Route '35

Policy Exchange

How a California-style ZEV Mandate can deliver the phase-out of petrol and diesel cars.

By Ed Birkett

Foreword by Rt Hon Grant Shapps MP, Secretary of State for Transport

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Policy Exchange's award-winning Energy & Environment unit examines the issues and challenges in achieving a sustainable economy whilst ensuring prosperity and democratic values. The unit's recent work has included:

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Foreword

By The Rt Hon Grant Shapps MP, Secretary of State for Transport

After Britain's world-leading progress in cutting emissions from other sectors, especially electricity, transport has become our number one source of greenhouse gases. That makes it a leading priority for change.

For that reason, Clean Transport will be one of five key themes on the agenda when we host COP26 in November next year. We plan to lead the world by example, with high ambition and pragmatic plans for meeting it. We should show the world that a forward-looking economy can and should make bold moves against climate change, even amid the economic damage left by COVID-19.

This Government has already set out its determination to be radical in cleaning up transport.

We set out plans for the UK to develop the first electric commercial planes – an international challenge that requires the British genius for innovation and advanced technologies.

We have prioritised green and modern public transport throughout the UK, including funding for towns to switch to all-electric bus fleets.

We have launched a review of the railways, making them more attractive by focusing on punctuality and reversing some of the Beeching cuts that created our dependency on cars in the first place.

Most importantly, we have raised the UK's ambition for phasing out new petrol and diesel cars. In October last year, I argued that we should examine bringing forward the phase-out date. That is now government policy and we are exploring how to make it a reality.

That is why I applaud the ambition in this important new paper from Policy Exchange. It proposes a plan for turning ambition into reality, with policies that could be implemented in the short term. Policy Exchange's thoughtful report examining a ZEV Mandate design is one I will study closely as we consider how to make the date a reality.

Key to those considerations will be how to bring both consumers and manufacturers with us. Britain's pioneering automotive sector can create the next generation of cars and sell them around the world. It can also train and employ the next generation of engineers, designers and mechanics. By setting a clear path for EV adoption and by providing support for industry along the way, we will ensure that British car makers continue to lead the world.

Glossary of Terms

Term	Definition
Department for Business, Energy & Industrial Strategy (BEIS)	UK Government department responsible for business, energy and industrial strategy.
Battery electric vehicle (BEV)	A vehicle propelled by electric motors that are powered solely by an on-board battery.
Committee on Climate Change (CCC)	Committee on Climate Change. Independent statutory body advising the UK and devolved governments on emissions targets and preparing progress reports to Parliament.
Carbon dioxide (CO_2)	Carbon dioxide (CO_2) is the main greenhouse gas. The vast majority of CO_2 emissions come from the burning of fossil fuels.
Department for Transport (DfT)	UK Government department responsible for transport.
Electric Vehicle (EV)	Electric Vehicle. Definition typically includes BEVs and PHEVs, but not FCEVs.
Fuel cell electric vehicle (FCEV)	A vehicle that is propelled by an electric motor that uses an on-board hydrogen fuel cell as a source of electricity, rather than just a battery.
Fleet-average CO_2 emissions	The average (mean) emissions of a manufacturer's new vehicle sales in a given year, measured in grams of carbon dioxide per kilometre (gCO_2/km). More fuel-efficient vehicles have a lower gCO_2/km.
Grams of CO_2 per kilometre (gCO_2/km)	A measure of the greenhouse gas emissions of vehicles, per kilometre travelled. Note these are the emissions from burning fuel, rather than lifecycle emissions.
Green hydrogen	The production of hydrogen using renewable electricity sources. In the UK, the term 'green hydrogen' is typically used to describe all hydrogen produced with electricity.
Hybrid electric vehicle (HEV)	A vehicle powered by a combination of a battery and a petrol or diesel engine.
Hydrogen	A clear, odourless gas which is highly flammable, the most common element in the universe which can be used as a low emission alternative fuel source.
Internal Combustion Engine (ICE)	Traditional engines powered by petrol, diesel, biofuels, or natural gas.

Plug-in hybrid EV (PHEV)	Similar to an HEV, but the battery can be charged from an electricity socket.
Plug-in Car Grant (PiCG)	UK Government grant available to those buying a new Battery Electric Vehicle (BEV). The PiCG is up to a maximum of £3,000.
New European Driving Cycle (NEDC)	A testing procedure designed to assess the fuel efficiency and range of passenger cars. The NEDC is designed to represent the typical usage of a car in Europe, comprising a mixture of urban and non-urban driving conditions.[1]
Non-Exhaust Emissions (NEE)	NEEs include brake wear, tyre wear, road surface wear and resuspension of road dust. All road vehicles produce NEEs, including ZEVs.[2]
New Energy Vehicle (NEV)	NEV is used interchangeably with ZEV. The term 'NEV' is commonly used in China.
Office for Low Emission Vehicles (OLEV)	Part of BEIS and DfT.
Ultra-low-emission-vehicle (ULEV)	A motorised vehicle that produces extremely low levels of emissions in comparison to other vehicles. Typically refers to PHEVs, BEVs and FCEVs.
Worldwide Harmonised Light Vehicle Test Procedure (WLTP)	WLTP replaces the NEDC driving cycle. In Europe, the range of a ZEV is typically measured using WLTP and reported as the car's 'WLTP range'.
Zero-emission vehicle (ZEV)	ZEVs include BEVs, PHEVs, and FCEVs. ZEVs have zero exhaust emissions, i.e. no carbon dioxide or nitrogen oxides (NO_x) exhaust emissions. However, ZEVs still contribute to local air pollution through non-exhaust emissions (NEEs).

1. Auto Express (June 2019). *What are the NEDC fuel economy tests?* - Link
2. Air Quality Expert Group (July 2019). *Non-Exhaust Emissions from Road Traffic.* Link

Executive Summary

The UK's 2050 Net Zero law requires all sectors of the economy to decarbonise.[3] Transport is the leading contributor to UK greenhouse gas emissions, comprising 28% of domestic emissions in 2018.[4] Within transport, cars make up over half of domestic greenhouse gas emissions. The UK Government is consulting on ending the sale of new petrol, diesel and hybrid cars and vans by 2035 or earlier, aiding the transition of the UK's vehicle fleet to zero-emission vehicles (ZEVs). However, the UK now needs the policy framework to deliver this petrol and diesel phase-out.

The US state of California introduced a zero-emission vehicle mandate ('ZEV mandate') in the 1990s, a programme later joined by nine other US states. China and two Canadian provinces have since introduced their own ZEV mandates. Under a ZEV mandate, manufacturers must sell an increasing number of ZEVs as a share of their overall sales, or purchase credits from other manufacturers. In Europe, Norway is the leader in zero-emission vehicles, but it has taken a different approach. Norway has large financial subsidies and non-financial benefits for ZEVs, and high taxes on Internal Combustion Engine (ICE) vehicles.

The UK Government currently supports ZEVs with a 'Plug-in Car Grant' of up to £3,000,[5] as well as supporting public and private charging infrastructure for electric vehicles (EVs). The Plug-in Car Grant has already cost the Government over £800m and is expected to cost another £400m by 2023.[6] In the post-COVID-19 economy, the Government will want to support the recovery of domestic car manufacturing whilst accelerating the UK's transition to Net Zero. However, the demands on public finances will be numerous, so policy for zero-emission vehicles should be fiscally neutral as far as possible.

Our research finds two policy recommendations for the UK Government:

1. **Introduce a zero-emissions vehicle mandate:** Without a comprehensive policy framework, the UK will not be able to end the sale of new petrol, diesel and hybrid cars and vans by 2035 or earlier. Expanding existing approaches such as plug-in grants is likely to be unnecessarily expensive and fails to harness market competition. By contrast, a ZEV mandate can be revenue-neutral for the Government, whilst giving car manufacturers the confidence to invest in manufacturing ZEVs in the UK.

3. BEIS (June 2019). *UK becomes first major economy to pass net zero emissions law.* Link
4. DfT (March 2020). *Decarbonising Transport: Setting the Challenge.* Link *(paragraph 1.6).*
5. UK Government (accessed 17 July 2020). *Low-emission vehicles eligible for a plug-in grant.* Link
6. DfT and OLEV (March 2020). *Update on plug-in vehicle grants following today's budget.* Link

2. **Develop complementary policies:** A ZEV mandate frees up Government funding that should instead be used to expand policies that complement the roll-out of ZEVs. These complementary policies should include support for EV charging infrastructure, as argued for in Policy Exchange's 2017 report, *Driving Down Emissions*.[7] Once the ZEV mandate is in force, the Government should gradually phase out conflicting policies, including the Plug-in Car Grant and favourable tax treatment for ZEVs, including for those used as company cars.

Brexit provides an opportunity to lift EU restrictions that currently prevent EU and EEA member states from banning petrol and diesel vehicles, a restriction derived from the 'four freedoms' principles of the EU.[8] Denmark's proposed ban on petrol and diesel cars from 2030 has had to be delayed due to concerns over compliance with EU rules.[9,10] Now that the UK has left the EU, the UK Government has more freedom to set its own policy for the decarbonisation of vehicles. This includes the ability to ban the sale of petrol, diesel and hybrid cars and vans, and to introduce a ZEV mandate.

The UK Government should put a market-based ZEV mandate at the heart of its plan for transport decarbonisation, in line with the Government's commitment to pursue a future approach post-Brexit that is "at least as ambitious as the current arrangements".[11] A UK ZEV mandate, combined with appropriate industrial strategy, will make the UK more attractive to world-leading electric vehicle manufacturers such as Tesla. The Committee on Climate Change endorsed the concept of a UK ZEV Mandate in its 2020 Progress Report to Parliament.[12] Our report provides the framework for the design of such a mandate and the complementary policies that are needed to deliver the petrol and diesel phase-out.

Context

Transport increasingly lags behind other sectors in the UK's transition to a Net Zero economy. In the last five years emissions from the electricity sector fell by nearly 60% whilst emissions from surface transport (including cars) have increased by 5%. In 2018, the carbon emissions intensity of new cars actually worsened, due to increased sales of large SUVs and concerns over the air quality impact of diesel cars.[13] The Government is consulting on bringing forward a ban on sales of new petrol, diesel and hybrid cars and vans from 2040 to 2035 or earlier,[14] as well as preparing the Transport Decarbonisation Plan.[15] In 2019, just 3.5% of new car sales in the UK were ZEVs.[16] Between 2018 and 2019, UK ZEV market share grew by just one percentage point, compared to the six percentage points per year required to deliver a ban on the sale of new petrol, diesel and hybrid cars and vans by 2035.

7. Howard, R. Policy Exchange (2017). *Driving Down Emissions: How to clean up road transport?*. Link
8. Bannon, E. Mileu Law & Policy Consulting (March 2020). *Phasing-out sales of internal combustion engine vehicles*. Link
9. Ekblom, J. Reuters (October 2019). *Denmark calls for EU strategy to phase out diesel and petrol cars from 2030*. Link
10. Danish delegation, support by the Luxembourg delegation (October 2019). *Transition to a fleet of zero-emission passenger cars – a necessity for a climate neutral EU by 2050 at the latest*. Link
11. Ibid (DfT). Decarbonising Transport: Setting the Challenge
12. CCC (June 2020). *Reducing UK emissions: Progress Report to Parliament*. Link
13. CCC (2019). *Reducing UK emissions: 2019 Progress report to Parliament*. Link – pages 24-27.
14. DfT and OLEV (February 2020). *Consulting on ending the sale of new petrol, diesel and hybrid cars and vans*. Link
15. Ibid (DfT). *Decarbonising Transport: Setting the Challenge)*. Link
16. European Alternative Fuels Observatory (EAFO). www.eafo.eu

Recommended policy approach

#1: Harness market competition to minimise the cost of the transition to ZEVs

The transition from internal combustion engine (ICE) vehicles to zero-emission vehicles (ZEVs) could severely strain the public finances. The UK's current support for ZEVs comprises grants and favourable tax treatment. As the sale of ZEVs increases, these schemes will become increasingly expensive and will need to be phased out. The tax treatment of ZEVs needs to be considered in the context of a long-term fall in Fuel Duty as petrol and diesel vehicles are replaced by ZEVs. The Government must design policies that accelerate the roll-out of ZEVs, whilst reducing the cost to the Exchequer.

#2: Learn from international leaders

Norway is the international leader in ZEV sales, with ZEVs accounting for over 50% of new car sales in 2019. The Norwegian Parliament has adopted a 2025 target for ending the sale of petrol and diesel cars in the country.[17] Norway has an ambitious mix of tax policies and incentives for EV drivers, including VAT exemptions, free parking, preferential access to bus lanes, reduced road tolls, and reduced fares on ferries. The Norwegian approach has been successful, but it has put substantial costs on the Government and consumers. One study estimates that, in 2014, the cost of subsidising a ZEV in Norway was over $8,000 (£6,400) per year.[18] In the post-COVID fiscal landscape, Norwegian-style ZEV policies may not be affordable or appropriate for the UK.

California and China are also leaders in zero-emission vehicles. California has operated a market-based ZEV mandate since the 1990s. The ZEV mandate requires manufacturers to sell an increasing proportion of ZEVs, or to buy credits from other manufacturers (Box 1 and Box 2). A ZEV mandate has some similarities with cap-and-trade, which is used in many jurisdictions to reduce carbon emissions and other pollutants, including the EU's Emissions Trading System (ETS) and the UK's proposed successor ETS. In 2019, China introduced a similar ZEV mandate. China is already the world's largest market for ZEVs, with over one million sales in 2018.

A ZEV mandate harnesses market competition to promote a cost-effective roll-out of ZEVs, whilst reducing the cost to the Government and taxpayers. In designing a UK ZEV mandate, policymakers must consider five principles:

1. Simplicity;
2. Policy stability;
3. Transparency of the market for ZEV credits;
4. The distributional impact on low-income motorists;
5. Controlling costs.

