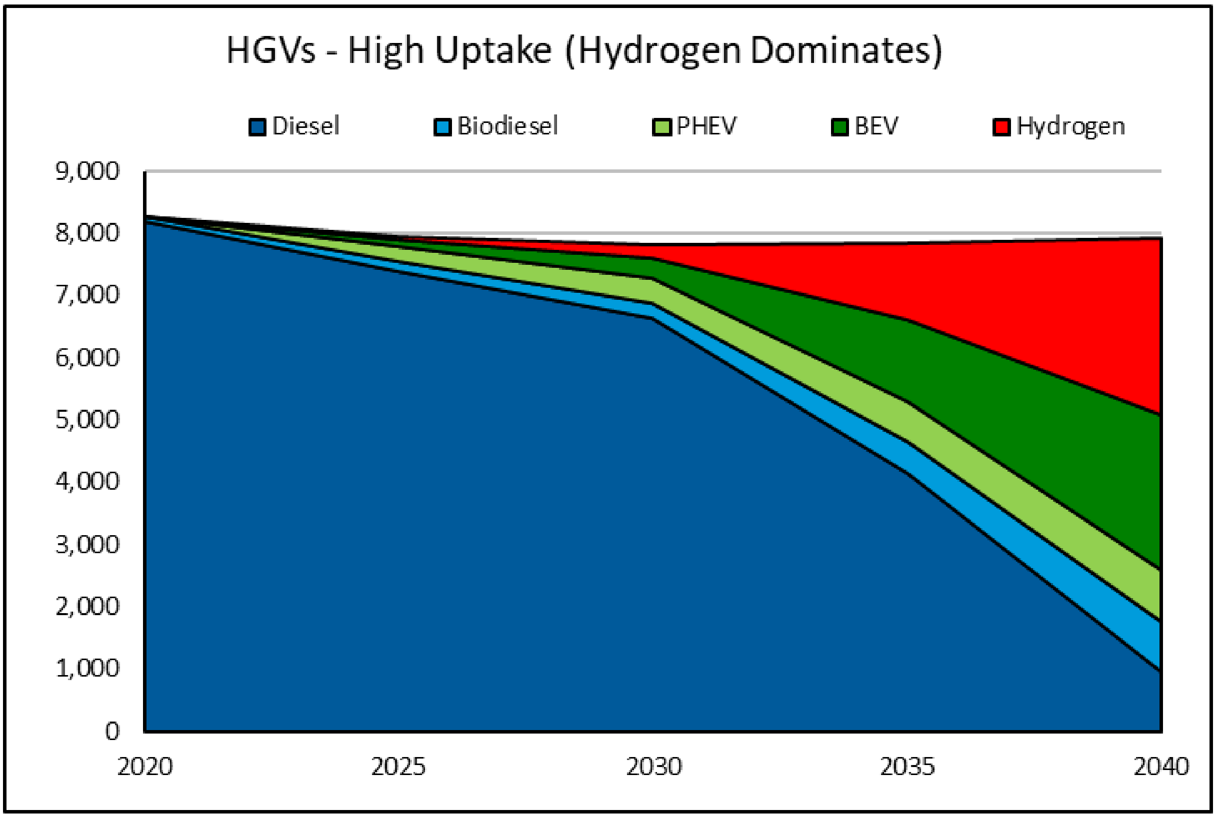


Figure 24.CCC high hydrogen scenario - HGV numbers by fuel type through 2050.

This illustrates that the CCC expect the fleet composition to change little between now and 2030, with diesel continuing to dominate during that decade. Under this scenario significant investment in hydrogen infrastructure would not be required until the 2030s. The implication for the fleet composition in the CCR up to 2030 is shown in the table and chart below.

Table 6. CCC high hydrogen scenario - HGV numbers by fuel type up to 2030.

	2020	2025	2030
Diesel	8,200	7,400	6,640
Biodiesel	80	150	230
PHEV	10	250	400
BEV	0	100	310
Hydrogen	0	50	220
CNG & LNG	20	10	0
Biomethane	10	0	0
Total	**8,320**	**7,960**	**7,800**

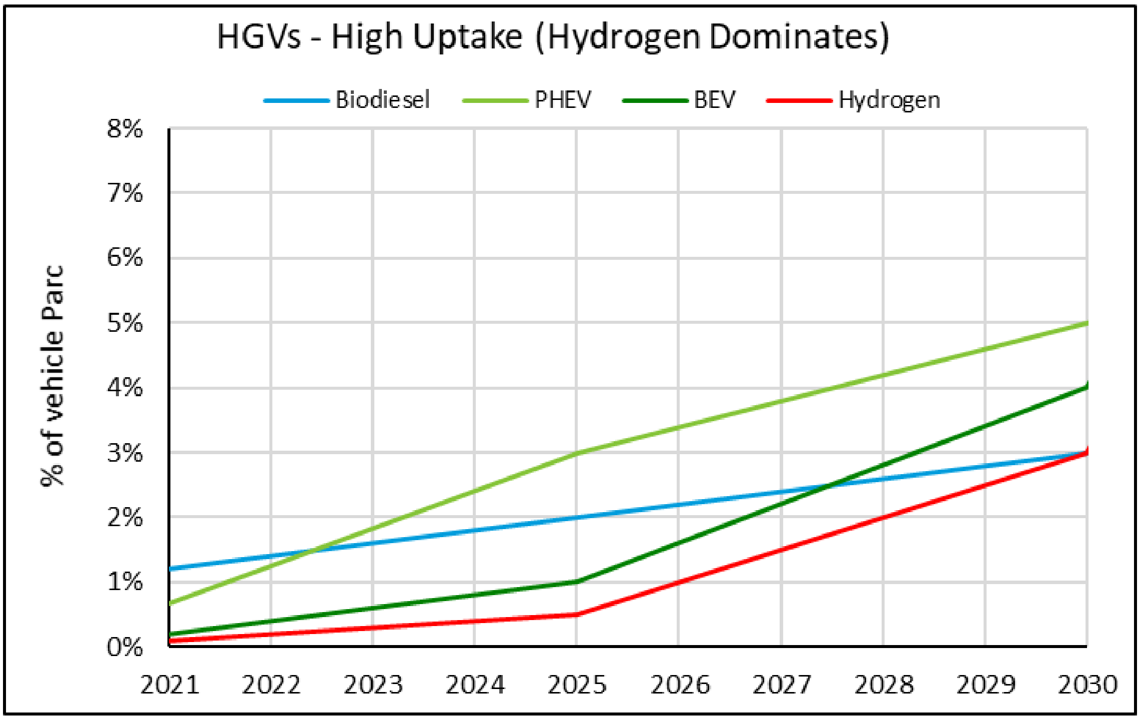


Figure 25. Percentage of HGVs that are alternatively fuelled, CCC high hydrogen uptake scenario.

To better illustrate the alternative fuel mix we have removed diesel and just displayed the other options on this chart. This shows that in the short to medium term, the CCC expects PHEVs will be the technology that displaces most use of diesel, limited to rigid trucks up to around 18 tonnes GVW. In this scenario heavier vehicles, including all articulated trucks, will continue to operate on conventional diesel. Cenex's view is that there will be limited uptake of PHEVs for HGVs, based on the shift to pure BEV for buses and vans, and the push by policy makers to drive uptake of zero tailpipe emission vehicles. This would increase the number of BEVs on the road; in either case chargepoint infrastructure will be required.

HGV Scenario 2: High Biomethane Uptake

The chart below shows the Zemo Partnership scenario through to 2040.

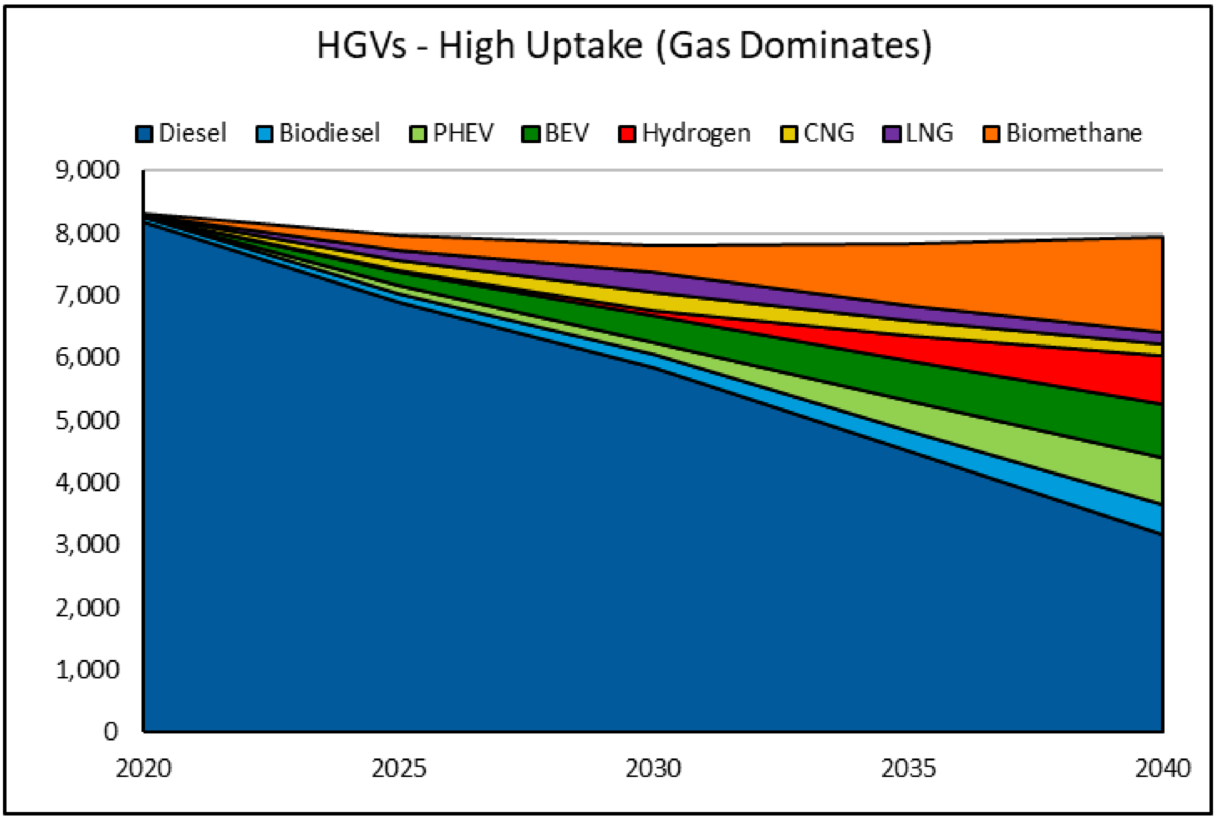


Figure 26. CCC high biomethane scenario - HGV numbers by fuel type through 2050.

In this scenario the fleet composition starts changing much earlier than in the CCC forecasts, with the market share for diesel falling significantly by 2030. The implication for the fleet composition in the CCR up to 2030 is shown in the table and chart below.

Table 7. CCC high biomethane scenario - HGV numbers by fuel type up to 2030.

	2020	2025	2030
Diesel	8,200	6,900	5,860
Biodiesel	80	150	200
PHEV	10	100	200
BEV	0	220	430
Hydrogen	0	40	70
CNG & LNG	20	320	600
Biomethane	10	230	440
Total	**8,320**	**7,960**	**7,800**

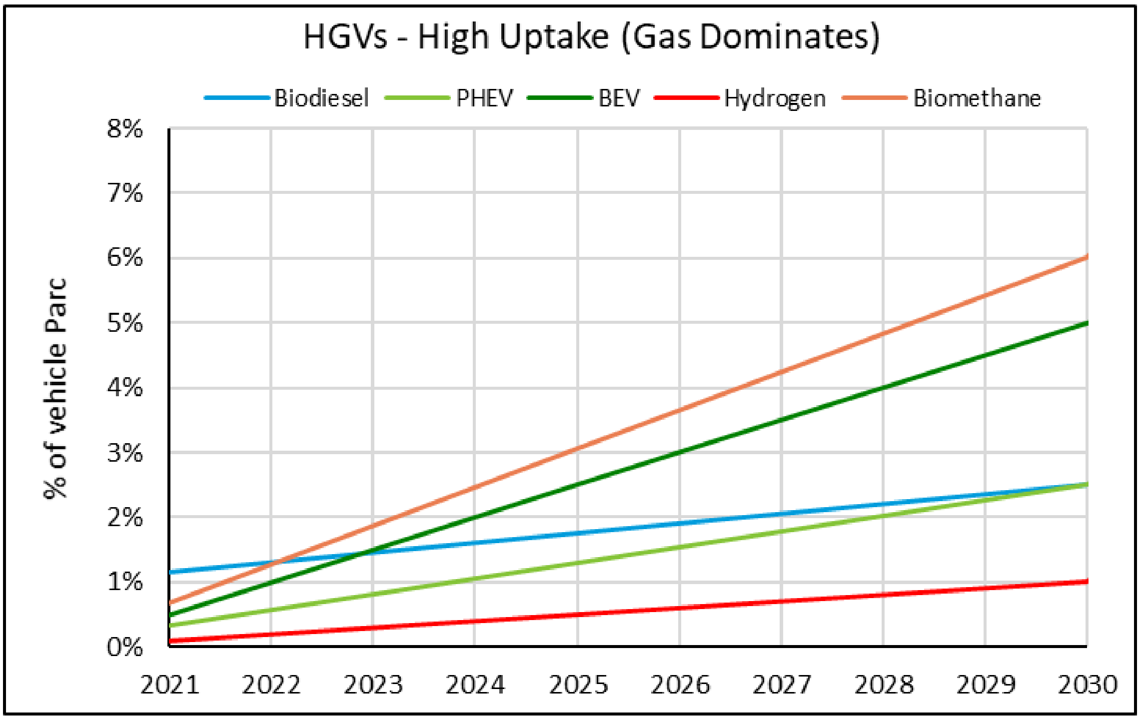


Figure 27. Percentage of HGVs that are alternatively fuelled, CCC high biomethane uptake scenario.

Again, we have removed diesel and just displayed the other options on this chart. This illustrates the role that alternative propulsion options would play in displacing diesel in this scenario.

In summary there are two likely pathways for decarbonisation of HGVs. In one scenario, the fleet will remain almost wholly diesel powered while zero emission technologies are being developed, with a switch to plug-in and hydrogen powered vehicles from 2030 onwards. Cenex's view is that the Ricardo 'gas' scenario is less likely than the CCC 'hydrogen' scenario. Biomethane can be used in the short to medium term to reduce CO_2 emissions while other technologies are developed. However, it is not a pathway fuel to net zero emissions and therefore will be displaced in the medium to long term by BEVs and fuel cell vehicles. Its short-term role in decarbonisation is still important and its use should not be discounted by fleets or policymakers.

7.2 Infrastructure

7.2.1 Chargepoints for Cars and Vans

The technology roadmaps and ULEV scenarios presented above indicate that plug-in vehicles are likely to displace use of petrol and diesel for cars and vans. This sub-section provides estimates of the number of chargepoints that will be required in the CCR under each scenario. In this report we have provided figures for the overall network needed to support cars and vans.

Table 8. Charger type and number required by scenario for target year.

	2022			2025			2030		
	7kW	22kW	50kW+	7kW	22kW	50kW+	7kW	22kW	50kW+
Low uptake	240	60	17	600	160	70	2,000	400	1,000
Aspirational	225	56	16	1,500	400	170	3,100	600	1,500

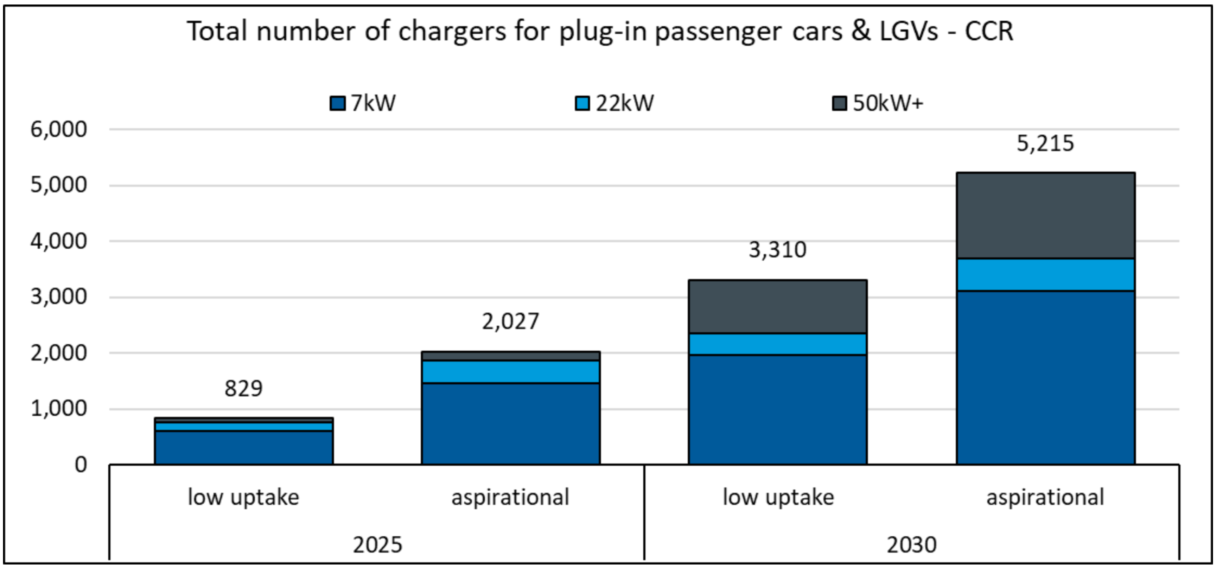


Figure 28. Charger type and number required by scenario for target year.

The table and chart show that significant investment in chargepoint infrastructure will be required to support additional ULEV uptake, particularly in aspirational scenario. Compared to the 2019 version of this strategy, our scenarios show substantially increased demand for charging infrastructure, as a direct result of the 2030 phase out date for new petrol and diesel vehicle sales. In all cases a mixed chargepoint network will be required, offering slow, fast and rapid charging to meet the needs of a wide variety of plug-in vehicle users with different duty cycles. The results are sensitive to assumptions around how much slow and rapid charging will be provided and used. We assume a shift to more rapid charging as hubs become more prevalent and vehicle range continues to increase.

There is a significant difference between the infrastructure requirements between the scenarios, with over 5,000 chargepoints estimated in 2030 to be needed to support the aspirational ULEV uptake scenario. By way of a benchmark, in this scenario we estimate that around 1,500 rapid chargepoints will be needed by 2030: the Wales EV Charging Strategy[59] estimate that across Wales up to 4,000 rapid chargers will need to be installed by that year.

7.2.2 Chargepoints and Refuelling Stations for HGVs

The requirements for chargepoints, hydrogen and/or gas refuelling infrastructure for HGVs varies depending on which of the pathways described in Section 7.1 is followed.

HGV Scenario 1: High Hydrogen Uptake

The table below shows the infrastructure required[60] to support a transition to hydrogen as forecast by the CCC.

Table 9. Required supporting infrastructure for hydrogen transition.

	Capacity (kg)	2025	2030
50kW Chargepoints	-	6	13
150kW Chargepoints	-	2	5
Medium Gas Refuelling Stations	34,500	0	0
Medium Hydrogen Refuelling Stations	800	2	6

Under this scenario, two hydrogen refuelling infrastructure would be required from 2025, although this would entail a significant increase in the speed of development and deployment of fuel cell HGVs. We suggest treating this estimate with caution, and reviewing technology developments in

2022 and 2023. By 2030, we estimate 6 medium capacity hydrogen refuelling stations would be required[61]. In addition, by 2030 we estimate the CCR will need 13 rapid and 5 ultra-rapid chargepoints to support a ULEV HGV fleet.

HGV Scenario 2: High Biomethane Uptake

The table below shows the infrastructure required to support a transition to biomethane as forecast by Ricardo for the Zemo Partnership.

Table 10. Required supporting infrastructure for biomethane transition.

	Capacity (kg)	2025	2030
50kW Chargepoints	-	7	13
150kW Chargepoints	-	3	5
Medium Gas Refuelling Stations	34,500	2	2
Medium Hydrogen Refuelling Stations	800	1	2

Under this scenario, refuelling infrastructure would be required in the short to medium term, with an estimated two gas refuelling stations and one hydrogen station required by 2025, and two gas (biomethane) and two hydrogen stations[62] in total by 2030. In addition, by 2030 we estimate the CCR will need 13 rapid and 5 ultra-rapid chargepoints to support a ULEV HGV fleet.

Indicative costs associated with each of these options are in Section 8.

7.3 Scenario Evaluation

7.3.1 Emissions Reductions

The main reasons for increasing ULEV use are to reduce pollutant and GHG emissions. We have evaluated each scenario to quantify the CO_2, NOx and PM emissions expected to be mitigated in each case. The results can help the City Deal Office in setting their level of ambition around ULEV uptake.

To avoid unnecessary complexity, we have appraised each scenario by consolidating forecast emissions for all vehicle types, rather than evaluating cars, PSVs, vans and HGVs separately[63]. The results are illustrated in the table and chart below.

Table 11. Percentage change 2030 vs 2019.

	TTW CO_2 ('000s tonnes)	NO_x (tonnes)	PM (tonnes)
Low uptake	12%	28%	52%
Aspirational	24%	41%	60%

The table displays the estimated emission reductions under the low uptake and aspirational scenarios in 2030, compared to the 2019 values. This illustrates that ULEVs can significantly reduce local pollutant and GHG emissions. The aspirational scenario is particularly effective, reducing NOx emissions by over 40% and PM emissions 60%. Although the table only displays values until 2030, it is evident that beyond that year the two scenarios would achieve much greater emissions cuts.

7.3.2 Damage Costs Mitigated

We then applied the damage costs approach outlined in Section 3 to estimate and monetise the social benefits of these emissions savings. The results are displayed in the table below.

Table 12. Annual costs mitigated in 2030.

	CO_2 Cost Saving[64]	NO_x Cost Saving[65]	PM Cost Saving[66]	Total Cost Saving
Low uptake	£22.5m	£18.2m	£13.1m	**£53.9m**
Aspirational	£43.6m	£26.6m	£15.2m	**£85.3m**

The damage cost savings have increased significantly since the 2019 version of this strategy. This is driven by two factors. First, the damage cost factors published by the government for NOx, PM and CO_2 emissions have increased. Second, and of greater impact, the expected higher uptake of ULEVs means greater emissions benefits over the next 10 years.

It is beyond the scope of this strategy to undertake a detailed air quality damage cost assessment. However, the estimates provided here show that the monetised social benefits of reducing emissions through ULEV uptake can be significant. These results are indicative based on average damage cost values. These costs vary depending on factors such as whether emissions occur in an urban or rural location. Therefore, a scheme which reduces emissions in a dense urban area such as Cardiff will have a greater monetary value than a similar scheme in a sparsely populated rural area. More detailed appraisals should be undertaken as part of business case analysis to support investment in targeted local measures to promote ULEV uptake. The key message is that there are significant social cost benefits associated with reducing emissions and these increase in inverse proportion to the reduction in emissions achieved.

8 Infrastructure Sites and Costs

This section presents indicative site types and costs for infrastructure and reviews alternative charging technologies for buses.

Key points:

- Chargepoints should be located where vehicles are stationary and have time to charge, with the rate of charge provided being matched to the vehicle dwell time.
- Site types for HGV refuelling infrastructure can include industrial parks, business parks, ports and docks, sites near the motorway network and the SRN, freight consolidation and distribution centres and rail-road freight interchanges.
- Bus infrastructure will almost entirely be at depots and garages in the short term.
- Inductive wireless, conductive pantograph and in-motion pantograph charging are at the early demonstration phase and are not expected to provide a significant contribution to charging requirements in the 2020s.

8.1 Introduction

This section first considers potential site types for EV chargepoints and then outlines potential site types and locations for refuelling infrastructure for HGVs. Next, it provides indicative costs for the installation of recharging and refuelling infrastructure, based on the scenarios in Section 7. Finally, it looks at future alternative charging technologies and their potential applications in the bus sector. It is beyond the scope of this report to provide specific locations, for infrastructure installations; these decisions should be taken by the local authorities, working with chargepoint installers and network operators, and by PSV and freight fleet operators.

8.2 Site Types: Electric Vehicle Chargepoints

There are three categories of locations where charging infrastructure is required: on private property (such as a residential driveway or fleet depot); destination charging, where a vehicle may be stationary for at least a couple of hours; and opportunity or on-route charging, where rapid charging is required to minimise vehicle downtime on a long journey or during a working duty cycle. This report only considers the second and third of these; installations on private property should be planned and managed by the householder or business.

Households with access to off-street parking will primarily charge their vehicles at home, as will van fleet drivers who take their vehicle home. A network of public access slow, fast and rapid chargers will be required across the CCR. Key users of this network will include:

- Householders who want to operate an EV but don't have off-street parking.
- EV drivers who cover relatively high mileages and therefore need access to opportunity charging.
- Commercial vehicle fleets which can't do all their charging at drivers' homes or depots.

This network needs to provide good spatial coverage across the region with enough density at key locations to ensure there is sufficient supply to meet demand. The rate of charging provided at each location should be matched to the likely vehicle downtime at that site. Slow (7kW) charging should be provided where vehicles will be stationary for several hours, such as park and ride car parks. Fast (22kW) charging should be provided where vehicles will be stationary for an hour or two, for example leisure centre car parks. Rapid and ultra-rapid charging (50kW or above) should be provided where the aim is to minimise vehicle downtime, for example at motorway service stations and charging hubs.

The following table proposes potential site types for EV charging infrastructure for cars and vans together with suggestions for the speed of charge that should be provided, based on estimated dwell time. This list is not intended to be exhaustive but rather to provide some examples of sites that should be considered for chargepoint provision. We also emphasise that further work will be required to assess the need for the number and rate of chargepoints at individual locations.

Table 13. Potential site types for EV charging infrastructure.

Vehicle type	Site Type	Rate(s) of Charging
Cars	Street side where off-street charging can't be installed, park and ride car parks, rail station car parks	7kW
	Hotels for business travel and visitors, Conference centres, university campuses	7kW, 22kW
	Supermarkets, medical facilities such as hospitals, leisure facilities such as sports centres, retail parks / shopping centres	22kW
	Service stations on the SRN, new charging hubs	50kW
Vans	Local authority depots	7kW
	University Campus	7kW, 22kW
	Business parks, industrial estates	22kW, 50kW
	Service stations on the SRN, new charging hubs	50kW

There is considerable uncertainty around future trends in the rate of charging that will be required for different vehicles, duty cycles and locations. Vehicle battery capacities will increase which means fewer recharging events will be needed per week to support a given mileage requirement. Drivers may only need to charge a vehicle with a 200 mile range once a week[67]. It also means delivering a full charge to a typical vehicle in 2025 or 2030 on a 7kW chargepoint will take considerably longer than fully charging a typical vehicle in 2019.