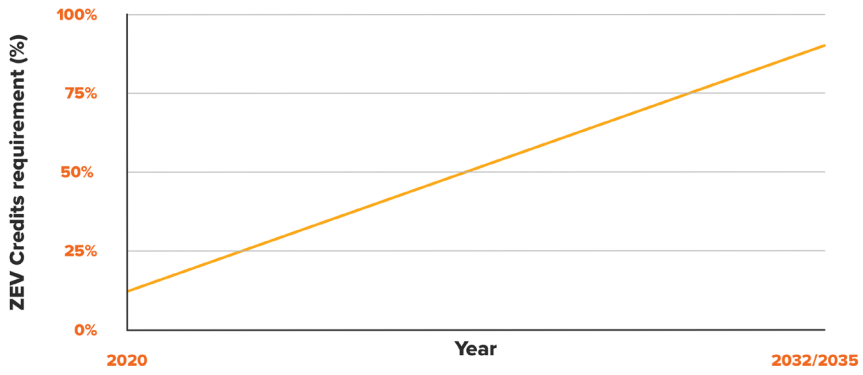
17. Norsk elbilforening (Norwegian electric car association). *Norwegian EV Policy.* Link

18. Holtsmark, B. and Skonhoft, A, Environmental Science & Policy (2014). *The Norwegian support and subsidy policy of electric cars. Should it be adopted by other countries?* Link.

Box 1: How does a ZEV Mandate work?

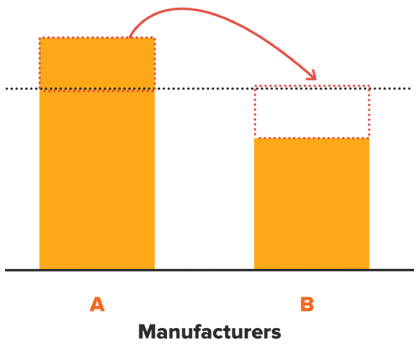
Each Zero-Emission Vehicle generates a set number of ZEV credits. Government sets an annual requirement for credits, expressed as a percentage of overall sales, which rises over time. Manufacturers must therefore sell an increasing proportion of ZEVs each year to meet a rising requirement for ZEV credits. In California, the ZEV requirement increases linearly.

Example annual ZEV credit requirement

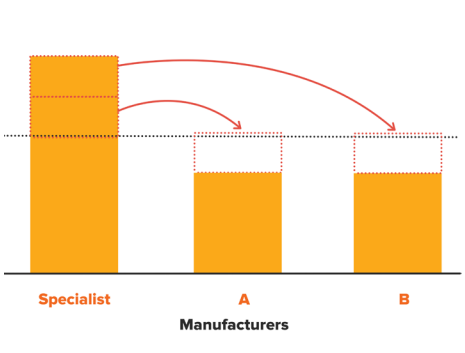


Box 2: How are ZEV credits traded?

If Manufacturer B does not sell enough ZEVs, they can purchase excess ZEV credits from a competitor (e.g. Manufacturer A).



A ZEV Mandate encourages the entry of new specialist ZEV manufacturers, who can sell credits to other manufacturers. For example, in California, Tesla sells ZEV credits to other manufacturers.



#3: Develop complementary policies

A ZEV mandate should be the anchor policy for the decarbonisation of cars and vans in the UK. However, complementary polices are needed to ensure a smooth transition to ZEVs, and that no area of the country is left behind, especially those with established automotive industry workforces. These policies will also help to support consumer demand for ZEVs, increasing certainty for the automotive industry.

Complementary policies include investment in public EV charging infrastructure and Clean Air Zones (CAZs). Once a ZEV mandate is in force, existing policies such as plug-in grants and preferential tax treatment for ZEVs should be gradually phased out. Policy Exchange has done extensive work on complementary policies in our reports on *How to clean up road transport*,[19] and *How to solve London's air quality crisis*.[20]

Policy recommendations

This report makes specific recommendations for the design of a UK ZEV mandate and complementary policies:

Table 1: List of specific policy recommendations

Designing a UK ZEV mandate	
1.	The ZEV credit requirement should increase linearly to reach nearly 100% by the phase-out date for petrol, diesel and hybrid cars and vans.
2.	ZEV credits should be based solely on range, and not on additional technical parameters.
3.	A UK ZEV mandate should not be linked to existing fleet-average CO_2 targets.
4.	PHEVs should be included in a UK ZEV mandate until a fixed end date, for example between 2025 and 2028.
5.	Banking and trading of ZEV credits should be permitted.
6.	The ZEV mandate regulations should include the key design parameters, including the end date and the annual ZEV credit requirement.
7.	The Government should commit to giving at least three years' notice for changes to the ZEV mandate regulations.
8.	A UK ZEV mandate should establish a public market index of ZEV credit prices to aid transparency.
9.	The Government should consider increasing taxes for the most polluting vehicles to mitigate the distributional impacts of a ZEV mandate.
10.	The price of ZEV credits should be capped to control costs.
Complementary Policies	
11.	Existing fleet-average CO_2 targets should be retained, despite some inefficiencies. The Government should consider minor changes to the scheme, such as allowing full banking and trading.

19. Ibid (Policy Exchange). *How to Clean Up Road Transport.*
20. Howard, R. Policy Exchange (2016). Up in the Air. *How to Solve London's Air Quality Crisis: Part 2.* Link

12.	The UK Government and Devolved Administrations should continue to support the competitive procurement of rapid EV charge points on strategic routes and in rural areas.
13.	Government support for on-street and workplace chargers should continue, using competitive procurement wherever possible.
14.	The Government's proposed green number plate scheme for ZEVs is a no-regrets option. However, it should not distract from other more substantial recommendations in this report.
15.	Clean Air Zones (CAZs) – The Government should support Local Authorities to introduce CAZs, including by supporting EV charging infrastructure in these areas.
16.	Regulation of vehicle fleets – The Government should consider an accelerated ZEV requirement for vehicle fleets operating in the most polluted areas. This requirement should include buses, taxis, private hire vehicles, HGVs and delivery vehicles.
17.	Technical training, lifelong learning and apprenticeships will be particularly important in the UK's automotive sector as it transitions to zero-emission vehicles. Policy Exchange's recent essay collection, *The Training We Need Now*, makes a number of recommendations in this area.[21]
Contradictory Policies	
18.	Once the UK ZEV mandate is in operation, purchase incentives for ZEVs should be phased out, including the Plug-in Car Grant.
19.	Once the ZEV mandate is in place, the Government should gradually phase out favourable tax treatment for ZEVs, including for those used as company cars or fleet vehicles.
20.	Scrappage schemes – A vehicle scrappage scheme would likely overlap with a UK ZEV mandate and Clean Air Zones, so should not be considered at this stage.

21. Goodhart, D. Policy Exchange (July 2020). *The Training We Need Now. Essays on technical training, lifelong learning and apprenticeships.* Link

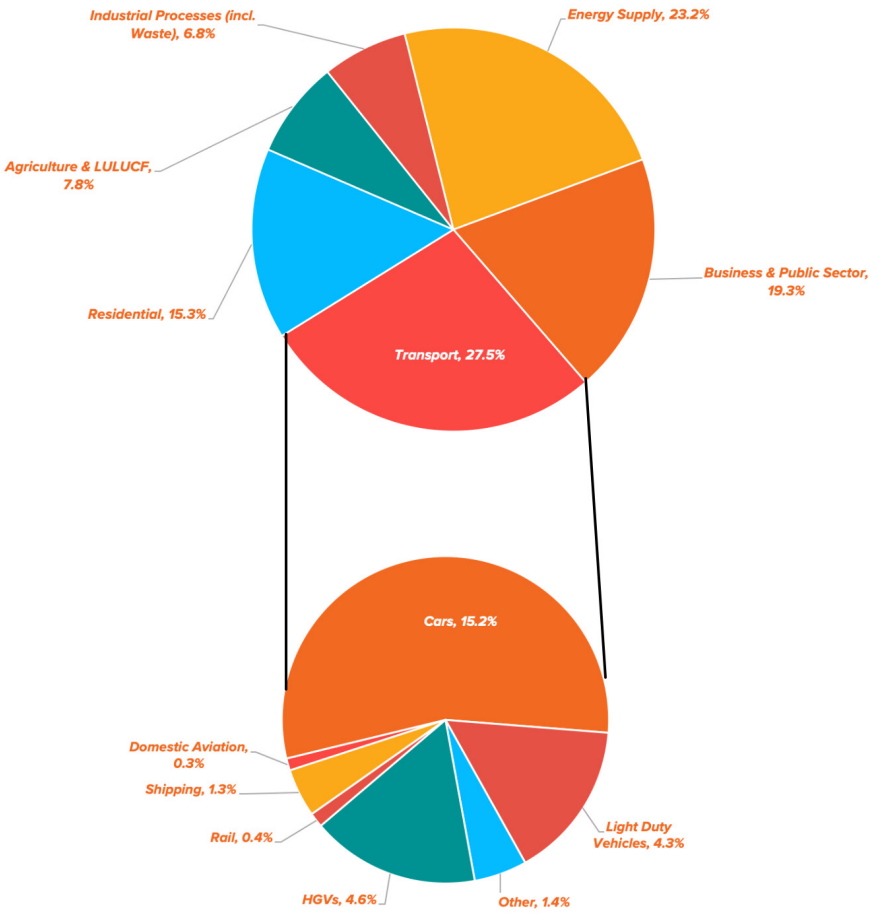
1: Introduction

This section analyses the UK's greenhouse gas emissions by sector and sets out the UK's progress to date in deploying zero-emission vehicles.

Greenhouse gas emissions from vehicles in the UK

Transport is now the largest contributer to greenhouse gas (GHG) emissions in the UK, generating over a quarter of domestic greenhouse gas emissions (Figure 1). Cars account for over half of transport emissions and around 15% of the UK total.

Figure 1: Total UK greenhouse gas emissions by sector (2018).[22]

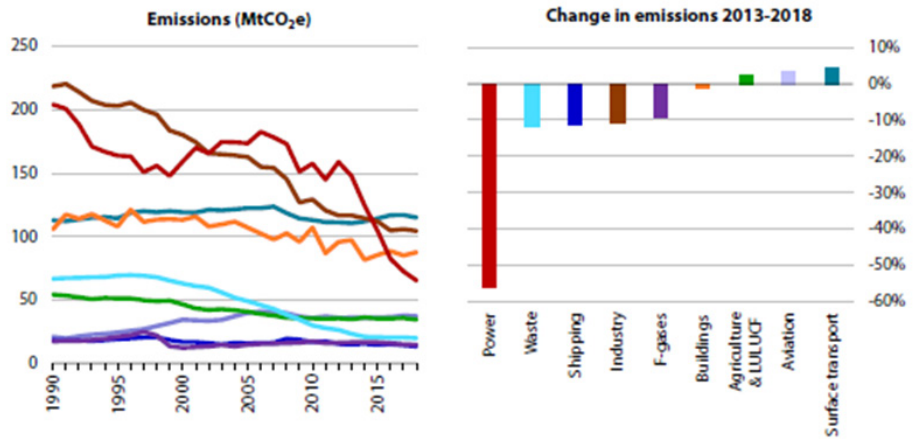


Since 1990, UK greenhouse gas emissions have fallen by 40%. However,

22. BEIS (March 2020). *Final UK greenhouse gas emissions national statistics (Annex: 1990-2018 final emissions by end user and fuel type).* Link

emissions from the transport sector have barely changed (Figure 2). Between 2013 and 2018, emissions from surface transport (including cars) actually increased by 5%. This lack of progress in the transport sector is in stark contrast to the electricity ('power') sector, where emissions have fallen by over 50% in the same period.

Figure 2: UK greenhouse gas emission by sector, 1990-2018.[23]



The UK's Net Zero target will only be achieved if the transport sector is decarbonised. The most promising zero-emission vehicles are battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs). Both of these are likely to rely on the UK's electricity sector, either to charge BEVs or to produce 'green hydrogen' for FCEVs. The rapid decarbonisation of the UK's electricity sector further enhances the emissions reductions from an accelerated transition to ZEVs.

History of UK road transport emissions and policy

The UK's total road transport emissions have remained relatively constant since 1990, however there have been some significant underlying trends, as outlined in Policy Exchange's 2017 report, *Driving Down Emissions: How to clean up road transport*.[24]

Three recent trends are: more fuel-efficient petrol and diesel vehicles; an increase in distance travelled; and UK Government support for lower carbon transport fuels.

More efficient petrol and diesel vehicles

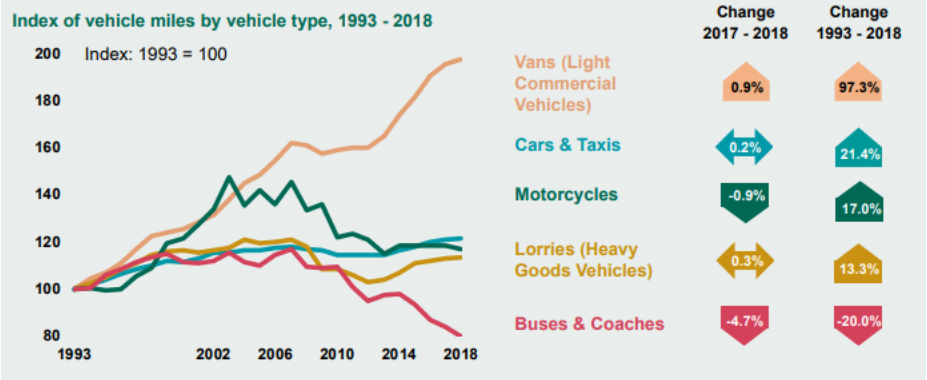
Vehicle fuel economy has improved markedly since 1970, when the first European exhaust emission standards were introduced.[25] The UK Government has also encouraged the purchase of vehicles with lower CO_2 emissions through financial incentives such as Vehicle Excise Duty (often known as 'road tax'), Company Car Tax, and enhanced capital allowances.[26] The European Commission has also set EU-wide targets for car manufacturers to achieve an average of 95 grams of carbon dioxide per kilometre (gCO_2/km) by 2021, as discussed later in this report.