As EV adoption becomes more widespread, it is likely that rapid and ultra rapid charging hubs will be set up to help meet demand. These will be particularly useful for householders without off-street parking and drivers who cover relatively high mileage.

Beyond 2025 there may be a reduction in the need for 7kW and 22kW destination charging and that units installed in the first half of the decade may suffer from poor utilisation. Conversely, if these units can offer charging at a more competitive price than the rapid charging hubs then they would still be used by some price-conscious drivers.

Providing on-street residential charging can help open up EV ownership beyond the current narrow demographic of owners who typically have off-street driveway parking. However, it has a number of drawbacks including high upfront cost, possible requirement for ongoing funding, installation challenges (whether to install units incrementally or by street), maintenance costs, and streetscape clutter. Rapid charging hubs will offer more convenience to the driver and an experience more similar to petrol or diesel refuelling, but at a higher per unit cost than home charging. Local authorities have an important role to play in shaping which way the market will proceed on charging provision, and significant influence through their procurement channels. Tenders for charging infrastructure should reflect the upfront and ongoing costs for the public and private sector, the risk of underutilised assets, and the social inclusion and equality agendas.

8.3 Site Types: Refuelling Stations for HGVs

The maps in Section 4 showed that there is poor coverage of refuelling infrastructure in the CCR to support a gas and/or hydrogen HGV fleet. A suitable network needs to be developed to give businesses confidence to acquire and operate alternatively fuelled vehicles. Some fleets may choose to install gas (biomethane) or hydrogen refuelling at their depots; these locations are not in scope of this section. We are only considering the need for publicly available refuelling stations.

We identified potential locations for additional infrastructure locations via the freight stakeholder workshop, a review of projects in other parts of the UK and by desk-based research into the CCR. This exercise was not intended to provide comprehensive or detailed guidance to inform investment in specific locations. Rather, the aim was to identify potential locations to provide an indication of where further feasibility work should be concentrated. Outputs are shown in the table below.

Table 14. Locations for potential feasibility studies.

Fuel type	Site Type	Example Location(s)
Gas (biomethane) and/or Hydrogen	Industrial parks	Felnex Industrial Estate The Avenue, Pontprennau Parc Bedwas Aberaman Park Leeway Industrial Estate
	Business parks	Edwards Business Park Merthyr Tydfil Business Park Phoenix Business Park East Moors Business Park
	Ports and Docks	Barry Docks Cardiff Docks Newport Port
	Motorway network and the SRN	M4 services: Magor, Cardiff Gate, Cardiff West, Sarn Park Laybys on the SRN
	Freight consolidation and distribution centres	Caldicot Magor Cardiff Airport
	Rail-road freight interchanges	N/A

Key criteria to consider for site suitability are as follows:

- Sites should be near to a motorway or the SRN to increase demand fleet operators, including those passing through the CCR.
- Ensure there is enough space for large vehicles, including consideration of turning circles.
- Access to the high pressure gas grid can reduce installation costs for CNG and LNG refuelling stations and will marginally improve overall GHG emissions performance.
- Sufficient electricity supply is needed to run compressors and other components of gas and hydrogen refuelling stations.
- Consider planning requirements and the likelihood of securing consent.
- The cost of land is a key component for infrastructure providers when analysing the potential business case for installing a new station.

In previous sections of this report we highlighted the uncertainty around technology pathways for decarbonising the HGV fleet. It is therefore not possible to make specific recommendations about which type of infrastructure (e.g. gas and/or hydrogen) should be installed at these locations in the short term. It is likely that biomethane will be required in either scenario so that option could be taken forward for further consideration, but the role of hydrogen is less clear. For now, we recommend assessing the feasibility of co-locating recharging and refuelling infrastructure together at each location. Investment is likely to come primarily from the private sector; by helping to stimulate this investment, for example via favourable planning conditions, the CCR can then allow the market to select the best technology. In the medium to long term (2025 onwards) the City Deal Office should fund, or support access to funding, for hydrogen demonstration projects; in such cases the location of the infrastructure will depend on the chosen demonstration area and project requirements.

As noted above, these sites were identified by a limited data collection approach. Wider market research and business engagement will be required to identify further locations which would form a comprehensive network across the region and to refine the list presented above. The results in this report are presented as an indicative network and not a definitive guide to where infrastructure should be installed.

8.4 Estimated Costs

This sub-section presents high level costs for chargepoints for cars and vans and chargepoints, gas and hydrogen refuelling stations for HGVs. These costs are indicative estimates and do not represent detailed site-specific costs for installation. Individual site surveys and quotes will be required to refine these estimates.

8.4.1 Chargepoints for Cars and Vans

The table below shows the estimates for chargepoint requirements for cars and vans in 2025 and 2030, together with total indicative costs for hardware and installation (capital costs). Costs are provided as the total amount that will be required by 2025 and then by 2030.

Table 15. 2025 and 2030 chargepoint estimate and indicative costs.

	2025				2030			
	7kW	22kW	50kW+	Total cost by 2025	7kW	22kW	50kW+	Total cost by 2030
Low uptake	600	160	70	**£5m**	2,000	400	1,000	**£38m**
Aspirational	1,500	400	170	**£10m**	3,100	600	1,500	**£68m**

The total investment required increases with the level of ambition within the CCR to transition to a ULEV car and van fleet; £68m of investment will be needed to provide enough chargepoints to achieve the aspirational vehicle uptake scenario. As noted in Section 3, these costs exclude groundworks and any upgrades to the local electricity grid, which can be substantial. Depending on the network operating model selected, the majority if not all of the costs in the table above can be leveraged from the private sector. This would be contingent on investors identifying a strong business case for installing chargepoints, which in turn relies on a clear signal from local government that ULEV adoption will be encouraged and incentivised.

8.4.2 Chargepoints and Refuelling Stations for HGVs

The costs of hydrogen and gas refuelling infrastructure vary depending on which scenario unfolds.

HGV Scenario 1: High Hydrogen Uptake

The table below shows the cost of infrastructure to support a slow transition to hydrogen as forecast by the CCC.

Table 16. 2025 and 2030 HGV chargepoint & refuelling estimate & indicative costs, High hydrogen scenario.

	2025		2030	
	Number required	Total cost by 2025	Number required	Total cost by 2030
50kW Chargepoints	6	**£0.16m**	13	**£0.35m**
150kW Chargepoints	2	**£0.2m**	5	**£0.44m**
Medium Gas	0	**£0**	0	**£0**
Medium Hydrogen	2	**£7.4**	6	**£22.2m**

In this scenario, a substantial investment in hydrogen refuelling stations will be required by 2030, as well as a relatively small investment in rapid and ultra rapid chargepoints. As noted above, the need for two HRS in 2025, as extrapolated from the CCC scenario, would entail a significant increase in the speed of development and deployment of fuel cell HGVs. We suggest treating this estimate with caution, and reviewing technology developments in 2022 and 2023.

HGV Scenario 2: High Biomethane Uptake

The table below shows the cost of infrastructure to support a transition to biomethane as forecast by the Zemo Partnership.

Table 17. 2025 and 2030 HGV chargepoint & refuelling estimate & indicative cost, high biomethane scenario.

	2025		2030	
	Number required	Total cost by 2025	Number required	Total cost by 2030
50kW Chargepoints	7	**£0.2m**	13	**£0.4m**
150kW Chargepoints	3	**£0.3m**	5	**£0.4m**
Medium Gas	2	**£4.8m**	2	**£4.8m**
Medium Hydrogen	1	**£3.8m**	2	**£7.4m**

In contrast to Scenario 1, significant investment is needed for gas refuelling stations. The investment in two gas stations are similar to one hydrogen station, due to its higher unit cost. By 2030, total investment in infrastructure is significantly lower than in Scenario 1, as fewer hydrogen refuelling stations are needed due to the uptake of gas ULEVs.

8.5 Infrastructure for PSVs

The vehicle and infrastructure technology roadmaps showed that for PSVs a mixture of different fuel types is likely to penetrate the fleet and displace use of diesel. Between now and 2030 the most likely options are plug-in and biomethane powered gas vehicles. The vast majority of recharging and refuelling is likely to take place at bus stations and depots where vehicles have enough dwell time to be recharged or refuelled.

For BEVs this will primarily involve slow charging at locations where PSVs are kept overnight or between shifts. Gas refuelling takes less time and could be carried out at any location such as a station or stop where vehicles are stationary for around 15 minutes or more. Recharging or refuelling on route is not generally operationally feasible for PSVs using current technology so longer routes are restricted to being operated by gas or diesel vehicles. However, the following sub-section considers some alternative charging solutions that may allow the operation of BEVs on longer routes.

8.5.1 Alternative Charging Technologies

There are three main technology options that could potentially support use of BEVs on longer routes (intra-city) using on-route rapid charging to increase effective range:

- **Inductive wireless charging**: this involves charging the vehicle via a primary coil fixed to the road surface and a secondary coil fitted to the vehicle. The main challenge with this technology is its efficiency; typically, there is a 60-80% loss of energy during the charging process. In addition, it’s currently very expensive and can potentially delay journeys if used on route.
- **Conductive pantograph charging**: this consists of an overhead charging unit which will typically be installed at bus stops or depots where the bus is stationary for a short period of time. The unit charges a battery fitted to the top of the vehicle. This has some of the same barriers as inductive systems; it can add to journey times and will be expensive if multiple units are required to support a single bus or route. Finally, it adds to street furniture.
- **In-motion pantograph charging**: this involves charging vehicles directly from overhead wires. As a wired solution it doesn’t suffer from the efficiency losses associated with inductive charging. However, it does add to street furniture and attracts significant installation and maintenance costs.

The current and forecast technology status for these are summarised in the roadmap below.

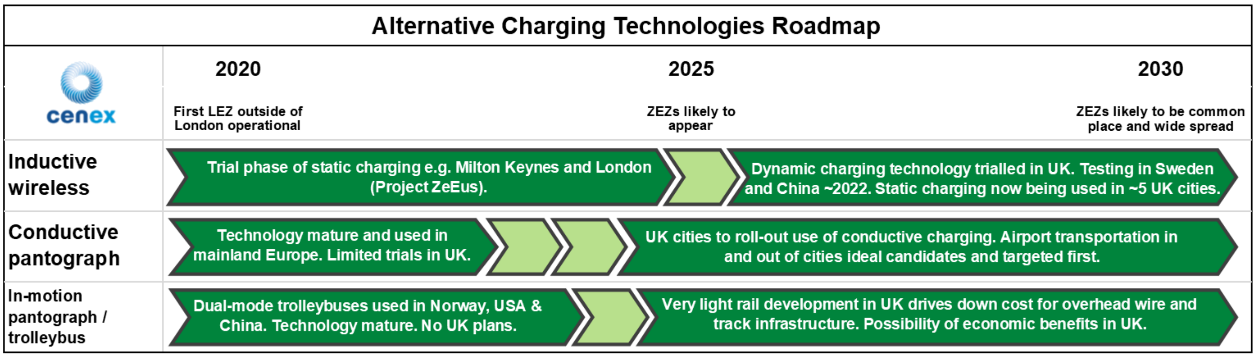


Figure 29. Opportunity Charging Infrastructure (buses).

Currently the challenges and barriers outlined above outweigh the potential benefits, and so these technologies are all at the trial and demonstrator phase. We do not expect any of these solutions to achieve significant market deployment in the 2020s.

We emphasise that the technologies discussed here would only have a potential application for long inter-city coach routes, and even then costs will need to come down to make them feasible. Any buses or coaches which operate within the CCR, even if they travel through more than one local authority, should be switched to pure BEVs when vehicles with a suitable range are available. The information provided above is only provided to illustrate the challenges with these technologies.

9 Recommendations

This section presents a longlist of recommendations for the CCR City Deal Office including a high level assessment of their expected impact, cost and ease of implementation. It also discusses renewable energy, economic growth prospects, and links with other activity.

Key points:

- Cars: the priority should be facilitating an increase in the provision of chargepoint infrastructure. Other measures to support this could include workplace parking levies and a public engagement campaign.
- Buses: engagement with operators via a Bus Working Group will be key to encouraging ULEV uptake. The City Deal Office can also help increase operators' knowledge and awareness of different technologies and support them with access to funding.
- Vans and HGVs: the priority should be facilitating an increase in the provision of chargepoint and (in the short-term) gas refuelling infrastructure. Engagement with operators via a Freight Working Group is also recommended.
- For all heavy vehicles a retrofit program to reduce emissions from the oldest most polluting vehicles would be effective.
- Public sector bodies should lead by example by increasing ULEV use in fleets and supply chains.
- Renewable energy can help maximise the benefits of ULEVs; further work is needed to understand the potential and how to exploit it.
- Accelerating the transition to ULEVs can bring significant benefits around economic growth and job creation.