23. Ibid (CCC).*2019 Progress Report to Parliament.*
24. Ibid (Policy Exchange) *Driving Down Emissions*
25. The AA (accessed 17 July 2020). *Limits to improve air quality and health.* Link
26. Ibid. (Policy Exchange) *Up in the Air.*

Increase in distance travelled by cars, vans, HGVs, and motorcycles

The increased fuel efficiency of vehicles has been offset by people driving more than they did previously. Statistics from the Department for Transport show that the total vehicle miles travelled (VMT) in Great Britain increased 14% in the 1990s and 6% in the 2000s. VMT for cars and vans increased more than for other vehicle types (Figure 3). Without improvements in vehicle efficiency, greenhouse gas emissions from transport would have risen significantly since 1990, whereas they have stayed broadly constant.

Figure 3: Index of vehicle miles travelled in Great Britain (1993-2018).[27]



UK Government support for lower carbon transport fuels

Unleaded petrol in the UK currently contains up to 5% bioethanol, known as E5. The Government is consulting on increasingly the bioethanol share to 10% in 2021, known as E10.[28] Blending petrol and bioethanol lowers the carbon emissions of road transport, however not all cars can use E10 petrol.

The Renewable Transport Fuel Obligation (RTFO) is an obligation on large suppliers of fuel to generate transport fuel from renewable energy sources, or to buy credits from producers of renewable transport fuel. Unlike E5 and E10, the RTFO applies to all types of vehicles, not just road vehicles.[29] Renewable transport fuels include those derived from crops and from waste cooking oil. There is a cap on the proportion of crop-derived biofuel that can be counted towards a supplier's RTFO target.

Sales of zero-emissions vehicles in the UK

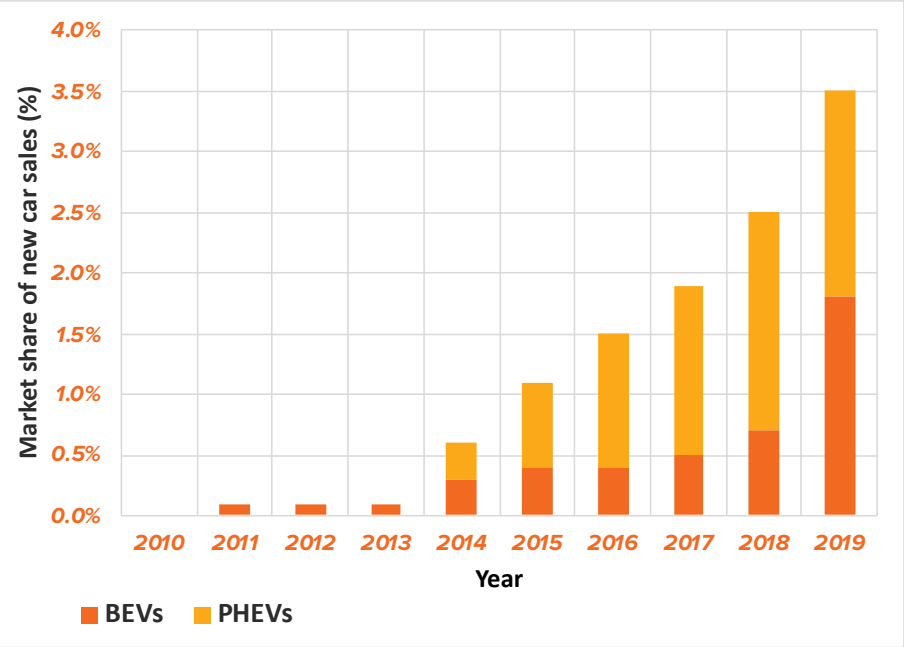
Sales of ZEVs in the UK are increasing, but still only comprised 3.5% of total new car sales in 2019 (Figure 4). The Government is consulting on including plug-in hybrids such as PHEVs on the list of new cars and vans that will not be allowed to be sold after 2035. PHEVs currently account for around half of the ZEVs sold in the UK.

27. DfT (May 2019). *Road Traffic Estimates: Great Britain 2018*. Link

28. DfT (March 2020). *Introducing E10 Petrol*. Link

29. DfT (accessed 17 July 2020). *Renewable Transport Fuel Obligation*. Link

Figure 4: UK BEV and PHEV annual sales shares of new cars (2010-2019).[30]



In the first half of 2020, sales of ZEVs comprised 7.7% of total new UK car registrations (Figure 5). This is in part due to rising sales of ZEVs, particularly BEVs, and also in part due to a collapse in sales of petrol, diesel and hybrid vehicles during the Coronavirus pandemic.

Figure 5: UK car registrations by fuel type (Jan-June 2020).

	YTD 2020	YTD 2019	% change	Mkt share -20	Mkt share -19
Diesel	118,957	339,330	-64.9%	18.2%	26.7%
Petrol	392,608	822,521	-52.3%	60.1%	64.8%
BEV	30,957	11,975	158.6%	4.7%	0.9%
PHEV	19,508	15,136	28.9%	3.0%	1.2%
HEV	39,328	49,004	-19.7%	6.0%	3.9%
MHEV diesel	21,884	9,840	122.4%	3.3%	0.8%
MHEV petrol	30,260	21,439	41.1%	4.6%	1.7%
TOTAL	653,502	1,269,245	-48.5%		

Source: SMMT.[31]

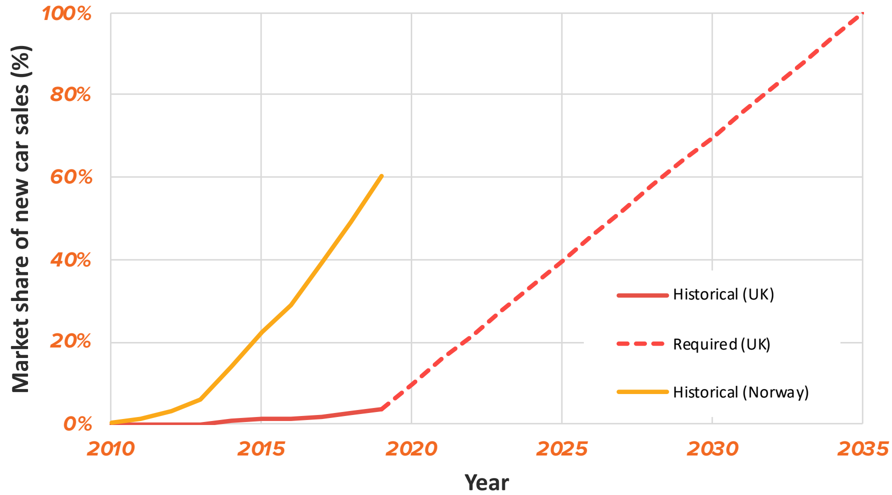
The UK needs rapid and sustained increases in the market share of zero-emission vehicles between now and 2035 (Figure 6). Figure 6 also shows the market share of ZEVs in Norway, which increased from 6% of new sales in 2013 to 60% in 2019 thanks to ambitious public policy.

30. Ibid. (EAFO)

31. Society of Motor Manufacturers and Traders (SMMT) (accessed 17 July 2020). *SMMT Vehicle Data: Car Registrations (June 2020).* Link

This provides evidence that ambitious public policy can lead to a rapid transition to ZEVs.

Figure 6: Indicative pathway to 100% ZEV sales in the UK by 2035.[32]



Current UK Government support for zero-emission vehicles

The UK Government currently supports ZEVs through grants and favourable tax treatment (Table 2). These policies have helped to support early sales of ZEVs in the UK; however, they require the Government to set fixed subsidies and favourable tax treatment, rather than relying on market competition to deliver ZEVs at the lowest cost. These policies also put substantial costs on the UK Government and risk over-rewarding certain ZEV buyers, particularly those who use ZEVs as company cars.

Table 2: UK Government support for ZEVs

Policy measure	Description
Plug-in Car Grant (PiCG)	Grant of up to £3,000 for buyers of plug-in cars. Extended to 2022-23 in the Budget 2020.[33] There are similar grants for vans, trucks, taxis, and motorbikes.
Reduced Benefit in Kind (BIK) bands (Company Car Tax)	ZEVs attract significantly lower rates of BIK tax, also known as Company Car Tax (CCT). These rates are currently in place until 202223.
Preferential capital allowances for ZEVs	Pure ZEVs (BEVs and FCEVs) qualify for "first year allowances" that allow companies to deduct the full cost from profits before tax.[34]
Preferential rates of Vehicle Excise Duty (VED)	Vehicle Excise Duty (also known as 'Road Tax'), is an annual tax on vehicle ownership. The rates vary based on the CO_2 emissions of the vehicle. ZEVs are currently exempt from VED.

32. Ibid. (EAFO)

33. Ibid. (DfT and OLEV). *Updated: plug-in vehicle grants.*

34. UK Government (accessed 16 July 2020). *Claim capital allowances.* Link

Between January 2011 and March 2020, the Plug-in Car Grant has cost over £800m, and it is expected to cost another £400m until the end the financial year 2022-23.[35] In the Budget 2020, the Government reduced the maximum PiCG from £3,500 to £3,000 and excluded ZEVs costing over £50,000.

The Company Car Tax benefit for ZEVs can be substantial, especially for higher rate and additional rate taxpayers with the most expensive company cars. For similar electric and diesel cars, each costing around £40,000, a higher rate taxpayer would pay annual CCT tax of £4,500 on the diesel car in 2020/21, whereas the EV attracts no CCT.[36]

BEVs and FCEVs are currently exempt from Vehicle Excise Duty (VED). Compared to a typical petrol car, this provides a benefit of approximately £150 per year, or £475 for a car with a list price of more than £40,000 (which attracts the 'expensive car supplement').[37] In March this year, the Treasury published a Call for Evidence on Vehicle Excise Duty and its role in supporting the transition to ZEVs.[38]

The Plug-in Car Grant and preferential tax treatment have all helped to support the UK's nascent ZEV market, however they will become increasingly expensive as ZEV sales increase. It is notable that there is currently no long-term Government commitment to the Plug-in Car Grant beyond 2022-23, or to preferential rates of CCT beyond 2024-25.

Existing UK/EU policy to decarbonise passenger cars

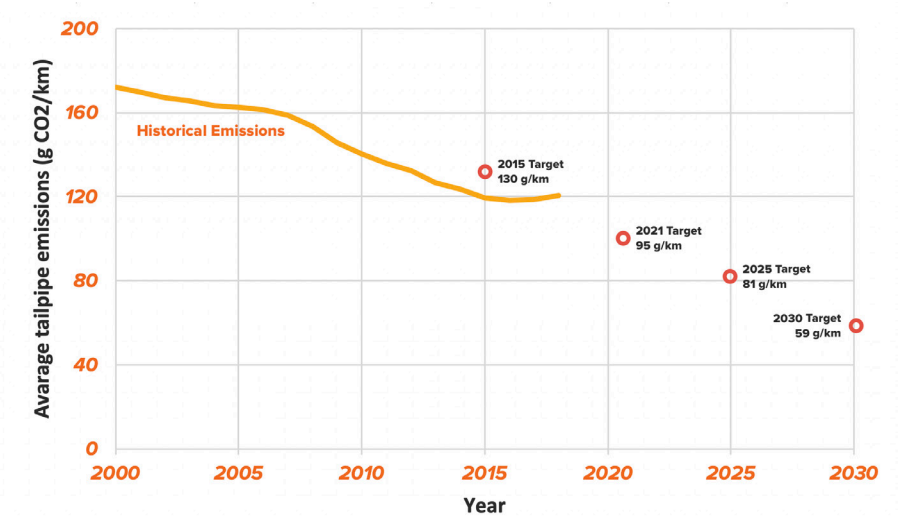
The European Union's approach to decarbonising passenger cars is to set an average CO_2 emissions target for each manufacturer's vehicle fleet.[39] New car CO_2 emissions for each manufacturer must, on average, reduce by 15% by 2025 and by 37.5% by 2030, relative to a 2021 baseline. This is equivalent to a fleet average of 81 gCO_2/km by 2025 and 59 gCO_2/km by 2030 (Figure 7). The UK has committed to an approach post-Brexit that is "at least as ambitious as the current arrangements for vehicle emissions regulations", and the EU targets for 2025 and 2030 both apply in the UK, as do the fines for non-compliance.[40]

Existing EU regulations provide incentives for low emission vehicles, with "zero- and low-emission vehicles" (ZLEVs) defined as those with CO_2 emissions of 50 gCO_2/km or lower, typically BEVs, FCEVs, and PHEVs. The EU has set a ZLEV target of 15% for 2025 and 35% by 2030. Manufacturers who exceed the ZLEV target will be rewarded with a higher average CO2 emissions limit. Manufacturers who do not meet the ZLEV target will not face penalties.

Manufacturers must pay "excess emission premiums" of €95 per vehicle for every gCO_2/km by which the manufacturer's fleet-average emissions exceeds its targets. There is a derogation for 'niche manufacturers' of less than 300,000 vehicles per year, which expires in 2028, and there is a similar scheme for vans.

Figure 7: EU CO_2 standards for new passenger cars up to 2030, including historical emissions.[41]

35. Ibid. (DfT and OLEV). *Update on plug-in vehicle grants.*
36. CLM (accessed 06 July 2020). *Electric Company Car Tax.* Link
37. UK Government (accessed 16 July 2020). *Vehicle tax rates.* Link
38. HM Treasury (March 2020). *Vehicle Excise Duty: Call for Evidence.* Link
39. International Council on Clean Transportation (ICCT) (January 2019). *CO_2 emissions standards for passenger cars and light-commercial vehicles in the EU.* Link
40. Ibid (DfT). *Decarbonising Transport: Setting the Challenge. page 21, paragraph 2.14.*
41. Ibid (ICCT). *CO_2 emissions standards for passenger cars ... in the EU.*



Recent analysis from PA Consulting forecasts that the top 13 EU car manufacturers will miss their 2021 targets and will face fines of more than €14.5bn (Figure 8) vs. 2021 target. Source: PA Consulting.).[42] In fact, average CO_2 emissions per vehicle in the EU are now increasing, in part due to rising demand for SUVs and in part due to changing consumer preferences for petrol rather than diesel vehicles based on concerns over the air pollution impact of diesel vehicles.

Figure 8: CO_2 emissions by manufacturer (2018 actual and 2021 forecast) vs. 2021 target.

Source: PA Consulting.

The EU approach to decarbonising passenger cars has been relatively successful to date, encouraging manufacturers to develop more fuel-efficient ICE cars, as well as more hybrid and electric models. However, with most manufacturers expected to miss their 2021 targets, there are questions over the whether the scheme is the best way to drive further decarbonisation. The EU scheme applies a target to each manufacturer

42. PA Consulting (January 2020). *PA Consulting's analysis shows top car makers will face €14.5bn fines for missing the EU's CO_2 emissions targets.* Link

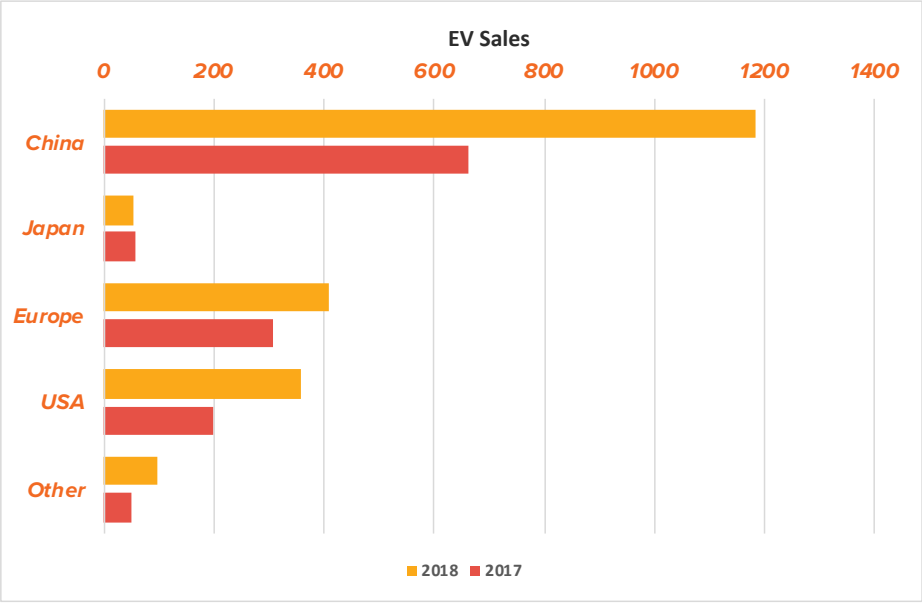
individually, unless they form a 'pool' with other manufacturers. Arguably, this approach favours large manufacturers with a diverse product range, as they can adjust the relative sales of different models to meet the targets. Manufacturers who exceed their targets are not financially rewarded, reducing the incentive for major manufacturers to reduce their CO_2 emissions faster. This approach also fails to encourage the emergence of specialist ZEV manufacturers such as Tesla.

In contrast to the EU approach, a zero-emissions vehicle mandate applies to the whole market, rather than individual targets for each manufacturer. Manufacturers who exceed their ZEV requirement can sell their excess credits to other manufacturers. A ZEV mandate, combined with appropriate industrial strategy, should help to attract specialist ZEV manufacturers to the UK, similar to how California's early ZEV policies spawned a nascent ZEV manufacturing base.

Comparison of ZEV sales by country

China is the largest market for EV car sales (BEVs and PHEVs), with over one million EVs sold in 2018 (Figure 9). Sales of EVs in Europe and the United States were approximately 400,000 in each region and around two million EVs were sold globally in 2018. By contrast, sales of hydrogen-powered ZEVs (FCEVs) were only around 7,500 in 2019.[43]

Figure 9: EV sales by region (2018 and 2017).



Source: EV-Volumes.com.[44]

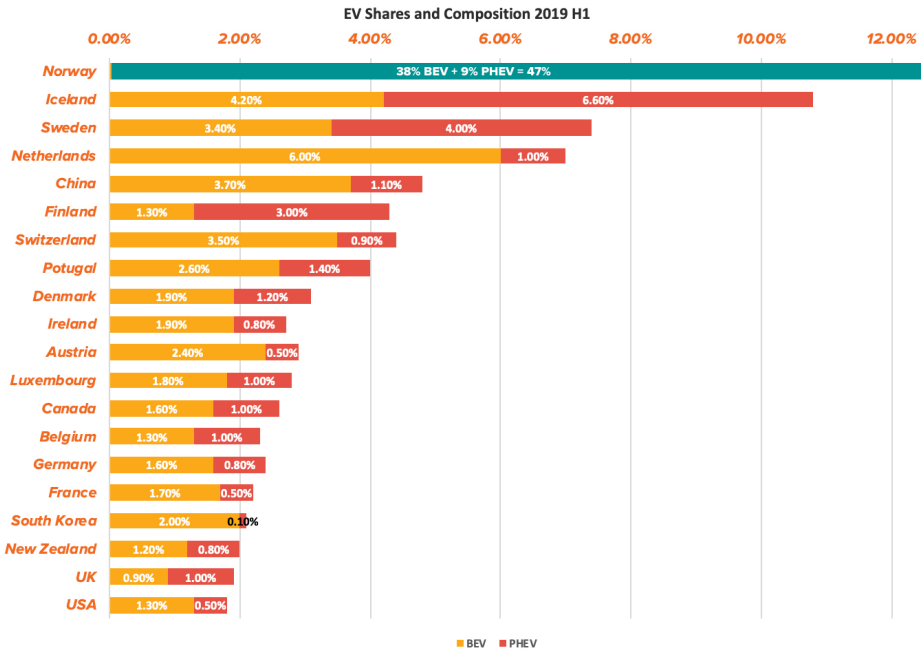
Norway has the highest EV market share at 47% in the first half of 2019 (Figure 10). Norway's market share for EVs is four times higher than the next

43. Mark Kane, Inside EVs (February 2020). *Hydrogen Fuel Cell Car Sales in 2019 improved to 7,500 Globally.* Link

44. Roland Irle, EV-Volumes.com (accessed 06 July 2020). *Global EV Sales for 2018 – Final Results.* Link

market, Iceland. China has an EV market share of around 5%, compared to around 2% in the UK and the United States.

Figure 10: EV sales share of light vehicles by country (H1 2019).



Source: EV-Volumes.com.[45]

45. Irle, V. EV-Volumes.com (accessed 06 July 2020). *Europe Plug-in Sales for 2019 H1.* Link

2: International approaches to ZEVs

California, China, and Norway lead the world in incentivising and deploying zero-emission vehicles. California has operated a ZEV mandate since the early 1990s. The scheme has been reformed multiple times and has been extended to include nine other US states.[46] China is the world's largest market for ZEVs. Since 2019, China has operated a mandate for so-called 'New Energy Vehicles' (NEVs), modelled on California's ZEV mandate. Norway has taken a different approach, offering monetary and non-monetary incentives for ZEVs, and heavily taxing Internal Combustion Engine (ICE) cars. This section analyses each of these three schemes in detail.

California: Zero-emission vehicle mandate ('ZEV mandate')

California's ZEV mandate requires manufacturers to sell a rising proportion of vehicles with zero exhaust emissions. If a manufacturer does not meet the target, then they must buy ZEV credits from other manufacturers who exceed their ZEV mandate. Due to the monetary value of ZEV credits, a ZEV mandate acts to decrease the price of ZEVs and to increase the price of petrol and diesel cars.

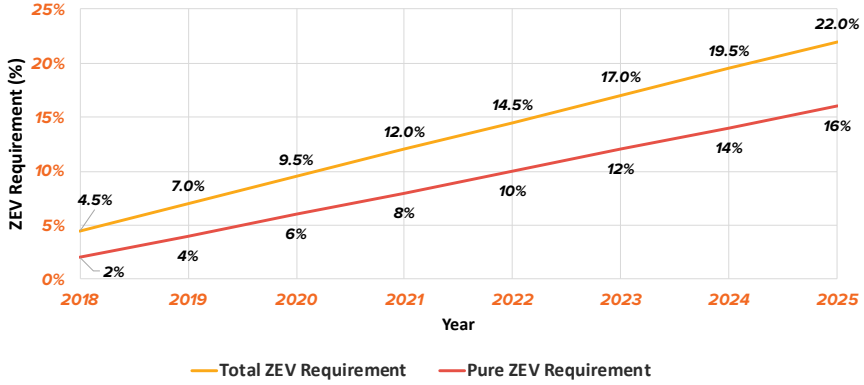
The ZEV programme is managed by the California Air Resources Board (CARB). Since its introduction in 1990, the ZEV programme has changed multiple times, as catalogued by Resources for the Future, a research institute, in a working paper titled *California's Evolving ZEV Program*.[47]

Since 2018, only Battery Electric Vehicles (BEVs), Fuel-Cell Electric Vehicles (FCEVs) and Plug-in Hybrid Electric Vehicles (PHEVs) have been eligible to receive ZEV credits. Manufacturers must present ZEV credits equal to 4.5% of their total sales in 2018, increasing to 22% in 2025. A proportion of the ZEV credits must come from "pure ZEVs", i.e. BEVs or FCEVs rather than PHEVs (Figure 11).

46. The 9 other states are: Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Vermont. Link.

47. McConnell, V. et al. Resources for the Future (November 2019). *California's Evolving Zero Emission Vehicle Program: Pulling New Technology into the Market*. Link.

Figure 11: California ZEV Mandate requirements (2018-2025).[48]



Different ZEVs generate a different number of credits. For example, a BEV with a range of over 350 miles per charge generates the maximum of 4 credits, whereas a BEV with a 150-mile range generates 2 credits. Manufacturers can therefore meet their 2025 ZEV requirement (22%) by selling 150-mile BEVs (11% of total sales), 350-mile+ BEVs (5.5% of total sales), or a combination (Table 3). The penalty for non-compliance is $5,000 per credit. A ZEV with a range of 350-miles can therefore generate ZEV credits worth $20,000 if ZEV credits are trading at the penalty price. Despite the presence of a $5,000 penalty price per credit, the California ZEV rules require manufacturers to eventually make up any credit deficit, which means that there is no price cap for ZEV credits in California.

Table 3: California ZEV credits per vehicle, based on range.[49]

BEV Range	ZEV credits per vehicle	% of total sales to meet 2025 ZEV requirement (22%)
150 miles	2.0	11%
250 miles	3.0	7.3%
350+ miles	4.0	5.5%

The ZEV requirement varies by size of manufacturer, based on the total sales in California, and is currently linked to the manufacturer's average greenhouse gas emissions across its whole fleet, known as the 'fleet-average'; this link will be phased out post-2022. In previous years, manufacturers have been able to use credits generated in the other nine ZEV states interchangeably, although this provision only remains for FCEVs post-2018.

We can draw several conclusions from the experience of the California ZEV mandate:

- The technologies defined as ZEVs have changed over time. For example, the cleanest ICE cars and hybrids such as the Toyota Prius have previously counted as 'Partial Zero Emission Vehicles' (PZEVs). Other aspects of the programme's design have also changed too

48. California Code of Regulations (accessed 18 July 2020). *Zero-Emission Vehicle Standards for 2018 and subsequent model years for Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles.* Link

49. Author's calculations.

many times. It is notable that California's early adoption of a ZEV Mandate has meant a high incidence of technology development. Whilst the UK could reasonably expect a lower rate of change than California's programme has seen, a UK ZEV Mandate would need sufficient flexibility to cope with big technological advances, such as moving from lithium ion batteries to lithium-silicon and/or solid state batteries.

- California's ZEV programme has been the key driver of ZEV innovation across the United States, despite operating in just ten states.
- As the cost of EVs has fallen, automakers as a whole are over-complying with their ZEV mandate requirements. This has resulted in manufacturers 'banking' ZEV credits in one year and using them in the next year (Box 3). If the ZEV credit requirement is set too low, then manufacturers will bank large numbers of credits for use in later years. This means that in later years manufacturers can produce fewer ZEVs or ramp up production more slowly. The advantage of banking is that it discourages manufacturers from holding back ZEV sales if they have already met their requirement for the year. The early stages of the EU Emissions Trading Scheme (EU ETS) also saw over performance and banking, which depressed credit prices.
- The market for ZEV credits allowed a few specialised manufacturers to enter the market early (Nissan, Tesla). This suggests that the UK should see a ZEV mandate as part of a broader industrial strategy to attract ZEV manufacturers to the UK.
- The price of ZEV credits is not transparent. Some price information can be inferred from public filings of Tesla, a leading ZEV manufacturer. Tesla is estimated to have received $1,500-$2,500 (c.£1,200-£2,000) per credit between 2015-2017. This lack of transparency means that manufacturers may not be able to accurately assess the value of the ZEV credits that they produce, and it makes it harder for the public to understand how the ZEV mandate is working. This may also make manufacturers reluctant to produce large numbers of ZEVs, as they have lower certainty over the market price for their excess ZEV credits.
- ZEV purchases have tended to displace purchases of hybrids, which are relatively fuel efficient. Bigger emissions reductions would be achieved if ZEV purchases displaced more 'average' ICE cars.
- The ZEV mandate could be changed to incentivise better battery density (higher kWh/kg) or energy efficiency (lower kWh/mile), in line with the Chinese NEV mandate (described below).