9.1 Introduction to Recommendations

This section presents a longlist of recommendations for the CCR City Deal Office. They may also be useful for local authorities in the CCR, fleet operators, infrastructure providers and landowners. The recommendations have been developed from the modelling outputs, roadmaps and stakeholder engagement activities described in this report. Recommendations reflect current and forecast operational, financial and environmental viability of each technology for different vehicle types and duty cycles. In some cases, the technology is mature and should be actively encouraged and incentivised in the short term, while for others further performance improvements are required before public sector investment is recommended.

The first sets of recommendations are categorised by vehicle type, covering cars, PSVs, and vans and HGVs. We have undertaken a preliminary assessment of these recommendations against three criteria: expected impact, cost (to the City Deal Office), and ease of implementation. This is illustrated with a red, amber or green status against each criteria. This is a high level exercise; as this is a strategy rather than a delivery or action plan, we have not undertaken a detailed assessment of each recommendation. Further feasibility work will be required before implementing these recommendations, including refining costs, assessing the benefits and defining roles and responsibilities for delivery. The definitions of each status is as follows:

- **Expected impact**: Green indicates this measure is likely to have a substantial impact on ULEV uptake rates, amber indicates a moderate impact, red indicates limited impact.
- **Cost**: Green indicates relatively low cost, e.g. under £50,000, for example to find a feasibility study; amber indicates higher cost, e.g. over £50,000 and below £200,000, to fund longer term implementation and delivery work; red indicates higher costs where for example a wide ranging grant programme would be needed. These do not indicate value for money or effectiveness in terms of outcomes per pound spent.

- **Ease of implementation**: This is a highly qualitative and uncertain assessment ranging from green, being the easiest and lowest risk options through to red which may be highly challenging to implement and/or carry substantial risk to the City Deal Office.

This section also outlines how the City Deal Office and the local authorities in the CCR can lead by example by increasing ULEV uptake in public sector fleets. After that it outlines the potential benefits of a transition to ULEVs for regional economic growth and job creation and how these might be exploited. Finally, it considers the importance of links with other policies, strategies and strands of activity.

9.2 Cars

Cars are the most numerous vehicle type in the CCR and, by category, are the major source of emissions. The roadmaps show that plug-in vehicle technology is suitable for deployment in the car fleet and will be cost-effective in many duty cycles. Electric cars are expected to reach price parity with conventional cars between 2025 and 2030. Price parity will be reached earlier for vehicles with smaller batteries and shorter range, and later for longer range models. In any case, electric cars are already often cheaper to run overall, with lower fuel and maintenance costs offsetting upfront price premiums. These factors mean there is significant potential to stimulate increased ULEV adoption in the short term. The City Deal Office should consider implementing the following recommendations.

9.2.1 Chargepoint Infrastructure

Recommendation: work with the CCR local authorities, Western Power Distribution (WPD) and the private sector to facilitate a step-change in the provision of chargepoint infrastructure for plug-in cars.

Increasing chargepoint network coverage is likely to be the most effective measure to stimulate ULEV uptake by private and business car owners. This network should provide good spatial coverage across the CCR and provide the right rate of charging at the right locations. It must be user-centric, offering pay as you go access via contactless card and app, and inter-operability across and beyond the CCR. It must be designed strategically to meet the needs of different vehicle and journey types.

Providing large numbers of on-street bollard-style chargepoints is viewed by some as the best solution to facilitating EV ownership for residents in areas without off-street parking. However, this approach has several drawbacks:

- 7kW units will only support charging by a small number of vehicles so it will be challenging for an operator to develop a business case to install and run units without public support.
- 22kW on-street units could support more vehicles, but would require consumers to unplug and repark their vehicle when it is fully charged.
- Consumers would be unable to guarantee access to a parking space with a chargepoint, so they may still be unwilling to switch to an EV.
- Units could be installed individually as demand steadily increases, but each installation would require disruptive groundworks and connection costs. Alternatively whole streets could be electrified, but in many cases assets would then be under-utilised.
- Maintenance costs may be higher for bollard chargers than for other asset types.

Providing on-street residential charging can help open up EV ownership beyond the current narrow demographic of owners who typically have off-street driveway parking. However, drawbacks include high upfront cost, possible requirement for ongoing funding, installation challenges (whether to install units incrementally or by street), maintenance costs, and streetscape clutter. Rapid charging hubs will offer more convenience to the driver and an experience more similar to petrol or diesel refuelling, but at a higher per unit cost than home charging.

Local authorities have an important role to play in shaping which way the market will proceed on charging provision, and significant influence through their procurement channels. Tenders for charging infrastructure should reflect the upfront and ongoing costs for the public and private sector, the risk of underutilised assets, and the social inclusion and equality agendas. We encourage the

CCR and other stakeholders to review all possible solutions to this challenge, with on-street chargers one option under consideration.

For destination and rapid chargers, the City Deal Office, working with the CCR local authorities, should identify a longlist of potential sites and assess them to produce a shortlist of suitable options. This should be made available to chargepoint installers and network operators to encourage private sector investment. The City Deal Office should liaise with WPD to obtain budget estimates and an outline timescale for grid connection. Further specific tasks will depend on the network operating model selected.

Table 18. 9.2.1 Chargepoint Infrastructure Feasibility Assessment Results.

Criteria	R/A/G Status
Expected impact	
Cost	
Ease of implementation	

9.2.2 Workplace Parking Levies

Recommendation: assess the feasibility of implementing workplace parking levies in major urban areas.

A Workplace Parking Levy (WPL) is a charge on employers which provide workplace parking. Employers can reclaim part or all of the cost of the WPL from their employees. The aim is to encourage employers to reduce the number of free workplace parking bays and encourage staff to switch to alternative modes of transport. A WPL can be used to increase ULEV uptake in two ways:

- Exemptions to the WPL can be provided to staff who drive a ULEV.
- Revenues raised by the charge can be used to fund chargepoint infrastructure and other measures to encourage ULEV use.

Nottingham City Council introduced a WPL in 2011. The current charge is £415 per parking space per year. The scheme has generated total revenue of around £64m (as of 2019) which has been used to attract additional funding, primarily from the government. The WPL has helped extend the city’s tram network, redevelop the city’s railway station and contribute towards an electric bus network. Other cities considering WPLs include Birmingham and Oxford.

Table 19. Workplace Parking Levies Feasibility Assessment Results.

Criteria	R/A/G Status
Expected impact	
Cost	
Ease of implementation	

9.2.3 Public Engagement

Recommendation: plan and deliver outreach and communications activity to raise awareness of the benefits of ULEVs among the general public.

In the UK there is relatively little understanding and awareness of the benefits of plug-in vehicles among private vehicle owners. The Go Ultra Low campaign[68], a joint government and car industry initiative, aimed to address this by providing facts and information to help people make informed decisions about plug-in vehicles. The City Deal Office could implement a similar campaign in the CCR, using channels including a website, social media and local press and radio. Campaign content could include:

- The positive benefits associated with ULEVs such as lower running costs and reduced maintenance requirements.
- The negative impacts of petrol and diesel vehicles on air quality and climate change.

- Addressing perceived barriers to ULEV ownership
- Raising awareness of initiatives such as increased availability of chargepoints and local measures such as free parking for EVs.

Table 20. Public Engagement Feasibility Assessment Results.

Criteria	R/A/G Status
Expected impact	
Cost	
Ease of implementation	

9.2.4 Fleet Reviews

Recommendation: fund independent fleet reviews to identify opportunities for accelerated ULEV uptake.

Around half of new car sales are to fleets rather than private buyers. In addition, a single fleet decision maker may be responsible for procurement decisions on hundreds or even thousands of vehicles a year. Actions to encourage increased fleet adoption of ULEVs can therefore be very effective and efficient.

Fleet adoption of ULEVs is constrained by uncertainty over operational, environmental and financial performance. This is linked to a lack of trust in information and data provided by vehicle manufacturers and suppliers. Fleet reviews which provide bespoke, independent information about ULEV suitability could help overcome this issue.

Table 21. Fleet Reviews Feasibility Assessment Results.

Criteria	R/A/G Status
Expected impact	
Cost	
Ease of implementation	

9.2.5 Scrappage Scheme for Cars

Recommendation: assess the feasibility of a targeted vehicle scrappage scheme.

Significant emissions benefits can be achieved by accelerating the rate at which older, more polluting vehicles are removed from the parc. Carefully designed and targeted scrappage schemes can be effective in achieving this objective. There are two possible options for a scrappage scheme; recipients could either receive:

- Cash towards the cost of acquiring a new plug-in vehicle.
- Mobility credits which can be used on a range of transport modes including public transport, car clubs and shared bicycles.

Eligibility could be restricted to low income households to contribute towards goals around inclusivity and reducing transport poverty. A similar model has been taken by TfL, which launched its ULEZ car and motorcycle scrappage scheme[69] in November 2019. Scrappage schemes can be highly effective but need to be designed and managed carefully to ensure they only benefit intended recipients.

Table 22. Scrappage Scheme for Cars Feasibility Assessment Results.

Criteria	R/A/G Status
Expected impact	
Cost	
Ease of implementation	

9.3 PSVs

The PSV fleet in the CCR includes a wide range of vehicles, from highly polluting pre-Euro V models to the latest low emission Euro VI standard. As shown in Section 4, PSVs have high emissions per vehicle but low total emissions. The situation is complex, with a number of different factors to consider. Removing the oldest vehicles from the fleet and replacing them with newer models, or using retrofit to comply with the latest emission standards, will significantly reduce pollutant emissions. In order to reduce GHG emissions, a shift to alternative fuels would be required. The key points to be aware of when considering investment in low and ultra low emission buses are as follows:

- There is an issue to be tackled with older more polluting vehicles operating in dense urban areas where exposure to air pollution is a serious public health problem. These vehicles are typically deployed by private operators on scheduled services, covering relatively high mileage. There is a case for encouraging, and potentially requiring, the accelerated replacement of these vehicles.
- The PSV fleet also includes vehicles which cover fewer miles but, as the age profile above revealed, will have very high intrinsic emissions. For example, these vehicles may be used on school services. In these cases, it is more difficult to make an economic case for vehicle replacement, and retrofit to meet newer emissions standards is often not feasible.
- From an operational perspective, most bus duty cycles can be covered by an alternatively fuelled vehicle. Shorter routes plied by single deck buses are well suited to BEVs, while biomethane powered vehicles can cover longer routes, with good availability of all sizes of vehicles.
- From a financial perspective, alternatively fuelled vehicles may only be cost effective on relatively long routes, or in double or triple shifted operations, where the high mileage and low running costs provide a payback on the higher capital investment. Further work would be required to identify specific routes and services where BEV or gas vehicles are viable.
- Scheduled service bus operators should consider electric and gas vehicles first and only purchase diesel Euro VI models when these alternatives have been shown to be unsuitable based on operational or financial criteria. Electric and gas buses can be operated using recharging and refuelling infrastructure installed at bus garages and depots; public access infrastructure is not required.
- Some vehicles, particularly those used on school routes or where daily mileages are low, will not be technically viable for retrofit or financially viable for replacement with new vehicles. Cenex recommends that the City Deal Office, Welsh Government, TfW and local authorities in the CCR consider whether investment in vehicle replacement should be made anyway to reduce pollutant emissions, particularly on vehicles which will operate mainly in residential areas and around schools. This will require grant funding from the Welsh Government. Operational costs should fall, as newer vehicles will be more efficient and require less maintenance.
- Given the constraints outlined above, in the absence of significant additional funding, diesel will continue to power the PSV fleet in the short to medium term. We understand that plans have been developed, subject to funding, for an upgrade to the bus fleet in Cardiff; this would need to be implemented and similar funding provided across the CCR.

The City Deal Office and the local authorities in the CCR have no control over the PSVs that are deployed by private sector operators in the region. Ultimately, decisions over vehicle acquisition and use will be made by these operators. The City Deal Office should therefore seek to facilitate and encourage a shift to alternative fuels via the recommendations below.

9.3.1 Engagement with PSV Operators

Recommendation: set up a PSV Working Group to provide structured engagement and collaboration between stakeholders.

In the absence of any control over PSV operators' vehicle deployment decisions, the key to increasing ULEV uptake will be communication and collaboration between different stakeholders. The City Deal Office should set up and chair or appoint a chair of a PSV Working Group. Attendees should include the City Deal Office, local authorities, PSV operators, Welsh Government and Transport for Wales. The objectives of this group should be to:

- Ensure operators are kept up to date with the latest technology developments, vehicle availability and funding opportunities.
- Develop and submit collaborative funding applications. Working as a coherent region with a clear strategy for ULEV adoption is likely to strengthen funding applications. Wales has historically been less successful than the rest of the UK in attracting funding for low emission buses[70]. A Working Group would help address this by providing a single voice for lobbying the Welsh Government and the DfT.
- Develop partnerships between local authorities, PSV operators, vehicle manufacturers and infrastructure providers to deliver demonstration projects and disseminate results.
- Explore options for joint procurement to reduce the costs of vehicles and infrastructure.
- Discuss the barriers to accelerate ULEV adoption and work to identify and implement solutions.
- Ensure alignment with other strategies and activities in the CCR and the rest of Wales.
- Disseminate best practice and resources already available, such as the LowCVP Low Emission Bus Hub[71] and Low Emission Bus Guide[72].

Table 23. Engagement with PSV Operators Feasibility Assessment Results.

Criteria	R/A/G Status
Expected impact	
Cost	
Ease of implementation	

9.3.2 Technology Review and Best Practice Guidance

Recommendation: commission a detailed technology review for PSV operators.