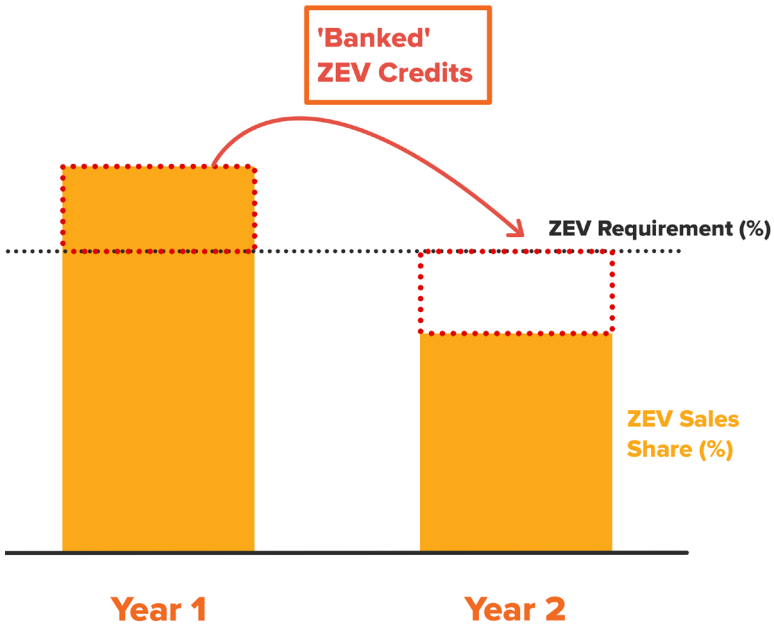
In addition to the ZEV mandate, California has consumer purchase incentives for ZEVs through the Clean Vehicle Rebate Program (CVRP). The CVRP offers a rebate (grant) of up to $7,000 (£5,550) depending on the vehicle and the purchaser's income.[50] The US Federal Government also offers a tax credit of up $7,500 (£6,000) for electric vehicle purchases,

50. Coltura (accessed 08 July 2020). *The Electric Vehicle rebate in California and other incentives.* Link

although these tax credits reduce once a manufacturer sells over 200,000 vehicles.[51] Arguably these state and federal rebates and tax credits are not required, given the presence of a California ZEV mandate, and have contributed to the banking of California ZEV credits. Rapid advances in battery technology and a steep fall in battery costs are also responsible for overcompliance with the California ZEV mandate.

Box 3: How does 'banking' of ZEV credits work?

If a manufacturer over-complies with the ZEV credit requirement in a particular year, they can 'bank' their excess ZEV credits and use them in later years. In the example below, the manufacturer over-complies with the ZEV requirement in year 1 and uses the banked credits in year 2.



China: New Energy Vehicle mandate ('NEV mandate')

China is the world's largest market for electric vehicles, with over 1 million sales of ZEVs in 2018, 56% of the world total.[52] China has introduced a NEV mandate to complement some existing policies and to replace others. For example, the Chinese Government is reducing the grants available for most Electric Vehicles.[53] The NEV mandate started in 2019 with a target of 10%, equivalent to an estimated 5% market share of new sales for NEVs. The target reaches 18% by 2025, giving an estimated 8% market share of new sales for NEVs.

China has a broad range of complementary policies at a local level, including exemptions from vehicle licensing restrictions, incentives for public EV charging stations, and mandatory EV charging points in residential building complexes and car parks.

51. Aarian Marshall, Wired. (October 2019). *Want a Tax Credit for buying an electric vehicle? Move fast.* Link

52. Hui He (March 2020). The International Council on Clean Transportation (ICCT). *China New Energy Vehicle Market and Policies.* Link

53. Kenji Kawase (May 2019). Nikkei Asian Review. *From China to the US, dwindling subsidies take shine off electric cars.* Link

NEV credits vary depending on vehicle range, similar to the California ZEV mandate. More credits are also awarded to NEVs with higher energy efficiency (higher km per kWh) and higher battery density (higher kWh per kg).[54] Table 4: NEV credits per vehicle for four example vehicles. shows the number of Chinese NEV credits awarded per vehicle for four best-selling EVs.

Table 4: NEV credits per vehicle for four example vehicles.

Model	Volt	Bolt	Qin 100[54]	EV200[56]
Manufacturer	Chevrolet	Chevrolet	BYD	BAIC
Vehicle Type	PHEV	BEV	PHEV	BEV
Electric Range (km)	85	383	100	200
Energy Consumption (kWh/100km)	19.3	17.6	18.6	14.5
Weight (tonnes)	1.7	1.6	1.8	1.3
Fuel Consumption (litres/100km NEDC)	5.8	n/a	6.1	n/a
NEV Credits per vehicle	2	5	2	3.2

Source: ICCT

In line with the EU and the US, China has fleet-average fuel efficiency standards, known as the Corporate Average Fuel Consumption (CAFC) targets. CAFC requires decreasing fleet-average fuel consumption, similar to the EU and US schemes. In China, NEV credits can be used to offset obligations under the Chinese CAFC targets. This decision to directly link the NEV mandate to fleet-average fuel consumption targets is in contrast to California's decision to phase out such linkages. There is a risk that Chinese manufacturers over comply with the NEV mandate and use excess NEV credits to offset their CAFC requirements. This would allow manufacturers to continue to sell ICE vehicles with higher greenhouse gas emissions.

Norway: Substantial package of incentives

The Norwegian Government's support for ZEVs is characterised by a "substantial package of incentives", according to the Norwegian Electric Vehicles Association.[57] Norwegian EV incentives include:

- No purchase or import taxes;
- Exemption from 25% VAT;
- No annual road taxes;
- Access to bus lanes;
- 50% discounts on ferry fares, toll roads, parking fees, and company car tax.

54. ICCT (January 2018). *China's New Energy Vehicle Mandate Policy (Final Rule).* Link
57. Ibid (Norsk elbilforening)
55. China Auto Web (accessed 17 July 2020). *BYD* Qin. Link
56. China Auto Web (accessed 17 July 2020). *BAIC EV 200.* Link

These incentives often mean that the upfront purchase price of EVs is competitive with their petrol and diesel equivalents. Table 5: Purchase price of a Volkswagen Golf (Petrol) and e-Golf (BEV) in Norway shows an example for the VW Golf (petrol) and VW e-Golf (BEV). However, the Norwegian incentives system is expensive. For a petrol-powered VW Golf, the Government receives €12,000 of tax revenue, whereas it receives nothing for a VW e-Golf. In addition, EVs receive ongoing discounts for road tolls, ferry tolls, and parking fees. One study found that, in 2014, Norwegian EV policies were costing as much as $8,000 (£6,400) per vehicle per year, including both tax breaks and ongoing discounts.[58] The majority of this benefit was free parking, which has now been removed in some regions.

Table 5: Purchase price of a Volkswagen Golf (Petrol) and e-Golf (BEV) in Norway

Model	Volkswagen Golf	Volkswagen e-Golf
Type	Petrol	BEV
Import Price	€ 22,046	€ 33,037
CO2 Tax	€ 4,348	-
NOx Tax	€ 206	-
Weight Tax[58]	€ 1,715	-
Scrapping Deposit[60]	€ 249	€ 249
VAT (25%)	€ 5,512	-
Retail Price	€34,076	€ 33,286

These incentives have undoubtedly worked, with ZEVs reaching over 50% market share of new sales in 2018, including both BEVs and PHEVs (Figure 12). The Norwegian Government has also supported the development of an EV fast charging network.[61]

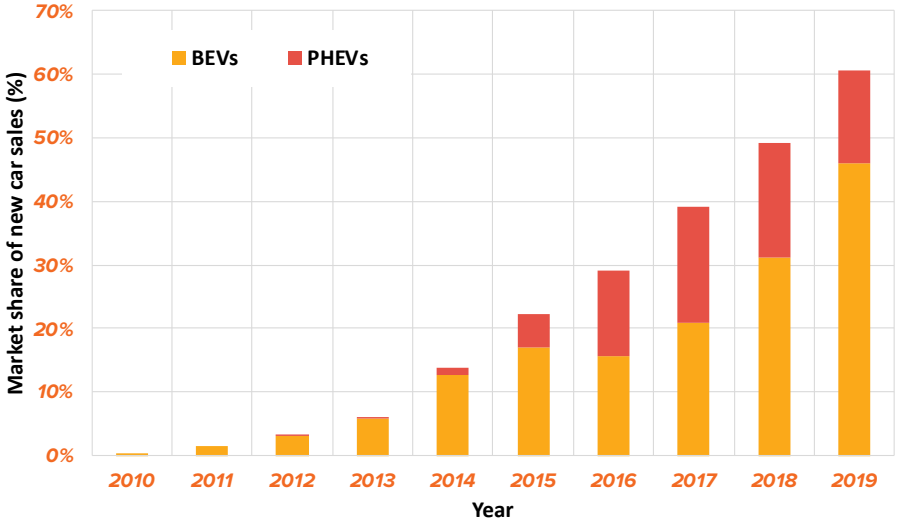
58. Ibid (Holtsmark, B. and Skonhoft, A.).

59. Norwegian vehicle registration tax is based on CO_2 emissions, NO_x emissions and weight. Electric Vehicles are exempt from all three elements of registration tax.

60. Owners of all new cars purchased in Norway must pay a scrapping deposit of NOK 3,000 (EUR 249), which is refunded once the vehicle is scrapped. Link

61. Lorentzen et al (October 2017). *Charging infrastructure experiences in Norway – the world's most advanced EV market.* Link

Figure 12: Market share of new car sales in Norway (2010-2019).[62]



Other markets with ZEV mandates

The Canadian Province of British Columbia passed the *Zero Emissions Vehicle Act* in May 2019.[63] The ZEV Act is similar to the California ZEV mandate and requires manufacturers to reach 10% ZEVs by 2025, 30% by 2030, and 100% by 2040. The detailed regulations to implement the ZEV Act were in draft form as of October 2019.[64]

The Canadian Province of Quebec passed a ZEV mandate in October 2016.[65] The ZEV credit requirement increases from 3.5% in 2018 to 22% in 2025. Long-range ZEVs generate a maximum of four credits per vehicle, meaning a minimum market share for ZEVs of 5.5% in 2025.[66]

62. Ibid. (EAFO)

63. Government of British Columbia (accessed 17 July 2020). *Zero-Emissions Vehicle Act.* Link

64. Government of British Columbia (October 2019). *B.C. Zero-Emissions Vehicle Act: Regulations Intentions Paper.* Link.

65. Government of Quebec (accessed 17 July 2020). *The zero-emissions vehicle (ZEV) standard.* Link

66. Moawad, B. and Wolinetz, M. Navius Research (May 2019). *California and Québec's ZEV mandates description.* Link (pages 12-14).

3: Designing a UK ZEV mandate

Ending the sale of new petrol, diesel and hybrid cars and vans by 2035 or earlier requires an ambitious and overarching policy framework. The UK Government can either choose to follow the Norway model of generous subsidies for ZEVs, or the California model of a zero-emission vehicle mandate. As described in earlier sections, a ZEV mandate will reduce the cost of the transition to ZEVs in the UK, whilst preserving Government funds to spend on complementary policies including EV charging infrastructure and Clean Air Zones.

ZEV mandates operate in ten US states (including California) and in China. The differences between these mandates determine both their effectiveness and their political acceptability. Based on the successes and failures of these programmes, we can establish five key design requirements for a UK ZEV mandate:

- Simplicity;
- Policy stability;
- Price transparency;
- Mitigating distributional impacts;
- Controlling costs.

Simplicity

The ZEV mandates in California and China are both complex, with opt-outs for small manufacturers, credits based on a variety of vehicle parameters, and overlap with existing fuel efficiency programmes. There is a risk that the complexity of these schemes could undermine their effectiveness by increasing the potential for gaming and unintended consequences. A UK ZEV mandate should be simpler.

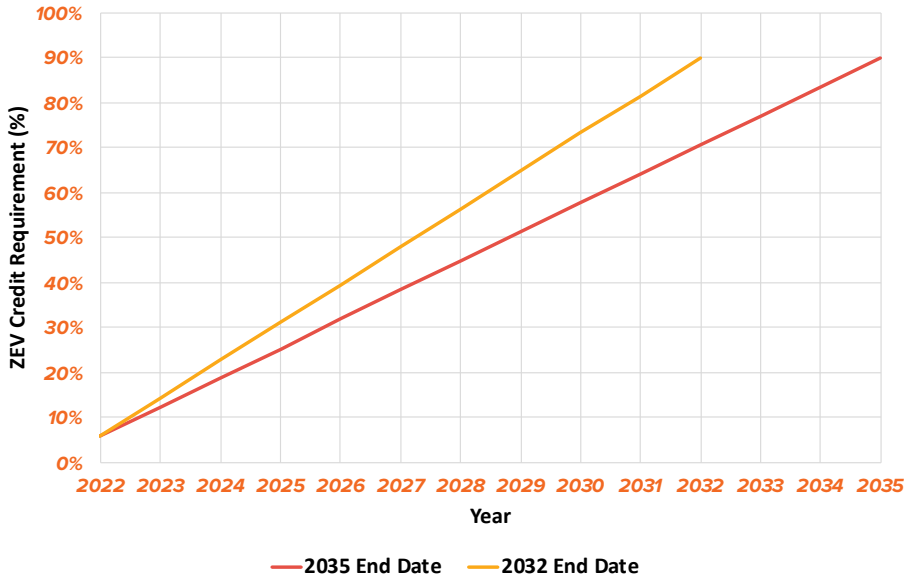
ZEV credit requirement

The California ZEV mandate sets the ZEV credit requirement for a number of years in advance. Most recently, the ZEV credit requirements were set for the years 2018-2025, with the ZEV credit requirement rising from 4.5% to 22% over that period. Because the California ZEV credit requirement is only set a few years in advance, there is limited long-term certainty for manufacturers.

The UK will have a fixed end date for the sale of new petrol, diesel and hybrid cars and vans. After this date only ZEVs will be sold, and the ZEV mandate will end. Because of this certainty over the end date, and because

the end date is relatively soon (10-15 years), a UK ZEV mandate should set the ZEV credit requirement in advance for all years of the scheme. The ZEV credit requirement should start at around the current level of ZEV sales and increase linearly to reach nearly 100% by the end of the scheme. An end date of 2032 or 2035 only changes the trajectory of the ZEV credit requirement (Figure 13). As explained below, the ZEV credit requirement does not reach 100% because some ZEVs will earn less than one credit per vehicle.

Figure 13: Indicative ZEV credit requirement for an end date of 2032 (Yellow) and 2035 (Red)



Recommendation 1: The ZEV credit requirement should start at around the current level of ZEV sales and increase linearly to reach nearly 100% by the phase-out date for petrol, diesel and hybrid cars and vans.