Operators would benefit from access to better information about the real-world operational, financial and economic performance of different fuels and technologies for different vehicles, routes and duty cycles. This would support informed decision making and business case development for investing in alternative fuels. The City Deal Office could commission a technology review to help achieve this objective. Outputs could be disseminated to PSV operators via the working group and a series of webinars. The technology review should include:

- **Operational performance**: Technology maturity and vehicle availability, range, refuelling and recharging options and operational restrictions (for example, impacts of alternative fuels on passenger carrying capacity).
- **Fuel use and energy consumption:** Modelling expected fuel consumption and efficiency for alternative fuels and technologies in different operating conditions (for example, different vehicle types, routes and topography).
- **Total cost of ownership:** Modelling expected TCO for alternative fuels and technologies in different operating conditions. Results will give operators confidence to invest in ULEVs.
- **Alternative charging infrastructure:** A detailed assessment of the potential role of pantograph and/or inductive charging for buses, including comparing the costs of these technologies with the costs of upgrading bus depot electricity supply. This can also include the potential role for smart charging, V2G, on-site renewable energy generation and energy storage.

Table : Feasibility Assessment Results:

Table 24. Technology Review and Best Practice Guidance Feasibility Assessment Results.

Criteria	R/A/G Status
Expected impact	Amber
Cost	Green
Ease of implementation	Green

9.3.3 Encourage use of Retrofit Systems

Recommendation: provide information about the benefits of retrofit systems and support operators with access to funding.

Retrofitting older PSVs with exhaust after-treatment equipment to reduce tailpipe pollutant emissions is a cost effective alternative to replacing these vehicles with new models. Vehicles are typically fitted with selective catalytic reduction (SCR) systems which can reduce NOx emissions by at least 50% and up to 90%, allowing Euro V vehicles to meet Euro VI emissions standards. Since 2013, the government has awarded over £27 million to retrofit around 3,000 vehicles in the UK.

The City Deal Office can encourage use of such systems by:

- Including retrofit systems in the technology review outlined above.
- Undertaking a supplier engagement exercise to better understand the market for these products, covering availability, performance and cost.
- Facilitating collaborative procurement across the CCR to reduce costs.

Note that retrofit is not technically viable for most pre-Euro IV vehicles so, while it can be part of the solution, it will not tackle emissions from the oldest, most polluting vehicles.

Table 25. Encourage use of Retrofit Systems Feasibility Assessment Results.

Criteria	R/A/G Status
Expected impact	Amber
Cost	Green
Ease of implementation	Amber

9.3.4 Trials and Demonstrators

Recommendation: Facilitate the delivery of trials and demonstrators to prove the real-world benefits of alternative fuels.

A lack of trust in vehicle suppliers' data may be constraining ULEV uptake. In addition, there is uncertainty about the real-world benefits and drawbacks of new and emerging technologies and their likely performance in different duty cycles and vehicle types. Testing and proving vehicles' operational, financial and environmental performance in real-world applications can be very effective in overcoming this barrier. The City Deal Office should help coordinate consortia between fleets, manufacturers and infrastructure providers and facilitate access to funding by these groups. Consortia should seek to demonstrate emerging technologies in real-world use cases and ensure that the necessary infrastructure, knowledge and skills are being developed to support deployment of promising options. This should include working with local employers and higher education institutions (as discussed in depth in section 9.7) to help upskill and reskill the regional workforce.

Specific actions could include:

- Ensuring funding applications and trials reflect current and forecast technology performance and vehicle availability. For example, in the short-term it may be sensible to apply for funding for battery electric vehicles supported by ultra-rapid depot charging, in line with the roadmaps in this report.
- Coordinating activity across the CCR, ideally via the PSV Working Group.

- Monitoring and signposting funding opportunities from the EC, UK Government and Welsh Government.

Table 26. Trials and Demonstrators Feasibility Assessment Results.

Criteria	R/A/G Status
Expected impact	
Cost	
Ease of implementation	

9.3.5 Lobby for Funding

Recommendation: Lobby the Welsh Government and DfT for funding to support operators running low emission buses.

In England and Scotland, new buses accredited under the Low Carbon Emission Bus Accreditation Scheme and the Low Emission Bus Accreditation Scheme are eligible for the Low Carbon Emission Bus Operator Grant Incentive. This incentive is not available in Wales. The City Deal Office should lobby the Welsh Government and DfT for funding to support operators running low emission buses in the CCR.

Table 27. Lobby for Funding Feasibility Assessment Results.

Criteria	R/A/G Status
Expected impact	
Cost	
Ease of implementation	

9.3.6 Ultra Low Emission Bus Zones

Recommendation: explore the feasibility of implementing Ultra Low Emission Bus Zones.

If the 'nudge' measures outlined in this section fail to achieve an increase in ULEV adoption, the City Deal Office may need to explore more direct measures. As it has no control over operators' procurement and deployment decisions, one of the few options available would be to set up Ultra Low Emission Bus Zones where only ULEV buses are able to operate[73]. Non-compliant vehicles could be banned from these areas, or operators could be required to pay a daily charge to enter the zone. Although effective, this measure is likely to meet with significant resistance from bus operators.

Table 28. Ultra Low Emission Bus Zones Feasibility Assessment Results.

Criteria	R/A/G Status
Expected impact	
Cost	
Ease of implementation	

9.4 Vans and HGVs

Vans and HGVs are treated together here as many of the recommendations apply to all commercial vehicles irrespective of size or GVW.

Vans should be a priority focus area for three reasons. First, the baseline assessment showed that the fleet includes a significant number of older more polluting vehicles and few Euro 6 vehicles. Second, most of these vehicles will have real-world emissions that are higher than official test cycle values. Third, the roadmaps show there is a clear pathway to electrification for vans, the technology is mature and viable, and product availability is increasing rapidly.

ULEV penetration into the HGV fleet will be slower than for other vehicle types because plug-in vehicles are not generally operationally or financially viable and due to uncertainty over technology pathways. In the short term, encouraging increased use of biodiesel and, in the right circumstances, biomethane, can be regarded as 'no regret' options that will deliver significant GHG emissions benefits during the 2020s. Even if hydrogen ultimately becomes the primary HGV fuel after 2030, that still allows at least a decade which is ample time to achieve payback on gas vehicles and infrastructure.

The City Deal Office should consider the following options to encourage and facilitate a transition to ULEVs by van and HGV operators.

9.4.1 Infrastructure

Recommendation: work with the CCR local authorities, the private sector and WPD to facilitate a step-change in the provision of chargepoint infrastructure for plug-in vans and support the development of a gas refuelling network.

Increasing chargepoint and refuelling network coverage is likely to be the most effective measure to stimulate ULEV uptake by van and HGV operators. The criteria for a good chargepoint network and the steps necessary to facilitate it are the same as those listed in Section 9.2. Provision of gas refuelling infrastructure will be led by the private sector. The City Deal Office can help facilitate this by taking the following actions:

- Providing a clear policy signal that the CCR actively encourages increased use of gas HGVs and infrastructure.
- Working with local authorities, landowners and developers to help infrastructure providers access suitable sites near the motorway network and SRN.
- Ensuring that local authorities' planning processes actively support deployment of gas refuelling infrastructure, and that officers apply guidance appropriately.

Table 29.Infrastructure Feasibility Assessment Results.

Criteria	R/A/G Status
Expected impact	
Cost	
Ease of implementation	

9.4.2 Engagement with Freight Operators

Recommendation: set up a Freight Working Group to provide structured engagement and collaboration between stakeholders.

In the absence of control over freight operators' vehicle deployment decisions, facilitating communication and collaboration between stakeholders may help encourage ULEV uptake. The City Deal Office should set up and chair or appoint a chair of a Freight Working Group. Attendees should include the City Deal Office, local authorities, van and HGV operators including public sector organisations, local freight trade associations, Welsh Government and Transport for Wales. The objectives of this group should be to:

- Ensure operators are kept up to date with the latest technology developments, vehicle availability and funding opportunities.
- Develop and submit funding applications. Working as a coherent region with a clear strategy for ULEV adoption is likely to strengthen funding applications.
- Develop partnerships between local authorities, freight operators, vehicle manufacturers and infrastructure providers to deliver demonstration projects and disseminate results.
- Explore options for joint procurement to reduce the costs of vehicles and infrastructure.
- Discuss the barriers to accelerate ULEV adoption and work to identify and implement solutions.
- Ensure alignment with other strategies and activities in the CCR and the rest of Wales.

- The Working Group should engage with schemes such as TfL's LoCITY programme[74] to benefit from best practice elsewhere in the UK.

Table 30. Engagement with Freight Operators Feasibility Assessment Results.

Criteria	R/A/G Status
Expected impact	
Cost	
Ease of implementation	

9.4.3 Signposting and Awareness Raising

Recommendation: signpost existing resources and organise awareness raising events.

There are several tools and information sources already available which fleets in the CCR may not be aware of and which can help fleets make informed decisions about ULEVs. The City Deal Office should raise awareness of the following resources:

- The Freight Portal[75] which has been created by Energy Saving Trust in partnership with the DfT and LowCVP. The portal supports the DfT's Road to Zero strategy by providing advice to freight operators and directing them towards a range of schemes to help achieve lower costs and emissions.
- LoCITY Commercial Vehicle Finder[76] which provides fleet operators with information about the range of alternatively fuelled commercial vehicles on the market.
- LoCITY Fleet Advice Tool[77] which helps fleets analyse the TCO of different fuels and technologies.
- The LowCVP Low Emission Van Guide[78]; best practice guidance for van operators to reduce costs and emissions, primarily by switching to ULEVs.
- Financial incentives, including OLEV's plug-in van grant and extension for HGVs, the workplace charging scheme, and the CNG fuel duty incentive.

Events and roadshows have proved very successful in London and elsewhere to help fleets experience the latest ULEVs; interact with policymakers, vehicle manufacturers, technology experts, refuelling companies; and share best practice with industry peers. The City Deal Office should consider working with fleet operators, vehicle manufacturers and infrastructure providers to deliver similar events in the CCR.

Table 31. Signposting and Awareness Raising Feasibility Assessment Results.

Criteria	R/A/G Status
Expected impact	
Cost	
Ease of implementation	

9.4.4 Scrappage Scheme for Vans

Recommendation: assess the feasibility of a targeted vehicle scrappage scheme.

Significant emissions benefits can be achieved by accelerating the rate at which older, more polluting vehicles are removed from the parc. A carefully designed and targeted van scrappage scheme could be effective in achieving this objective[79]. A van scrappage scheme could provide funding to help with the cost of acquiring a new ULEV.

Eligibility could be restricted to micro-businesses and charities to ensure funding is targeted towards organisations that need it most. A similar scheme launched by TfL[80] in 2019 has helped mitigate the economic impact of the Ultra Low Emission Zone on these organisations. Scrappage schemes can be highly effective but need to be designed and managed carefully to ensure they only benefit intended recipients.

Table : Feasibility Assessment Results:

Table 32. Scrappage Scheme for Vans Feasibility Assessment Results.

Criteria	R/A/G Status
Expected impact	
Cost	
Ease of implementation	

9.4.5 Certification

Recommendation: work with fleet certification and standards schemes to ensure ULEV use is encouraged and incentivised.

Fleet recognition and certification schemes offer an incentive to operators to improve environmental standards and reduce emissions. There are already several schemes which provide standards and accreditation for fleets, including the Fleet Operator Recognition Scheme (FORS), Freight Transport Association (FTA) Van Excellence and EcoStars. The City Deal Office can encourage uptake of ULEVs through these schemes via the following actions:

- Engaging with the organisations listed above to explore options for increased use of ULEVs by their members and accredited fleets.
- Assessing the benefits, drawbacks and effectiveness of these schemes with a view to either promoting one or more of them to fleets in the CCR or supporting development of a new regional accreditation scheme.
- Working with local authorities to implement a requirement for an environmental certification scheme such as ECO Stars or FORS Gold in procurement contracts.

Table 33. Certification Feasibility Assessment Results.

Criteria	R/A/G Status
Expected impact	
Cost	
Ease of implementation	

9.4.6 Encourage use of Biodiesel

Recommendation: encourage HGV fleets to increase use of high blend biodiesel and HVO as bridging fuels if other options are not viable.

High blend biodiesel and HVO can deliver significant GHG emissions benefits. They are best suited to HGV fleets which use depot-based bunkered fuel. If fleets are unable to use plug-in, biomethane or hydrogen vehicles, biodiesel or HVO should be considered. The City Deal Office can encourage uptake of these fuels by the following actions:

- Undertaking a supplier engagement exercise to increase availability of these fuels in the CCR.
- Meeting with representatives of low emission freight programmes such as FORS and ECO Stars to develop options for incentivising and rewarding use of these fuels.

Table 34. Encourage use of Biodiesel Feasibility Assessment Results.

Criteria	R/A/G Status
Expected impact	
Cost	
Ease of implementation	

9.4.7 Retrofit

Recommendation: provide information about the benefits of retrofit systems and support operators with access to funding.

The benefits of retrofitting HDVs have been discussed in Section 3.3 and so are not repeated here. Retrofit is particularly useful for HGVs fitted with specialist or expensive equipment which are therefore intended to have a long lifecycle.

The City Deal Office can encourage use of retrofit systems by:

- Undertaking a supplier engagement exercise to better understand the market for these products, covering availability, performance and cost.
- Facilitating collaborative procurement across the CCR to reduce costs.

Table 35. Retrofit Feasibility Assessment Results.

Criteria	R/A/G Status
Expected impact	
Cost	
Ease of implementation	

9.4.8 Trials and Demonstrations

Recommendation: Facilitate the delivery of trials and demonstrators to prove the real-world benefits of alternative fuels.

A lack of trust in vehicle suppliers' data may be constraining ULEV uptake. In addition, uncertainty about whether to invest in gas and/or hydrogen is hindering investment in alternatively fuelled HGVs. Testing and proving vehicles' operational, financial and environmental performance in real-world applications can be very effective in overcoming these barriers. The City Deal Office could help operators access funding for trials and demonstrators and facilitate partnerships between fleets, manufacturers and infrastructure providers. It could even help position the CCR as an exemplar region for the demonstration and deployment of new HGV technologies such as fuel cell articulated trucks.

Specific actions could include:

- Ensuring funding applications and trials reflect current and forecast technology performance and vehicle availability. For example, it may be sensible to invest in (or attract investment in) hydrogen fuel cell HGV projects from 2025, in line with the vehicle roadmaps in this report. In the short term, funding should focus on plug-in light rigid trucks and biomethane articulated vehicles.
- Coordinating activity across the CCR, ideally via the Freight Working Group.
- Monitoring and signposting funding opportunities from the EC, UK Government and Welsh Government. For example, facilitating discussions with the EC's Fuel Cells and Hydrogen Joint Undertaking (FCH JU)[81] could help attract significant R&D funding to the CCR.

Table 36. Trials and Demonstrations Feasibility Assessment Results.

Criteria	R/A/G Status
Expected impact	
Cost	
Ease of implementation	

9.5 Public Sector: Leading by Example

Recommendation: work with local authorities to lead by example and increase ULEV uptake in the public sector.

The public sector in Wales procures around £6 billion of goods and services annually[82]. This spending power gives organisations significant influence over the market by using procurement standards to increase ULEV uptake. Public sector bodies should ensure that ULEVs are used wherever feasible in their fleet operations and in their supply chains. Specific actions to achieve this could include the following:

- The UK government has committed to making 25% of cars in the central government department fleet ULEVs by 2022. The City Deal Office should work with local authorities and other public sector bodies to adopt a similar commitment in the CCR.
- Using joint procurement to help reduce the cost of ULEVs and supporting infrastructure, increasing their competitiveness compared to conventional technologies.
- Ensuring that evaluation of tenders and bids accounts for and provides additional scores to submissions which demonstrate increased ULEV use over the contract lifecycle.
- Funding public sector fleet reviews to identify where ULEVs will be operationally, financially and environmentally beneficial.

Table 37. Public Sector: Leading by Example Feasibility Assessment Results.

Criteria	R/A/G Status
Expected impact	
Cost	
Ease of implementation	

9.6 Renewable Energy Generation

Recommendation: undertake a study to examine the potential for renewable sources to meet the energy requirements for ULEVs in the CCR.

In-depth consideration of the potential for renewable energy to support ULEV use in the CCR is outside the scope of this strategy. However, we note that this is an area of interest for the City Deal Office. The UK's electricity grid will be decarbonised steadily over the next few years, but WTW GHG emissions will always be higher than if 100% renewable electricity is used. Similarly, using electricity to make hydrogen only makes sense when the electricity comes from renewable sources. Renewable energy generation is therefore strategically important to the region and can help maximise the environmental benefits of ULEVs. It can also contribute to regional energy security and help retain economic benefits within Wales.

The City Deal Office should commission a study to assess the potential for renewable energy to meet the energy requirements for ULEVs and propose recommendations to unlock this potential. This should include consideration of:

- Local and regional onshore and offshore wind, solar and/or tidal power.
- On-site micro-generation of electricity from renewable energy to power rapid chargepoint hubs and chargepoints at bus garages and fleet depots. This may also include using second life batteries for energy storage.
- Combining renewable energy generation with smart charging and V2G to reduce upstream impacts on the electricity grid.
- Using 'excess' energy from renewable sources at times of low demand to produce hydrogen for use in road transport.

Table 38. Renewable Energy Generation Feasibility Assessment Results.

Criteria	R/A/G Status
Expected impact	
Cost	
Ease of implementation	

9.7 Economic Growth and Job Creation

Accelerating the transition to ULEVs can help the City Deal Office achieve its objective of delivering economic growth through investment and upskilling. The deployment of electric and alternatively fuelled vehicles will require products and services in specialised industries that the UK has existing expertise in, such as low carbon finance, insurance and consulting, power systems transmissions, membranes and catalysts. There are clear opportunities to attract investment into the CCR in these areas and develop a skilled workforce in the region.

The potential benefits are significant. DfT estimates that the global market for low and zero emission vehicles will be up to £2 trillion per year by 2030[83]. The Welsh low carbon economy already consists of 9,000 businesses, employing 13,000 people and generating £2.4 billion turnover in 2016[84]. There is ample potential for these numbers to grow: Innovate UK estimates that for every £1 invested in low and zero emission projects, companies will generate up to £8.40 in revenue over 5 to 10 years[85]. By adopting this ULEV Strategy and aiming to be an exemplar region for ULEV supply and use, the CCR can help attract additional investment to businesses based in the region.

Research and development (R&D) is critical to improving ULEV technologies and strengthening the automotive industry and supply chains. The City Deal Office should work with higher education institutions to strengthen R&D capabilities in these areas. This could include identifying and supporting applications for funding opportunities and encouraging universities to make incubator space available to help researchers turn concepts into products. Institutions to approach should include the Electric Vehicle Centre of Excellence at Cardiff University, the Centre for Automotive and Power Systems Engineering (CAPSE) at University of South Wales, the Hydrogen Centre at University of South Wales, and the Low Carbon Research Institute at University of Glamorgan.

There is likely to be a requirement to upskill and reskill the local workforce. This could be achieved by working with the Learning, Skills and Innovation Partnership (LSkIP) for South East Wales, one of three Welsh Regional Skills Partnerships. The LSkIP can review and identify skills gaps and shortages and propose measures to address regional employment needs to ensure a supply of suitably skilled candidates. The City Deal Office could also set up a scheme similar to LEVEL[86], a collaboration between Derby City Council, Nottingham City Council, Cenex and CleanTech Business. LEVEL delivers skills training courses and workshops, master classes and conferences on a wide range of ULEV technologies.

Recommendation: The City Deal Office should commission a study to investigate the potential for increased supply and uptake of ULEVs to contribute to regional economic development. This should cover the following areas:

- Improving the City Deal Office's understanding of, and clearly articulate, the CCR's strengths and capabilities in sustainable transport, including innovation, skills and commercial expertise.
- Identifying emerging gaps in the ULEV innovation and testing landscape, covering physical infrastructure and knowledge.
- Appraise areas where the CCR could support investment in new innovation infrastructure (including skills, testing facilities or other enabling infrastructure) to further its sustainable mobility outcomes.
- Propose specific interventions and new or changed policies and practice (such as funding mechanisms or approaches to procurement) to stimulate the long-term development of the sector and realise the economic opportunities.

Table 39. Economic Growth and Job Creation Feasibility Assessment Results.

Criteria	R/A/G Status
Expected impact	
Cost	
Ease of implementation	

9.8 Links with Other Policies, Strategies and Activity

Recommendation: The City Deal Office should review the strategy and policy landscape to identify potential synergies and risks associated with other strands of activity.

It's important that this ULEV Strategy complements other strategies, policies and activity in the CCR. This includes low emission road transport and air quality as well as indirectly related topics such as planning and active travel. The review should include the following:

- The Welsh Government has set out proposals for improving how bus services are planned and delivered. We understand this includes consideration of new legislation allowing local authorities to run their own bus services and Enhanced Quality Partnerships to improve collaboration between local authorities and bus operators.
- The Wales Freight Strategy (2008). The review should assess whether this document, which is over a decade old, is still fit for purpose and consider commissioning a new Freight Strategy for the CCR.
- The Welsh Government has proposed establishing a Joint Transport Authority with responsibility for public transport and some traffic management functions. If this was set up it would have a key role to play in stimulating increased ULEV uptake.
- The Cardiff Local Development Plan includes a forecast for 41,000 new homes by 2026 which is expected to increase road traffic by 32%. This will impact on the number and location of chargepoints needed to support ULEV uptake and may offset some of the expected environmental benefits.

Table 40. Links with Other Policies, Strategies and Activity Feasibility Assessment Results.

Criteria	R/A/G Status
Expected impact	
Cost	
Ease of implementation	

10 Funding and Delivery

This section first outlines the funding options available to help implement this strategy, then provides guidance on delivery, including identifying potential barriers and risks.

Key points:

- Funding will need to come from a range of public sector sources and private sector investment.
- R&D and implementation funding is available from European, UK and Welsh institutions.
- Private sector investment can be leveraged from private equity and venture capital investors, social enterprise schemes and Section 106 contributions.
- Delivery of this strategy and associated work should be managed by a new ULEV Steering Group. Progress should be monitored and reported annually.
- The City Deal Office has a key role to play in managing a coherent region-wide approach, increasing senior stakeholder engagement in this topic, and securing funding from Welsh and UK government departments.
- Barriers to delivery include a lack of control over bus operators, challenges around site availability and power constraints for infrastructure, and the challenge associated with attracting private sector investment.

10.1 Funding

Significant levels of capital funding will be required to deliver the recommendations in this strategy, particularly for recharging and refuelling infrastructure. It is highly unlikely that the full costs can be met by the City Deal Office and the local authorities in the CCR. Funding will need to come from a range of sources including international, national and regional public sector bodies. It will also be crucial to attract private sector investment, particularly if the CCR aims for the best practice or exemplar vehicle scenarios.

This sub-section details some potential funding options, covering European, UK and Welsh public bodies and the private sector. It is not intended to be exhaustive but instead to act as a guide to the types of funding available to support ULEV supply and uptake.

Since the original strategy was published, the CCR City Deal Office has made significant progress in securing funding to support the deployment of ULEVs and associated infrastructure, including:

- Funding for 112 on-street and car park chargers, which will be a combination of 7kW and 22kW units, as recommended by the WG's EV Charging Strategy for Wales[8]. Assets have already been installed in local authorities including Merthyr Tydfil and Caerphilly.
- Securing over £5m, in partnership with Bridgend and Cardiff and local authorities, to invest in sustainable public transport infrastructure.

10.1.1 European Funding

Horizon Europe[87] is an EU research and innovation programme. It has a budget of €95.5 billion and runs until 2027. The Global Challenges and Industrial Competitiveness pillar (€52.7 billion) will support research, reinforce technological and industrial capacities, and set EU-wide missions with ambitious goals tackling major societal challenges. It will also include activities pursued by the Joint Research Centre (€2.2 billion) which supports EU and national policymakers with independent scientific evidence and technical support. In January, the government announced that the UK will

[8] https://gov.wales/sites/default/files/publications/2021-03/electric-vehicle-charging-strategy-wales.pdf

associate to Horizon Europe. This means UK scientists, researchers and businesses will be able to access funding under the programme on equivalent terms as organisations in EU countries.

European Territorial Cooperation (ETC), better known as Interreg, provides a framework for the implementation of joint actions and policy exchanges between national, regional and local actors from the different Member States. Interreg VI will cover 2021 to 2027. A 'greener, carbon-free Europe' is one of the top two priorities for Interreg spending in this period. Interreg VI will offer match-funded grant schemes and investment loans for pan-European clusters for projects such as advanced manufacturing. The City Deal Office could facilitate access to funding for alternatively fuelled freight and logistics through Interreg VI.

NER 300[88] is a funding programme which will provide €2 billion for innovative low-carbon energy demonstration projects. The programme has been conceived as a catalyst for the demonstration of environmentally safe Carbon Capture and Storage (CCS) and innovative renewable energy (RES) technologies on a commercial scale in the EU. This could help fund renewable energy generation to power ULEVs.

10.1.2 UK Funding

R&D

Innovate UK, part of UK Research and Innovation, is a non-departmental public body funded by a grant-in-aid from the UK government. It drives productivity and economic growth by supporting businesses to develop and realise the potential of new ideas from the UK's research base. It provides funding through competitions on themes such as developing the UK's low carbon automotive capability. The City Deal Office should keep up to date with funding and competition announcements from Innovate UK and circulate these to relevant stakeholders or consider leading or forming consortia to submit bids. Refer to the Innovate UK website[89] for the latest details.

Plug-in Vehicles and Infrastructure

The main source of funding for the practical implementation of market ready low emission vehicles is OZEV's plug-in car and van grant scheme. This provides a discount on the price of new low emission vehicles via a grant provided to vehicle dealerships and manufacturers. Refer to the OLEV website[90] for the latest grant values and eligible vehicles. OZEV also administers grant schemes for chargepoints. For example, the Workplace Charging Scheme (WCS)[91] provides funding for the purchase and installation of chargepoints for eligible businesses, charities and public sector organisations. Refer to the OZEV website[92] for more details.

Buses

The ZEBRA scheme, funded by DfT and OZEV, will provide up to £120 million for local transport authorities to support the introduction of zero-emission buses and the infrastructure needed to support them. This funding will support the introduction of the 4,000 zero-emission buses announced by the Prime Minister in February 2020. More information is available on the UK government website[93].