Technical parameters

China's NEV mandate awards credits based on range (km), battery energy density (kWh/kg) and efficiency (km/kWh), whereas in California, ZEV credits are only based on range. The Chinese approach encourages manufacturers to develop more advanced battery chemistries and to improve the energy efficiency of their cars as part of an industrial strategy to build the Chinese ZEV manufacturing base. However, manufacturers are already incentivised to produce more energy efficient vehicles, because this increases the range and therefore the number of ZEV credits awarded. Also, California is home to leading ZEV manufacturer Tesla, despite its simpler ZEV mandate.

Range is the key parameter in all ZEV mandates because range is perceived as a key limitation to the take up of zero-emission vehicles. Both

California and China award ZEV credits based on the 'zero-emission range' of ZEVs. This is the range that the vehicle can travel without any form of recharging, either via an electric charging station for an EV, or using the ICE element in a PHEV. By awarding more ZEV credits to vehicles with a higher range, manufacturers are encouraged to develop and sell ZEVs with longer ranges. These vehicles should be more appealing to customers, further increasing ZEV sales. For example, the Nissan Leaf, a popular BEV, is now offered with a battery capacity of up to 62 kWh, compared to 24 kWh in the original model from 2010. This leads to a significantly higher range of up to 239 miles, compared to 73 miles for the original model.[67]

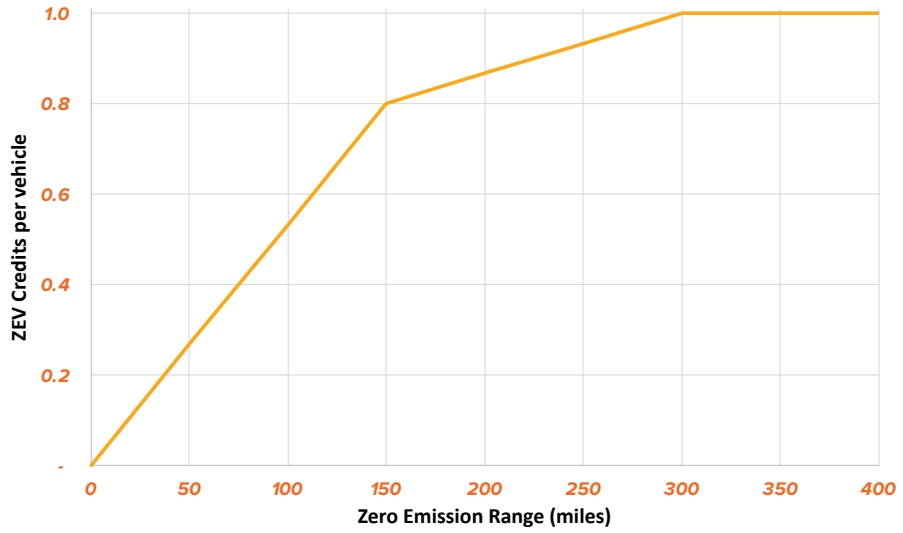
Whilst range is an important factor for potential owners of ZEVs, the average commute in the UK is only 10 miles.[68] This suggests that a key enabler of higher ZEV sales is access to reliable charging infrastructure for occasional longer journeys, and access to reliable overnight charging infrastructure for those who rely on on-street parking.

The California and China ZEV mandates award multiple credits to long-range ZEVs. This makes it difficult to compare the ZEV mandate requirement, which is quoted in percent, to the market share of ZEVs. A UK ZEV mandate should award a maximum of one credit per ZEV (Figure 14). This report proposes that the maximum number of ZEV credits is awarded to vehicles with a range of 300 miles. This does not prevent manufacturers from selling vehicles with a higher range. For example, the Tesla Model S Long Range Plus has a range of 402 miles, whereas the California ZEV mandate awards the maximum number of credits to vehicles with a range of 350 miles or more.[69]

With any vehicle regulation there is the potential for gaming, as exposed during the 'Dieselgate' scandal, when car manufacturers cheated tests for vehicle air pollution emissions.[70] By basing the support for ZEVs solely on range, there is relatively limited potential for gaming. However, the tests that are used to calculate vehicle range will need to be continuously monitored to ensure that the manufacturer-claimed range remains similar to the range achieved by drivers in practice, sometimes known as 'real-world range'.

67. Nissan website (accessed 17 July 2020). *Nissan Leaf: Overview.* Link
68. RAC Foundation (December 2013). *The Car and the Commute.* Link. Page 11.
69. Tesla website (accessed 17 July 2020). *Model S Long Range Plus: Building the First 400-Mile Electric Vehicle.* Link.
70. Russell Hotten, BBC News (December 2015). *Volkswagen: The scandal explained.* Link

Figure 14: Indicative ZEV credits per vehicle for a UK ZEV mandate



Recommendation 2: ZEV credits should be based solely on range, and not on additional technical parameters. To help public understanding, long-range ZEVs should receive a maximum of 1 credit per vehicle.

Interaction with fleet-average CO_2 emissions targets

Both California and China have fleet-average efficiency standards for manufacturers, known as CAFE standards in California and CAFC in China. From 2022, California will phase out links between its ZEV programme and fleet-average CO_2 targets. By contrast in China, overperformance against the NEV mandate can be used to offset CO_2 efficiency targets in CAFC. There are valid concerns that this linkage could undermine the CAFC program. The UK has fleet-average CO_2 emissions targets through its past membership of the European Union. The existing UK CO_2 emissions targets should be maintained but, when implementing a ZEV mandate, the UK Government should not link these two schemes.

Recommendation 3: A ZEV mandate should not be linked to existing fleet-average CO_2 emissions targets for manufacturers.

Inclusion of PHEVs

The UK Government is consulting on including plug-in hybrid vehicles such as PHEVs on the list of vehicles that cannot be sold after 2035. The treatment of PHEVs in ZEV mandates is always a delicate balance. Whilst PHEVs can reduce emissions in the short term, they are unlikely to be a long-term solution to deep decarbonisation of transport because they use petrol and diesel at least some of the time.

The California ZEV mandate includes PHEVs but has a rising requirement

for 'pure ZEVs' (BEVs or FCEVs). This creates two tiers of ZEV credits each with different prices, one for PHEVs and one for 'pure ZEVs'. This two-tier system adds complexity and should be avoided in a UK ZEV mandate. In China, PHEVs are included in the NEV mandate, but there is not yet clarity on when or whether support for PHEVs will end. A UK ZEV mandate should include an end date for the eligibility of PHEVs from the start, for example a date between 2025 and 2028. This would allow a UK ZEV mandate to be as simple as possible, whilst recognising that PHEVs only have a transitional role in decarbonising transport.

It is possible that manufacturers would aim to sell a large number of PHEVs in the early years of the scheme, banking credits for use in later years of the scheme. This risk is mitigated by the low number of credits that PHEVs would earn. A PHEV with an all-electric range of 25 miles would only earn 0.13 ZEV credits, whereas a BEV with a range of 200 miles would earn 0.87 credits.

Until November 2018, PHEVs were eligible for the UK Plug-in Car Grant (PiCG) if they had a minimum zero-emission range of 10 or 20 miles, depending on the vehicle's CO_2 emissions.[71,72] The Government may want to consider a similar minimum range requirement for PHEVs in a UK ZEV mandate. Given recent advances in battery technology, it may be appropriate to set the minimum PHEV zero-emission range higher than 10 or 20 miles.

Recommendation 4: PHEVs should be included in the UK ZEV mandate, initially on an equal basis to BEVs and FCEVs. After a fixed date, for example between 2025 and 2028, PHEVs should no longer be eligible for ZEV credits.

Banking and trading of ZEV credits

Banking of credits occurs when a manufacturer holds more ZEV credits at the end of a year than required to comply with that year's ZEV credit requirement. The manufacturer can 'bank' the excess credits and use them to comply with the next year's ZEV requirement. Banking tends to improve the economic efficiency of ZEV mandates because it reduces the incentive for manufacturers to hold back ZEV sales in a given year if they have already complied with that year's ZEV requirement. The risk with banking is that manufacturers built up a large bank of credits, thus depressing ZEV credit prices and ZEV incentives. This behaviour has been seen in the California ZEV programme.

A UK ZEV mandate would end within the next 15 years, for example in 2032 or 2035. Beyond this date the ZEV mandate would end, and banked credits would have no value. A UK ZEV mandate would have such an ambitious rate of increase of ZEV sales that there is unlikely to be large-scale banking of credits by manufacturers. Also, because a UK ZEV mandate would be backed up by a legal end date for the sale of petrol, diesel and hybrid cars and vans, manufacturers are less likely to see overcompliance

71. OLEV (November 2018) *Changes to the Plug-in Car Grant*. Link
72. OLEV (March 2016). *New Plug-in Car Grant Levels from March 2016*. Link

now as a way to sell more ICE vehicles in future.

Trading of credits occurs when a firm buys or sells ZEV credits with other manufacturers. Research has shown that this practice reduces the overall cost of decarbonising transport in the US context because some firms can produce more ZEVs at lower prices than others.[73] We should expect similar results in the UK.

Recommendation 5: Banking and trading of ZEV credits should be permitted in a UK ZEV mandate. Economic analysis shows that excluding these practices would increase the cost of decarbonising cars and vans.

Policy stability

The California ZEV program has changed significantly since its introduction in 1990. This is not surprising given the rate of technological progress in the last 30 years, particularly for battery technology. However, a UK ZEV mandate needs to have maximum policy stability to drive investor confidence. A UK ZEV mandate will only operate for a maximum of 15 years until 2035, so regular changes will be particularly damaging.

The UK Government has powers to introduce emissions trading schemes through the Climate Change Act 2008.[74] This should include the power to introduce a well-designed ZEV mandate. The Government should commit not to change the scheme's parameters at short notice.

Recommendation 6: The key design parameters of the UK ZEV mandate should be included in the ZEV mandate regulations, including: the end date (2035 or earlier), the annual ZEV credit requirement, the end date for the eligibility of PHEVs (e.g. 2025-2028), and the price cap for ZEV credits.

Recommendation 7: The Government should commit to giving at least three years' notice for changes to the ZEV mandate regulations.

Price transparency

In California, there is no reliable public market index for ZEV credit prices. This lack of transparency may limit market efficiency and may harm public and industry confidence in the programme. A UK ZEV mandate should include trading rules that establish a public market index of ZEV credit prices. The Government could choose to adopt approaches used in existing cap and trade programs, such as the EU Emissions Trading Scheme (EU ETS) and the US Environmental Protection Agency's (EPA) *Acid Rain Program*.[75] There will need to be some regulatory oversight of the market for ZEV credits to ensure compliance and to prevent insider trading or price fixing.

73. Kiso, T. (2019). *Evaluating New Policy Instruments of the Corporate Average Fuel Economy Standards: Footprint, Credit Transferring, and Credit Trading*. Environ Resource Econ 72, 445–476 (2019). Link
74. UK Government. *Climate Change Act 2008. Part 3 (Trading Schemes)*. Link
75. United States Environmental Protection Agency (accessed 17 July 2020). *Acid Rain Program*. Link

Recommendation 8: A UK ZEV mandate should establish a public market index of ZEV credit prices, based on principles from the EU ETS and the US EPA Acid Rain Program.

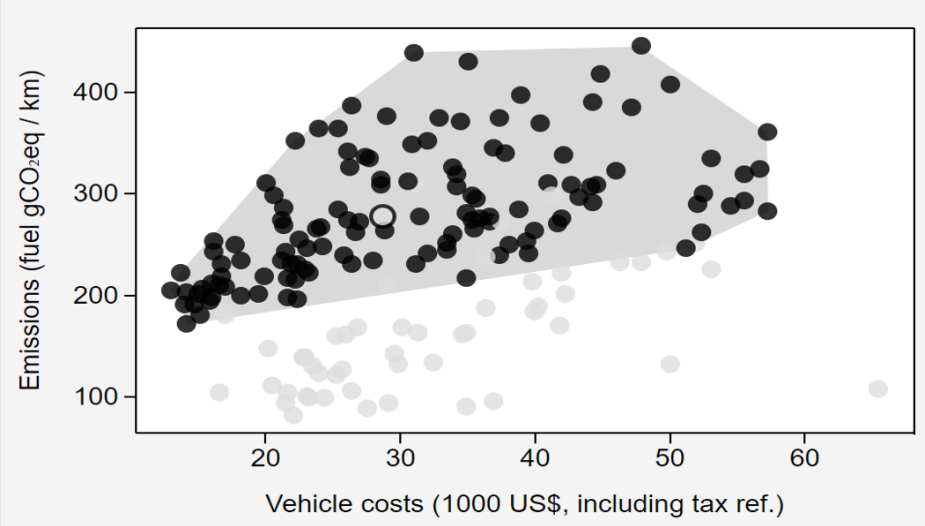
Mitigating distributional impacts

ZEV mandates tend to reduce the purchase price of ZEVs and to increase the purchase price of petrol and diesel vehicles. Today, ZEVs are generally more expensive to buy than equivalent petrol and diesel vehicles, although ZEVs are usually cheaper to run. The ZEV programmes in California and China require manufacturers to sell an increasing proportion of ZEVs, but the requirement is independent of the carbon emission intensity of manufacturers' petrol and diesel vehicles. This means that the ZEV mandates should increase the cost of all petrol and diesel vehicles equally. In percentage terms, this increases the cost of the cheapest vehicles the most.

A ZEV mandate is therefore regressive unless it is complemented by progressive measures. One approach would be to increase the ZEV credit requirement for the manufacturers of the most carbon-intensive cars and vans, however, this would add complexity to the UK ZEV mandate. It would also create a link between CO_2 emissions and ZEV credits, something that this report argues against in the case of the existing UK fleet-average CO_2 targets.

Research has shown that, in the US, the most expensive ICE cars tend to have the highest greenhouse gas emissions ( ). Similarly, the least expensive cars tend to have the lowest greenhouse gas emissions, and so cluster in the bottom left of . This result is likely to be repeated in the UK, with luxury vehicles emitting the most greenhouse gases. The recent trends towards higher SUV sales also increases greenhouse gas emissions.

Figure 15: Vehicle cost (USD 1000s) (x-axis) vs. fuel GHG emissions (gCO_2/km) (y-axis). Black dots represent petrol cars and vans.



Source: Carboncounter.com.[76]

To avoid hurting low income motorists, the Government should consider strengthening policies to discourage the highest emitting, and typically most expensive, petrol and diesel cars. This should include considering higher taxes (including Vehicle Excise Duty) on the vehicles that emit the most carbon dioxide. Because the highest emitting vehicles tend to be the most expensive, this would make the overall packages of measures more progressive.

Recommendation 9: The Government should consider increasing taxes on the most polluting petrol and diesel vehicles, for example through reform of Vehicle Excise Duty. This would help to mitigate the distributional impacts of a UK ZEV mandate.

Controlling costs

The UK Government's consultation on ending the sale of new petrol, diesel and hybrid cars proposes an end date of 2035 or earlier if a faster transition appears feasible. If the Government is overambitious with the end date, then the costs of the transition may rise to levels that are economically and politically unacceptable, and the Government may be forced to weaken its policy. The California ZEV program suffered exactly this problem in its early years. To mitigate this risk, a UK ZEV mandate should include a price cap for ZEV credits of, for example, £15,000 per credit. Any price cap needs to be sufficiently high that manufacturers do not routinely choose to pay the penalty rather than build ZEVs.

If the demand for ZEVs does not increase in line with the ZEV credits requirement, then the ZEV credits will trade at the price cap. Manufacturers

76. Carboncounter.com. (accessed 17 July 2020). *Cars evaluated against climate targets.* Link

who do not sell enough ZEVs, and who do not purchase enough from the market, will need to make penalty payments to the Government of £15,000 per credit. The Government could use these penalty payments to fund a further increase in EV charging or hydrogen refuelling infrastructure, which should help to increase the sales of ZEVs.

The California ZEV mandate has a penalty price of $5,000 per credit. However, the longest-range ZEVs can receive up to 4 credits per vehicle, so the effective penalty price is up $20,000 per vehicle, which is broadly equivalent to the £15,000 per credit that this report proposes for a UK ZEV mandate. Note that the California penalty does not remove the requirement to present ZEV credits in future years, so it is not a hard price cap.

Recommendation 10: A UK ZEV mandate should include a price cap per ZEV credit to control costs. The price cap should be indexed to inflation.

4: Developing complementary policies

California, China, and Norway have all implemented a range of policies to support ZEVs. In California and China, the central policy is a ZEV mandate, whilst in Norway the central policy is a tax regime that supports ZEVs. A UK ZEV mandate will be most effective if it is supported by complementary policies. This section proposes complementary policies to support a UK ZEV mandate, as well as identifying contradictory policies that should be phased out once a ZEV mandate is in place.

Complementary Policies

The following policies would support a UK ZEV mandate, and would likely lower the cost of the transition to zero-emission vehicles.

Fleet-average CO_2 targets

The UK has fleet-average CO_2 targets for new passenger cars as part of commitments made whilst a member of the European Union. The EU's fleet-average CO_2 target for new passenger cars was introduced in 2012 and now has targets until 2030.[77] By 2030, fleet-average CO_2 emissions will need to be below 59 gCO_2/km, compared to 95 gCO_2/km in 2021.

The EU fleet-average emissions scheme has some inherent inefficiencies:

- The scheme does not allow banking from one year to the next if a manufacturer exceeds the target. This removes the incentive for manufacturers to over comply with the CO_2 targets, even if they could do so cheaply.
- The scheme does not allow full trading of emissions reductions between manufacturers, although there is a 'pooling provision' for voluntary groups of manufacturers.
- The scheme relaxes average CO_2 targets for manufacturers who sell more than 15% "zero- and low-emission vehicles" (ZLEVs) by 2025 or 35% by 2030. California is already phasing out linkages between ZEV sales and fleet-average emissions due to concerns over undermining CO_2 targets.

Depending on the complexity of changing the existing CO_2 targets, the UK should keep the existing fleet-average CO_2 targets in place broadly unchanged. The Government could choose to make minor changes to the fleet-average CO_2 scheme, for example by removing the bonus to

77. European Commission (accessed 17 July 2020). *Reducing CO2 emissions from passenger cars - before 2020.* Link.

manufacturers who sell a higher proportion of ZLEVs. This would be justified if the UK introduces a ZEV mandate to encourage manufacturers to sell zero-emission vehicles. The UK could also allow manufacturers to join an unlimited number of 'manufacturer pools'. This would allow the fleet-average CO_2 targets to function more like a competitive market.

Recommendation 11: Existing fleet-average CO_2 targets should be maintained, despite some inefficiencies. The Government should consider minor changes to the scheme, such as allowing full banking and trading.

Rapid EV charging infrastructure

Potential EV drivers often cite "range anxiety" as a barrier to buying a Battery Electric Vehicle. Polling by Ipsos Mori in 2017 found that 42% of motorists were concerned about a lack of EV charging infrastructure and that 39% believed that EVs "have a driving range that is not suitable for long distance travelling".[78] Government support for public EV charging infrastructure, whether through subsidies or regulation, can encourage a faster take up of EVs. Research from the United States suggests that a dollar invested in EV infrastructure raises EV sales twice as much as a dollar in grants for EV buyers.[79] More recent research from Norway finds a similar result but notes that government support for EV charging stations will have diminishing returns as more charging points are built.[80]

In May 2020, the UK Government set out a vision for a rapid EV charging network in England, based on guaranteeing a minimum number of rapid charge points at strategic locations.[81] The Scottish Government is taking a similar approach, but with the Scottish Government owning public EV charging points.[82] These approaches are broadly sensible, although experience from other sectors, for example the UK's offshore wind procurement,[83] suggests that public bodies should use competitive procurement wherever possible to harness private sector competition. As the requirements of a UK ZEV mandate increase over time, the available charging infrastructure will need to increase accordingly. A ZEV mandate should help the Government to plan the roll-out of EV charging infrastructure by providing clearer foresight of future EV deployment.

Government support for electric vehicle charging points should include considering reforms to regulations that affect EV charging infrastructure, for example the electricity grid connection process and the ability to lay new electricity cables across adjoining land. The regulatory process for electricity network companies, RIIO-2, should also be aligned with the UK ZEV mandate.[84]

Recommendation 12: The UK Government and Devolved Administrations should continue to support the competitive procurement of rapid EV charge points on strategic routes and in rural areas.

78. Ipsos Mori (July 2017). *Speed and availability of charging biggest barriers to electric car adoption by 2040.* Link
79. Li, S. et al (2017). *The Market for Electric Vehicles: Indirect Network Effects and Policy Design.* Journal of the Association of Environmental and Resource Economists. 4.1 (2017): 89-133. Link. Page 38.
80. Springel, K. (March 2019). *Network Externality and Subsidy Structure in Two-Sided Markets: Evidence from Electric Vehicle Incentives.* Link
81. BEIS, DfT, OLEV (May 2020). *Government vision for the rapid chargepoint network in England.* Link
82. ChargePlace Scotland (accessed 17 July 2020). Link
83. BEIS (September 2019). *Clean energy to power over seven million homes by 2025 at record low prices.* Link
84. Ofgem (July 2020). *RIIO-2 draft determinations for Transmission, Gas Distribution and Electricity System Operator.* Link

On-street and workplace charging

Publicly accessible rapid EV charging infrastructure is important to allay fears of range anxiety. However, the majority of EV charging is likely to take place at home or in workplaces. In England, the 2018 National Travel Survey found that 72% of households had off-street parking.[85] Off-street parking is likely to be suitable for at-home charging. However, a third of urban households relied on street parking, compared to less than a fifth for rural households.

A 2032 or 2035 end date for the sale of petrol, diesel and hybrid cars and vans implies that ZEVs will need to be attractive to the vast majority of the population, including those with no off-street parking at home. Solutions include workplace charging and on-street public EV chargers in residential areas. The Government already offers a range of support in these areas through the Electric Vehicle Homecharge Scheme, the Workplace Charging Scheme and the On-street Residential Chargepoint Scheme.[86]

As these schemes expand, the Government should continually re-evaluate the level of support to ensure value for money. For larger schemes, the Government should harness competitive procurement. For example, where Local Authorities access funding through the On-Street Residential Chargepoint Scheme, they should be required to use competitive procurement.

Recommendation 13: The Government should work with local authorities to identify the need for on-street and workplace charging. Where the Government provides support to these schemes, they should ensure the competitive procurement is used wherever possible.

Green number plates

Green number plates can be installed on ZEVs, allowing the public to differentiate ZEVs and to normalise the idea of new, cleaner cars. Both China and Norway offer electric vehicle drivers green number plates, or a prefix reserved for EVs. These differentiated markings allow local authorities to offer perks to EV owners, for example free parking and preferential access to bus lanes.

Green number plates may also increase uptake by raising the 'status' of EV drivers. Research on EV sales in China estimates that a green number plate policy has the same impact as a purchase subsidy of RMB 20,000 (c. £2,250) per vehicle. Regions that introduced a green number plate policy are estimated to have seen 18% higher EV sales than they would have done without green number plates.[87]

In June 2020, the UK Government announced its intention to introduce a green number plate scheme for vehicles with 'zero tailpipe emissions', i.e. BEVs and FCEVs.[88] A green number plate policy is cheap, so it is a no-regrets option as long as it is accompanied by the other more substantial recommendations in this report.

85. DfT (July 2019). *Vehicle mileage and occupancy (Parking).* Link
86. OLEV (accessed 17 July 2020). *Grant schemes for electric vehicle charging infrastructure.* Link
87. Li, S. et al. (June 2020). *The Role of Government in the Market for Electric Vehicles: Evidence from China (Working Paper).*
88. DfT, OLEV (June 2020). *Green number plates get the green light for a zero-emission future.* Link

Recommendation 14: The Government's proposed green number plate scheme for ZEVs is a no-regrets option. However, it should not detract from the other more substantial recommendations in this report.

Clean Air Zones

Clean Air Zones (CAZs) set pollution limits on vehicles entering the zones, which are typically in city centres. Vehicles that exceed pollution limits typically pay a daily charge, although they can also be banned. CAZs can apply differently to different types of vehicles. For example, in London the Low Emission Zone (LEZ) for larger vehicles covers most of the area within the M25 orbital motorway. A separate Ultra Low Emissions Zone (ULEZ) applies to all vehicles in central London, covering the same area as the London Congestion Charge.

Clean Air Zones discourage the dirtiest diesel and petrol vehicles from driving in the most polluted areas. They also encourage residents and businesses operating in urban areas to purchase ZEVs, so that they avoid the CAZ charges. However, CAZs do not typically tackle non-exhaust emissions (NEE) such as particulate matter, which are produced by all vehicles including ZEVs.

Local authorities across the UK are now considering introducing Clean Air Zones.[89] To date only London and Glasgow have implemented CAZs, and in Glasgow the CAZ only applies to local bus services.[90] Many local authorities have delayed plans to implement their CAZs due to the COVID-19 pandemic.

Policy Exchange has long supported Clean Air Zones in the most polluted cities, provided that they correctly target the most polluting vehicles. Our 2017 report, *Driving Down Emissions*,[91] sets out design recommendations for Clean Air Zones. As the UK recovers from the COVID-19 pandemic, the Government should support Local Authorities to introduce delayed Clean Air Zones, including by targeting EV charging infrastructure in these areas. Clean Air Zones will encourage a faster roll-out of ZEVs in areas with poor air quality and will lower the overall cost of meeting twin climate change and air pollution policy objectives.

Recommendation 15: The Government should support Local Authorities to introduce Clean Air Zones, including by supporting EV charging infrastructure in these areas.

Regulation of fleet vehicles

Banning the sale of new ICE vehicles by 2035 or earlier should ensure that almost all of the UK's car and van fleet is zero-emission by 2050, in line with the UK's Net Zero target. However, in certain locations there are significant air quality advantages to phasing out ICE vehicles sooner, particularly in urban areas.

89. BVRLA (September 2019). *Where are the Clean Air Zones?* Link

90. Glasgow City Council (accessed 17 July 2020). *Low Emission Zone (LEZ).* Link

91. Ibid (Policy Exchange). *Driving Down Emissions.*

In London, since 2018 all new taxis have had to be 'zero emission capable', which in practice has meant that all new taxis are now BEVs or PHEVs. Combined with age limits, this means that London's taxis will all be zero emission capable by the 2030s.[92] Transport for London also sets standards for private hire vehicles (PHVs). From 2023, all PHVs licensed for the first time must be zero emission capable, a definition that again includes PHEVs.[93]

During the height of the Coronavirus lockdown, air pollution associated with road transport fell dramatically in some major cities.[94] Following the easing of the lockdown, these gains risk being reversed as vehicle travel increases towards pre-Coronavirus levels. The Government should therefore consider an accelerated ZEV requirement for vehicle fleets operating in urban areas. These regulations would complement Clean Air Zones by encouraging zero-emission vehicles in the most polluted areas.

Recommendation 16: The Government should consider an accelerated ZEV requirement for vehicle fleets operating in the most polluted areas. This requirement should include buses, taxis, private hire, HGVs and delivery vehicles.

Technical training, lifelong learning and apprenticeships

The transition from petrol and diesel cars and vans to zero-emission vehicles will lead to profound changes in the skills that are needed in the UK automotive sector. These changes will apply both to manufacturers and their supply chains, as well as to those who maintain and repair vehicles. This skills transition is required regardless of the policy used to achieve the phase out of petrol, diesel and hybrid cars and vans by 2035 or earlier.

Policy Exchange's recent essay collection, *The Training We Need Now*,[95] makes several proposals to improve the UK's training ecosystem including a proposal for an "opportunity grant" of £3,000 for every individual over 21. This grant would be drawn down by the providers of approved job-relevant courses. Training will be particularly important in the automotive sector given the planned rapid transition to zero-emission vehicles.

Recommendation 17: Technical training, lifelong learning and apprenticeships will be particularly important in the UK's automotive sector as it transitions to zero-emission vehicles. Policy Exchange's recent essay collection, *The Training We Need Now*, makes a number of recommendations in this area.