10.1.3 Regional and Local Funding

There is a wide range of regional and local funding opportunities which the CCR and other local stakeholders could benefit from. These include:

- **City Deal Capital Finance**: a £1.2bn funding agreement between the Welsh Government and the 10 local authorities in the CCR. This funding aims to leverage private sector investment to increase its impact and help create 25,000 new jobs.
- **Local Transport Fund**: funding available from the Welsh Government via the local transport fund.
- **Building for the Future**: a £120m EU-funded programme which runs to 2023 and which aims to regenerate town centres by investing in under-utilised land or buildings. This could be used to provide recharging or refuelling infrastructure.

- **Welsh Government fund for EV charging infrastructure**: funding to help create a publicly accessible national network of rapid charging points, focusing on locations on or near strategic Welsh road networks.
- **Welsh Government Invest to Save**: a fund to support deployment of low carbon technology across the public sector. It is typically used for energy efficiency measures but can be used in conjunction with other funding if project payback exceeds eight years but still meets the carbon criteria.
- **Public Works Loan Board (PWLB)**: The public sector has unique access to low cost finance via the PWLB. Local authorities can use this funding to take forward several large-scale renewable energy developments across South East Wales and might be suitable for an own and operate chargepoint infrastructure model.

10.1.4 Private Sector Investment

The capital costs required to install recharging and refuelling infrastructure are significant and must be met at least in part by private sector funding. As the number of ULEVs on the road increases, the business case for investing in chargepoints and gas and hydrogen refuelling stations will improve. The City Deal Office could explore the following options to attract private sector investment.

- Private equity and venture capital investors are increasingly active in the low emission and alternative fuel road transport sector. Areas of interest may include chargepoint and refuelling infrastructure and vehicle financing.
- Social enterprise schemes can also provide funding for ULEVs and infrastructure. For example, TrydaNi, a for-profit social enterprise, has been set up to accelerate deployment of chargepoints across Wales.
- The Welsh Government has set up The Mutual Investment Model (MIM) in partnership with the private sector to deliver infrastructure schemes. MIM schemes allow private partners to finance major capital projects and build and maintain public assets.
- Section 106 funding from private sector developments could be used to fund chargepoint and refuelling infrastructure. Section 106 agreements can also be used to mandate chargepoint infrastructure in new developments, parking bays and at taxi ranks.

10.2 Delivery

This sub-section provides high level guidance on delivering the recommendations in this strategy.

10.2.1 Governance

The CCR City Deal Office should set up a ULEV Steering Group to lead on the implementation of this strategy and manage any additional projects. While the City Deal may not want to chair this group, it should set it up, including drafting terms of reference, inviting attendees and appointing a chair. Organisations to consider inviting include the Welsh Government, Transport for Wales, the 10 local authorities in the CCR, regional transport authorities, Western Power and the National Grid. This Steering Group should be combined with or incorporate the ULEV Taxi Steering Group which Cenex proposed in the CCR ULEV Taxi Strategy. Objectives of the Steering Group should include:

- Monitoring and reporting progress against this strategy and local air quality and climate change objectives.
- Commissioning and managing delivery of further work.
- Coordinating funding bids.
- Strategic engagement with the private sector.

10.2.2 Monitoring and Evaluation

Monitoring progress against this strategy will be vital to evaluate the effectiveness of interventions, provide an ongoing evidence base to support funding applications and help local authorities develop effective AQAPs. Monitoring and evaluation should focus on two areas: increased uptake of ULEVs and reduced emissions.

Increased uptake of ULEVs can be tracked using the following sources:

- DfT VEH statistics tables provide details of vehicles registered by local authority and fuel type.
- Fleet operators could be encouraged to voluntarily report ULEV acquisition via the Working Groups or directly to the City Deal Office. This will help with tracking uptake and can be used to develop case studies.

Reduced emissions can be tracked using the following sources:

- Roadside air quality monitoring sensors should be used to track reductions in NOx and PM concentrations.
- NOx and PM emissions should also be tracked via the National Atmospheric Emissions Inventory (NAEI) which estimates pollutant emissions from a wide range of sources including national energy statistics.
- The NAEI also tracks local and regional CO_2 emissions and road transport fuel consumption.

While it may not be possible to directly link emissions reductions to increased ULEV uptake, monitoring of locations may highlight correlations, for example roads which have a high volume of bus traffic. We suggest that evaluation is undertaken annually and the results made public.

Finally, the City Deal Office should ensure that this strategy is regularly updated to reflect new technologies, new evidence about the real-world benefits of different alternative fuels for different vehicle types and duty cycles, and strategies and grants released by the UK and Welsh governments.

10.2.3 Role of the City Deal Office

When implementing this strategy, the primary task of the City Deal Office should be to ensure there is a coherent and consistent approach to ULEVs across the CCR and that activity is joined-up with neighbouring regions and the rest of Wales. A strategic, region-wide approach to promote ULEV uptake will be more effective than individual local authorities implementing separate schemes and measures. Tangible benefits of better regional working will include reduced duplication of effort, more efficient use of resources, and potentially reduced costs money through joint procurement.

The second focus area should be raising awareness of air quality issues, climate change and the need for an increase in ULEV uptake in the CCR among senior stakeholders including councillors and business leaders. For example, the City Deal Office could organise and facilitate a roundtable with senior regional politicians and business leaders to highlight the importance of the ULEV agenda.

The third key area for the City Deal Office should be to secure public sector funding for ULEV uptake and supporting infrastructure by lobbying Transport for Wales, the Welsh Government, DfT and OZEV. Wales has received less funding for ULEVs than many areas of the UK, particularly for buses, and the CCR is starting from a low baseline of vehicle uptake and infrastructure provision. The City Deal Office should represent the needs and interests of the CCR with a single voice to help change this trend.

10.2.4 Potential Barriers to Delivery

This sub-section identifies some barriers and risks that may constrain delivery of this strategy.

PSVs

There are several barriers and risks to be aware of in relation to PSVs, particularly buses.

- The lack of control over PSV operators is a significant risk to increase ULEV uptake. Electric and gas vehicles are available and operationally viable but are typically more expensive to buy than diesel models and there is no incentive for operators to make the investment. The measures proposed in this strategy will help increase ULEV uptake but are unlikely to achieve the Welsh Government's ambition for a zero tailpipe emission bus fleet by 2028.
- The range of vehicles on the market is increasing, particularly for single decker BEVs and double decker gas vehicles. However, there are significant gaps in terms of product availability on the market, for example electric minibuses, which are not yet available in large

volumes at viable prices. This will constrain efforts to increase ULEV uptake in certain sectors and applications.

- Bus operators' costs are under pressure from declining passenger numbers and worsening congestion which reduces efficiency and may further drive down ridership.
- It's critical to ensure that any measures to accelerate churn of the bus fleet do not significantly increase fares or lead to some routes being decommissioned: the net effect could be an increase in private car use and associated emissions.

HGVs

The lack of vehicles on the market will be a short-term barrier to uptake in some segments and for some duty cycles. In turn this makes it more challenging for investors to develop a business case for installing recharging and refuelling infrastructure. The most significant challenge is arguably uncertainty over technology pathways. This report has discussed the debate about whether plug-in vehicles and/or hydrogen will ultimately have the largest market share. The UK government has adopted a technology neutral approach and the market is not yet backing either option. In the short to medium term, increased deployment of biodiesel and biomethane should not have any significant negative consequences, irrespective of which scenario materialises.

Refuelling infrastructure

Provision of gas and hydrogen refuelling infrastructure may be constrained by land availability and affordability. Infrastructure providers need sites near a motorway or the SRN, with enough space for large vehicles, access to the high pressure gas grid for large CNG stations, and sufficient electricity supply. These sites need to be available at affordable costs and be able to secure planning consent. These factors, plus the financial risks posed by a lack of vehicles on the road, can make it difficult for a strong business case to be developed.

Lack of power capacity

Power supply is often the biggest factor influencing the cost of rapid chargepoint installations, particularly when several units are installed at one location. Costs can be £100,000 or more if a new substation is required. Power supply is also important for gas and hydrogen refuelling stations to run compressors and other components. A lack of power capacity could constrain infrastructure deployment at some sites. WPD has stated that the regional distribution network generally has enough capacity to connect additional chargepoints without the need for reinforcement[94], though there will be some occasions where clusters of connections exceed available capacity and so the network would need to be reinforced.

ULEVs in public sector fleets

Public sector bodies in the CCR should lead by example by adopting ULEVs where feasible and financially viable on a TCO basis. However, some organisations may still procure based on cheapest upfront cost because of budget constraints. A TCO approach to vehicle procurement should be embedded in procurement standards across the CCR.

Attracting investment

Technology uncertainty presents a significant challenge for potential funders and investors in the public and private sectors. This applies to vehicle manufacturers developing new products, infrastructure providers installing and operating new recharging and refuelling sites, and fleets acquiring alternatively fuelled vehicles. In general, clear policy and strategy signals and long term incentives and measures would improve market confidence.

11 Conclusions

This strategy can help the CCR achieve a step-change in uptake of ULEVs for all vehicle types in the region. This will contribute to objectives around GHG emissions reduction, improved air quality, economic development and job creation. The case for increased public sector intervention in all three areas is strong: Wales has ambitious targets around decarbonising road transport, local authorities risk fines from continuing to exceed air quality limit values, and attracting inward investment would bring long term benefits to the region.

This strategy is based largely on the vehicle and infrastructure roadmaps which illustrate forecast technology pathways up to 2030. The roadmaps show that ongoing research and technology development significantly improve the availability and operational and financial performance of a range of fuels for multiple vehicle types and applications. However, achieving significant increased market take-up and deployment will require additional policy action. The CCR is currently behind the rest of the UK in rates of ULEV deployment and infrastructure provision so a substantial package of measures will be needed.

We recommend that the CCR aim for the aspirational scenarios for vehicle and infrastructure uptake. These are realistic and achievable with the right policies and measures in place. Both scenarios meet the UK government target of 100% of new car and van sales being ULEVs in 2030, with the aspirational scenario assuming measures and investment to accelerate uptake in the early part of the 2020s. The exemplar scenario may seem ambitious, with 60% of new vehicles sales to be ULEVs by 2025, but this only results in 8% of all vehicles on the road being ULEVs by that year. Stating an ambition to become an exemplar region for ULEVs will help attract investment in recharging and refuelling infrastructure, which will in turn create the conditions for high rates of ULEV uptake.

A significant increase in the provision of recharging and refuelling infrastructure will be vital to achieving the exemplar scenario. In the short to medium term this will consist mainly of chargepoints for cars and vans, with some gas refuelling for HGVs. PSV infrastructure will primarily be provided by the private sector on privately owned land. In the long term, other options such as hydrogen refuelling stations for HGVs and inductive or pantograph charging for long-range coaches may be deployed, but in the timescale considered in this strategy (up to 2030) these are unlikely to be required.

Passenger transport demand, particularly use of private vehicles, is forecast to continue increasing as the population grows. Economic growth and changes to shopping habits are expected to drive an increase in van traffic. Measures to increase ULEV uptake must be considered in the context of these trends to avoid reducing emissions but increasing congestion. The most effective emissions reduction strategy would be to replace car journeys with public transport wherever feasible. A transport hierarchy should reduce vehicle use first through active travel, investment in public transport and freight consolidation and mode shift. This ULEV Strategy should be closely aligned with a wider regional transport strategy that proposes measures in those areas.

The City Deal Office and the CCR generally are well placed to implement and benefit from a shift to ULEVs over the next 10 years and beyond. The City Deal Office should review the recommendations and delivery strategy proposed in this report and consider how best to implement them in partnership with local authorities, Welsh and UK government departments, PSV and freight operators and potential investors.

Abbreviations

ULEV	Ultra Low Emission Vehicles
CCR	Cardiff Capital Region
HGV	Heavy Goods Vehicle
GHG	Greenhouse Gas
R&D	Research and Development
WTW	Well-to-wheel
NO_x	Nitrogen Oxides
CO_2	Carbon Dioxide
PM	Particulate Matter
LPG	Liquid Petroleum Gas
LNG	Liquid Natural Gas
CNG	Compressed Natural Gas
DC	Direct Current
AC	Alternating Current
kW	Kilowatt
SRN	Strategic Road Network
WPD	Western Power Distribution
ULEB	Ultra Low Emission Bus
OLEV	Office for Low Emission Vehicles
DfT	Department for Transport
NO_2	Nitrogen Dioxide
CCC	Committee on Climate Change
EU	European Union
WHO	World Health Organisation
EV	European Commission
RDE	Real Driving Emissions
HDVs	Heavy Duty Vehicles
Km	Kilometre
AQMA	Air Quality Management Area
AQAP	Air Quality Action Plan
CAZ	Clean Air Zone
V2G	Vehicle-to-grid
BEV	Battery Electric Vehicle
E-REV	Extended Range Electric Vehicle
PHEV	Plug in Hybrid Electric Vehicles

GVW	Gross Vehicle Weight
Bio-CNG	Biologically sourced Compressed Natural Gas
Bio-LNG	Biologically sourced Liquified Natural Gas
HRS	Hydrogen Refuelling Station
B100	100% biodiesel
B##	Biodiesel %, ## represents the percentage of diesel that is biologically sourced
HVO	Hydrotreated Vegetable Oil
FAME	Fatty Acid Methyl Esters (biodiesel)
GVH	Gas Vehicle Hub
APC	Advanced Propulsion Centre
EV	Electric Vehicle
LGV	Light Goods Vehicle
TCO	Total Cost of Ownership
ZEZ	Zero Emissions Zone
DNO	Distribution Network Operators
WPL	Workplace Parking Levy
SCR	Selective Catalytic Reduction
FORS	Fleet Operator Recognition Scheme
FTA	Freight Transport Association
FCH JU	Fuel Cells and Hydrogen Join Undertaking
CAPSE	Centre for Automotive Power Systems Engineering
LSkIP	Learning, Skills and Innovation Partnerships
ETC	European Territorial Cooperation
CCS	Carbon Capture and Storage
RES	Renewable Energy
SIPF	Strength in Places Fund
Workplace Charging Scheme	WCS
PWLB	Public Works Loan Board
MIM	Mutual Investment Model
NAEI	National Atmospheric Emissions Inventory

[1] ONS statistics cited in Prosperity for All, available at: https://gov.wales/sites/default/files/publications/2019-06/low-carbon-delivery-plan_1.pdf
[2] Innovate UK Low and zero emission vehicles Impact review 2018. Available at: https://www.gov.uk/government/publications/low-and-zero-emission-vehicles-impact-review-2018
[3] Cenex was established in 2005 as the UK's first Centre of Excellence for Low Carbon and Fuel Cell Technologies. Today we operate on an independent not-for-profit basis, specialising in the delivery of consultancy, research and events to support innovation and market development for low emission vehicles and associated infrastructure.
[4] Cardiff Metro Infrastructure Review. Available at: https://www.cardiffcapitalregion.wales/wp-content/uploads/2019/02/appendix-3-cardiff-metro-infrastructure-review-cenex.pdf
[5] PM10 denotes particles less than <10 µm in diameter, PM2.5 denotes particles less than <2.5 µm.
[6] Defra GIS Mapping: https://uk-air.defra.gov.uk/data/gis-mapping
[7] Defra Clean Air Strategy 2019. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770715/clean-air-strategy-2019.pdf
[8] Climate Change: Global Temperature [Climate.gov, Rebecca Lindsey and LuAnn Dahlman, 01/08/2018]. Available at: https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature
[9] IPCC AR5 Synthesis Report. Available at: https://www.ipcc.ch/report/ar5/syr/
[10] IPCC AR5 Synthesis Report: Climate Change 2014. Available at: https://www.ipcc.ch/report/ar5/syr/
[11] BEIS UK Greenhouse Gas Emissions. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/679334/2016_Final_Emissions_Statistics_one_page_summary.pdf
[12] https://www.theccc.org.uk/publication/reducing-uk-emissions-2019-progress-report-to-parliament/ Accessed 6th November 2019.
[13] Transport and Environment. Cars with Engines: Can they ever be clean? Available at: https://www.transportenvironment.org/sites/te/files/publications/2018_09_TE_Dieselgate_report_final.pdf
[14] Initially, these standards will only apply to HGVs. The European Commission is expected to review the HDV market in 2022 and will consider extending the scope to cover other vehicle types such as buses and coaches.
[15] The Climate Change Act 2008 (2050 Target Amendment) Order 2019 [Department for Business, Energy & Industrial Strategy, 26/06/2019]. Available at: https://www.legislation.gov.uk/ukdsi/2019/9780111187654/pdfs/ukdsi_9780111187654_en.pdf
[16] UK Industrial Strategy White Paper. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/664563/industrial-strategy-white-paper-web-ready-version.pdf
[17] Estimated charging times vary depending on vehicle battery capacity.
[18] OLEV Plug-in Car and Van Grants: https://www.gov.uk/plug-in-car-van-grants
[19] OLEV Plug-in Car and Van Grants: https://www.gov.uk/plug-in-car-van-grants
[20] Gas Vehicle Hub: https://gasvehiclehub.org/is-natural-gas-right-for-me/available-vehicles/
[21] Hydrogen Mobility Europe: https://h2me.eu
[22] DfT Vehicle Statistics: https://www.gov.uk/government/collections/vehicles-statistics
[23] VEH0126 Gov UK
[24] VEH0105 Gov UK
[25] VEH0132 Gov UK
[26] Cars: National Travel Survey: Table NTS0901; Motorbikes National Travel Survey: Motorcycle use in England; LGVs and Buses Road Traffic Estimates: Great Britain 2017; HGVs Road Freight Statistics: Table RFS01112
[27] National Travel Survey: Table NTS0303
[28] Estimated based on Cenex fleet data
[29] Road Traffic Estimates: Great Britain 2017
[30] Defra GHG emissions factors: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019
[31] National Chargepoint Registry: https://www.national-charge-point-registry.uk
[32] Gas Vehicle Hub: https://gasvehiclehub.org/is-natural-gas-right-for-me/available-vehicles/
[33] https://www.netinform.net/h2/h2stations/h2stations.aspx
[34] Cenex did not develop equivalent scenarios for ULEV bus uptake as decisions about the technology and time of shifting to ULEVs must be taken by bus operators. The intention is for this strategy to be used to support their decision making processes. This is discussed further in the recommendations section.
[35] LowCVP Transport Energy Infrastructure Roadmap to 2050. Available at: https://www.lowcvp.org.uk/assets/reports/LowCVP%20Infrastructure%20Roadmap-Methane%20report.pdf
[36] VEH0105
[37] National Travel Survey data
[38] Systra: Plugging the gap: An assessment of future demand for Britain's electric vehicle public charging network. Available at https://www.theccc.org.uk/wp-content/uploads/2018/01/Plugging-the-gap-Assessment-of-future-demand-for-Britains-EV-public-charging-network.pdf
[39] Cenex Fleet Advice Tool
[40] Based on UK-wide data from Zap-Map.
[41] Road Traffic Forecasts 2018
[42] Table TSGB0304 (ENV0104)
[43] DEFRA emissions factors (2019)

[44] TAG Data Book: https://www.gov.uk/government/publications/tag-data-book
[45] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770576/air-quality-damage-cost-guidance.pdf
[46] Costs for public infrastructure are higher than for equivalent domestic units. Capital costs quoted here include equipment, an electrical connection (feeder pillar, Residual Circuit Breaker with Over-current device (RCBO), RCBO housing, RCBO protection, Miniature Circuit Breaker (MCB) installation, fixings and an assumed 5m electrical cable run), enabling works (foundations, 5m of ducting & surface reinstatement, guard raid/crash protection, bay markings, signage and branding) and warranty.
[47] LowCVP Biomethane for Transport: HGV cost modelling. Available at: https://www.lowcvp.org.uk/assets/reports/LowCVP%20Biomethane%20Report_Part%201%20Final.pdf
[48] Zero Emission HGV Infrastructure Requirements (Ricardo Energy and Environment). Available at: https://www.theccc.org.uk/publication/zero-emission-hgv-infrastructure-requirements/
[49] Zap-Map: https://www.zap-map.com/. Zap-Map classifies chargers as slow (below 7kW), fast (7kW to 25kW inclusive) and rapid (above 25kW)
[50] NCR Database: https://www.gov.uk/guidance/find-and-use-data-on-public-electric-vehicle-chargepoints
[51] ONS Population Statistics: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/populationestimatesforukenglandandwalesscotlandandnorthernireland
[52] HRS stations in the UK (Abergavenny station missing from map): http://www.ukh2mobility.co.uk/stations/
[3] Data acquired from Gas Vehicle Hub (https://gasvehiclehub.org/). Planned infrastructure data acquired through industry contacts.
[53] The roadmaps represent Cenex's best estimates of likely developments but are not a definitive guide to future technology pathways. Further research and independent verification should be carried out before making any investment decisions based on the information provided here.
[54] WTT CO_2 forecast for grid electricity from 'EEP2018' (Gov UK).
[55] WTT CO_2 forecast for grid electricity from 'EEP2018' (Gov UK).
[56] There is no 'other fuels' category for the infrastructure roadmaps as LPG infrastructure is on some forecourts and HVO and B100 will be used by fleets with depot bunkered refuelling, rather than being available via forecourt pumps.
[57] Committee on Climate Change Zero Emission HGV Infrastructure Requirements. Available at: https://www.theccc.org.uk/wp-content/uploads/2019/05/CCC-Zero-Emission-HGV-Infrastructure-Requirements-Ricardo-Energy-Environment-Final.pdf
[58] LowCVP Transport Energy Infrastructure Roadmap to 2050. Available at: https://www.lowcvp.org.uk/assets/reports/LowCVP%20Infrastructure%20Roadmap-Methane%20report.pdf
[59] https://gov.wales/sites/default/files/publications/2021-03/electric-vehicle-charging-strategy-wales.pdf
[60] We have assumed that medium capacity gas and hydrogen refuelling stations will be installed. These could be replaced by a larger number of smaller capacity stations, or a smaller network of large capacity stations.
[61] These are indicative estimates which vary depending on the capacity of the stations installed. For example, eight small hydrogen stations with a capacity of 400kg per day could be replaced by four medium stations with a capacity of 800kg per day.
[62] There is no difference between the two scenarios in terms of hydrogen refuelling requirements by 2030. Beyond that year, there is a significant divergence, with a rapid increase in demand for hydrogen in the LowCVP scenario.
[63] As we have not developed forecasts for buses, we assume they maintain the same share of emissions in all scenarios: 1.6% of CO_2, 8.5% of NOx and 5.1% of PM emissions.
[64] £0.086 per kg, DfT TAG Data Book, A3.4, price year 2021, value year 2030
[65] £14.99 per kg, DfT TAG Data Book, A3.2, price year 2021, value year 2030, road transport
[66] £191.69 per kg, DfT TAG Data Book, A3.2, price year 2021, value year 2030, PM10, road transport
[67] DfT National Travel Survey data shows that the average annual car mileage in England is 7,800 miles. Based on a vehicle being used 6 days a week this equates to just 25 miles a day.
[68] Go Ultra Low: https://www.goultralow.com/
[69] https://tfl.gov.uk/modes/driving/ultra-low-emission-zone/car-and-motorcycle-scrappage-scheme
[70] LowCVP Bus Hub: https://www.lowcvp.org.uk/Hubs/leb/areas.htm
[71] LowCVP Bus Hub: https://www.lowcvp.org.uk/Hubs/leb/Home.htm
[72] LowCVP Low Emission Bus Guide. Available at: https://www.lowcvp.org.uk/assets/reports/LowCVP%20LEB%20Guide%202016%20interactive%20V3.pdf
[73] Note this proposal is for streets or zones with restrictions for buses only rather than a general CAZ or ULEZ covering all vehicle types. We are aware that Cardiff Council has decided against implementing a CAZ and as such have not considered recommending this measure.
[74] LoCITY: www.locity.org
[75] Freight Portal: https://thefreightportal.org/
[76] LoCITY Commercial Vehicle Finder: https://locity.org.uk/locity-commercial-vehicle-finder/
[77] LoCITY: https://locity.org.uk/
[78] LowCVP Low Emission Van Guide. Available at: https://www.lowcvp.org.uk/assets/reports/Low_Emission_Van_Guide_2019_Update.pdf
[79] Scrappage for HGVs is not proposed because of the relatively high value of these vehicles.
[80] TfL van scrappage scheme: https://tfl.gov.uk/modes/driving/ultra-low-emission-zone/scrappage-scheme?cid=scrappage-scheme
[81] FCH JU: https://www.fch.europa.eu/

[82] Wales Audit Office Public Procurement in Wales. Available at: http://senedd.assembly.wales/documents/s67578/PAC5-27-17%20Paper%201%20Auditor%20General%20for%20Wales%20report.pdf
[83] Department for Transport, The Road to Zero, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/724391/road-to-zero.pdf
[84] ONS statistics cited in Prosperity for All, available at: https://gov.wales/sites/default/files/publications/2019-06/low-carbon-delivery-plan_1.pdf
[85] Innovate UK Low and zero emission vehicles Impact review 2018. Available at: https://www.gov.uk/government/publications/low-and-zero-emission-vehicles-impact-review-2018
[86] LEVEL Network: https://level-network.com/
[87] Horizon Europe: https://ec.europa.eu/info/horizon-europe-next-research-and-innovation-framework-programme_en
[88] NER 300: https://ec.europa.eu/clima/policies/innovation-fund/ner300_en
[89] Innovate UK: https://www.gov.uk/government/organisations/innovate-uk
[90] OLEV guidance to vehicles eligible for a plug-in grant. Available at: https://www.gov.uk/plug-in-car-van-grants
[91] OLEV guidance to grant schemes for electric vehicle charging infrastructure. Available at: https://www.gov.uk/government/collections/government-grants-for-low-emission-vehicles
[92] Grants to provide residential on-street chargepoints for EVs: OLEV guidance for local authorities. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/792884/onstreet-chargepoint-residential-scheme-guidance.pdf
[93] https://www.gov.uk/government/publications/apply-for-zero-emission-bus-funding
[94] The Economy, Infrastructure and Skills Committee inquiry into electric vehicle charging in Wales. Response by Western Power Distribution. Available at: http://senedd.assembly.wales/documents/s80377/11.%20Western%20Power.pdf

Independent, not-for-profit, low carbon technology experts

Cenex
Holywell Building
Holywell Park
Ashby Road
Loughborough
Leicestershire
LE11 3UZ

Tel: 01509 642 500
Email: info@cenex.co.uk
Website: www.cenex.co.uk