92. Transport for London (accessed 16 July 2020). *Emissions standards for taxis.* Link
93. Transport for London (accessed 16 July 2020). *Emissions standards for PHVs.* Link
94. Greater London Authority (April 2020). *Estimation of changes in air pollution in London during the COVID-19 outbreak.* Link
95. Ibid (Policy Exchange). *The Training We Need Now.*

Contradictory Policies

The following policies would be contradictory to a UK ZEV mandate, and would increase costs for the Government. Once a UK ZEV mandate is in operation, these policies should be phased out. This will release Government funds to spend on complementary policies.

Plug-in Car Grant (PiCG)

The UK's Plug-in Car Grant (PiCG) offer consumers up to £3,000 to purchase a ZEV. Once a ZEV mandate is in place, the price of ZEV credits will incentivise manufacturers to lower the price of ZEVs. Additional purchase incentives, such as the Plug-in Car Grant, risk undermining the market for ZEV credits, similar to the experience in California where state and federal grants have contributed to overcompliance with the California ZEV mandate and low prices for ZEV credits. Since introducing its NEV mandate, China has reduced purchase subsidies for ZEVs.[96]

The Plug-in Car Grant is currently scheduled to expire at the end of the financial year 2022-23. The Government could choose to allow the PiCG to expire on this date, assuming that a UK ZEV mandate was already in place.

Recommendation 18: Once the UK ZEV mandate is in operation, purchase incentives for ZEVs should be phased out, including the Plug-in Car Grant.

Reduced Vehicle Excise Duty, Company Car Tax, and accelerated depreciation

The UK has favourable tax treatment of ZEVs, which are currently exempt from Vehicle Excise Duty. There are further benefits for ZEVs used as company cars, covering both 'Company Car Tax' (also known as 'Benefit in Kind' or 'BIK' tax) and accelerated depreciation for fleet vehicles. These rules risk over-subsidising certain ZEV owners and, in the case company cars, subsidising wealthier ZEV drivers. As with the Plug-in Car Grant, this favourable tax treatment should be gradually phased out once a ZEV mandate is in place. The future tax treatment of ZEVs should be considered alongside the likely fall in Fuel Duty receipts as ZEV market share increases.

For VED, the Government could phase out favourable tax treatment for ZEVs whilst still maintaining higher tax rates for the highest-emitting petrol and diesel vehicles. For example, the minimum VED band could be set for all vehicles with emissions less than 100 gCO_2/km, attracting an annual charge of approximately £150 in the first year. The higher rates for more polluting vehicles could remain unchanged or could be strengthened.

A ZEV mandate gives long-term clarity on policy for supporting ZEVs. Similar long-term policy is required for ZEV vehicle taxes, including any

96. Sun, Y. and Goh, B. Reuters (April 2020). *China to cut new energy vehicle subsidies by 10% this year.* Link

replacement revenue streams to replace a long-term fall in Fuel Duty receipts. New approaches to vehicle and fuel tax should be phased in once a ZEV mandate is in place.

Recommendation 19: Once the UK ZEV mandate is in place, the Government should gradually phase out favourable tax treatment for ZEVs, including for those used as company cars or fleet vehicles.

Scrappage schemes

Vehicle scrappage schemes pay drivers to scrap old and polluting vehicles. In theory, these schemes can accelerate a transition to the cleanest vehicles. However, the design of a scrappage scheme is crucial to ensure that it does not just accelerate the purchase of new petrol and diesel vehicles. The French Government has announced a generous scrappage scheme that incentivises drivers to purchase an EV. The EV incentive could be worth up to €12,000; €5,000 for scrapping an old diesel vehicle and €7,000 for purchasing a new EV.[97]

If the UK introduces a ZEV mandate and Clean Air Zones, then it is likely that a scrappage scheme would overlap with these two policies. There are also concerns that generous scrappage incentives could over-subsidise some consumers, offering poor value for money for taxpayers. If the Government were to introduce a scrappage scheme, then it would need to be targeted at the dirtiest existing vehicles and would need to support only the purchase of the cleanest new vehicles.

Recommendation 20: A vehicle scrappage scheme would likely overlap with a UK ZEV mandate and Clean Air Zones, so should not be considered at this stage.

97. Sigal, P. Automotive News Europe (May 2020). *France's new $13,000 EV incentives is most generous in Europe.* Link

5: Impact on consumers and manufacturers

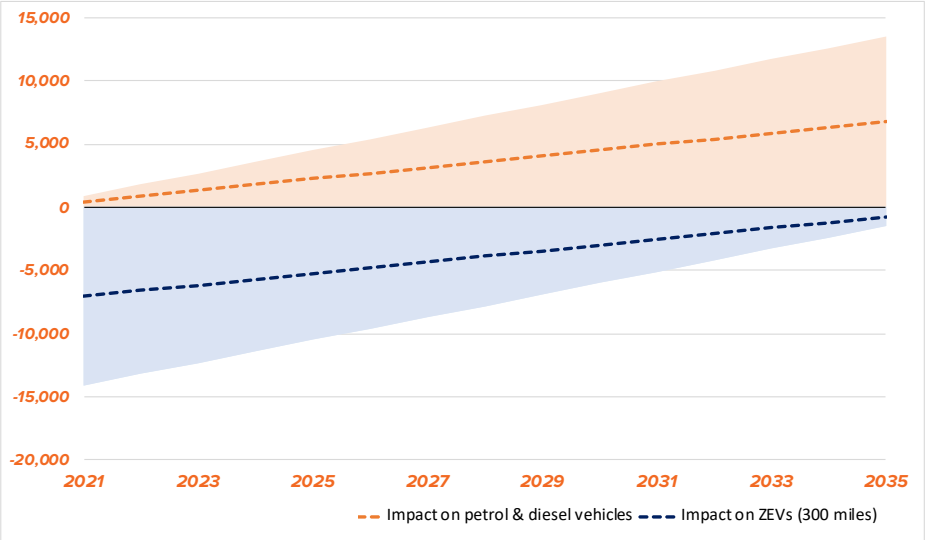
Car ownership is a significant cost for most households, so a UK ZEV mandate will need to address affordability concerns. This section explores the likely impact of a UK ZEV mandate on the cost of ZEVs and petrol and diesel vehicles, and the likely impact on manufacturers.

Impact on new vehicle prices

A ZEV mandate requires manufacturers to produce an increasing proportion of ZEVs, or to purchase credits from other manufacturers who exceed their requirement. Assuming that manufacturers pass through the cost of ZEV credits to consumers, we can estimate the likely impact on the price of ZEVs and on the price of petrol and diesel (ICE) vehicles. This analysis assumes a constant ZEV credit price of £7,500, midway between the floor (£0) and the cap (£15,000). In reality the price of ZEV credits will fluctuate depending on supply and demand of ZEVs.

In the early years of a ZEV mandate, only a small proportion of vehicles will be ZEVs, and the price of ICE vehicles increases only slightly, whereas the price of ZEVs decreases markedly (Figure 16). The price reduction of ZEVs in the short term could be greater than the UK Plug-in Car Grant (£3,000 per vehicle), depending on the market price of ZEV credits. In the later years of the ZEV mandate, the price of ICE vehicles increases more substantially, and the price reduction for ZEVs decreases.

Figure 16: Indicative price impact of a UK ZEV mandate on new ICEs (orange) and a new ZEV with 300 miles of range (blue). Dashed lines - £7,500 per ZEV credit. Shaded areas show ZEV credit prices ranging from £0 to £15,000 per credit. [98]



Using a central estimate of £7,500 per ZEV credit, the impact on the price of ZEV and ICE vehicles is shown in Table 6: Price impact on ZEVs and ICE vehicles. ZEV Credit Price = £7,500.. Manufacturers are more likely to pass through these cost changes to motorists if there is a transparent market for ZEV credits because they will have more certainty over the price of ZEV credits. Manufacturers may decide not to pass through the costs (and benefits) of ZEV credits to consumers, for example to maintain market share for their ICE vehicles in the short term, although in the long run this is unlikely. The price cap for ZEV credits limits the potential price increase for new petrol and diesel vehicles.

Table 6: Price impact on ZEVs and ICE vehicles. ZEV Credit Price = £7,500.

Year	ZEV Credit requirement (%)	Price impact on ZEVs (£)	Price impact on ICE vehicles (£)
2022	12%	- £6,600	+ £900
2025	30%	- £5,250	+ £2,250
2030	60%	- £3,000	+ £4,500
2035	90%	- £750	+ £6,750

Market share of ZEVs

The market share of new car sales that are ZEVs will depend on the range of the ZEVs sold, as longer-range ZEVs produce more credits. In this indicative example, the market share of ZEVs increases almost linearly, reaching around 95% by 2035 (Figure 17). This transition to ZEVs is slower than Norway's, which gives confidence that it is achievable. If ZEVs become cost-competitive with ICEs for most consumers, then we may see

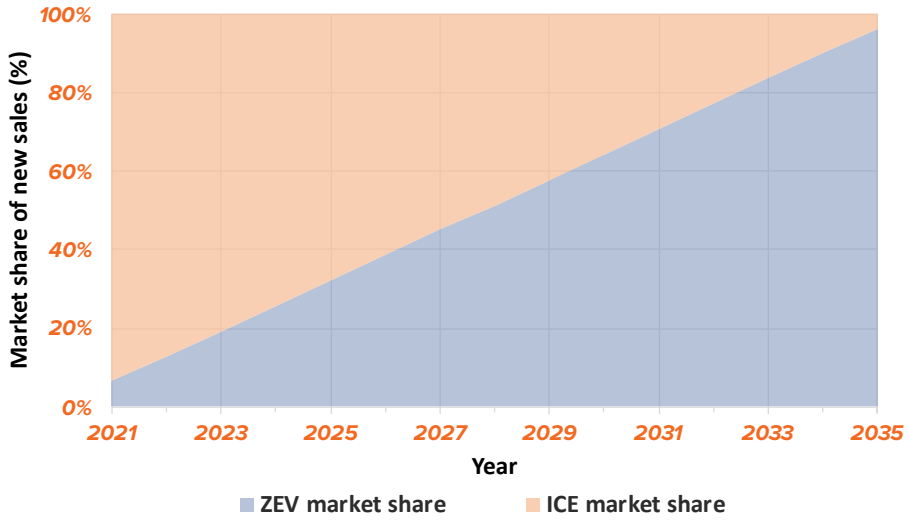
98. Source: Author's calculations:

ZEV price reduction = [ZEV Credit Price (£)] * ([Credits per ZEV] - [ZEV Credit Requirement (%)])

ICE price increase = [ZEV Credit Price (£)] * [ZEV Credit Requirement (%)]

a 'tipping point' with far higher ZEV sales than required by the mandate. The ZEV mandate only provides the minimum level of ambition for ZEV market share.

Figure 17: Indicative market share of ZEVs and ICE vehicles (new sales).[99]

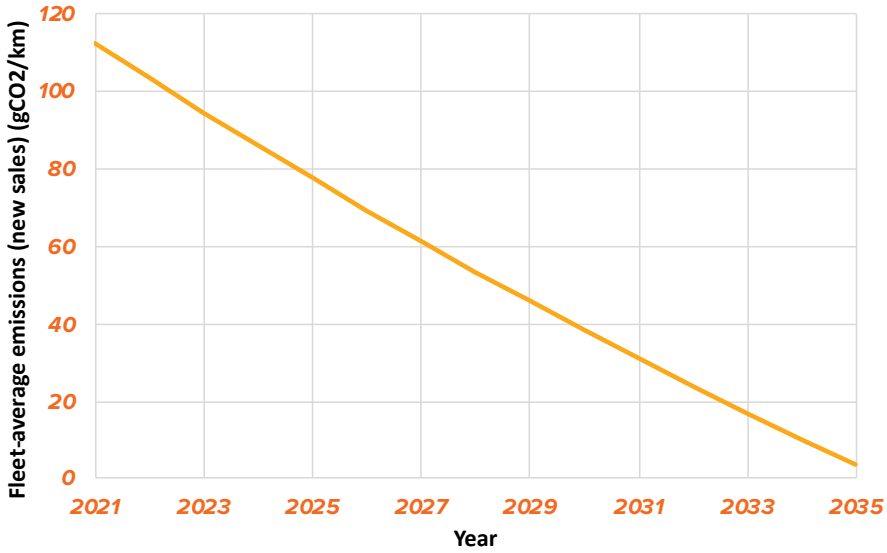


Average CO_2 emissions of new cars

The fleet-average emissions of new cars will depend on the ZEV market share and the average emissions of the ICE vehicles sold. In this indicative example, the average carbon emissions intensity of new cars falls to around 40 gCO2/km by 2030, one third lower than the level required by the EU fleet-average emissions targets (59 gCO2/km). By 2035, the average carbon emissions intensity of new cars falls to under 5 gCO2/km (Figure 18).

99. Author's calculations. Assumes an average range of 250 miles for ZEVs sold in the UK.

Figure 18: Indicative average GHG emissions (gCO_2/km) of new car sales.[100]



Impact on manufacturers

Any policy that requires manufacturers to stop selling petrol, diesel and hybrid cars and vans will be disruptive, including this proposal for a UK ZEV mandate. Given the Government's intention to phase out ICE vehicles by 2035 or earlier, a UK ZEV mandate is a technology-neutral and market-based policy to achieve that aim.

Domestic versus overseas manufacturers

The UK automotive sector is a large employer in the UK. The Society of Motor Manufacturers and Traders estimates that the sector employs around 170,000 people directly in manufacturing and a further 800,000 in the wider automotive industry.[101] A UK ZEV mandate would be based on cars *sold* in the UK, rather than cars *manufactured* in the UK, so domestic and overseas manufacturers would be treated the same. The California ZEV mandate uses the same approach, with the California ZEV mandate only applying to cars sold in California. To prevent gaming, the UK ZEV mandate regulations will need to carefully consider the definition of 'cars sold' in the UK, distinguishing it from 'cars delivered' to the UK for onward sale in other jurisdictions (e.g. Ireland). With a UK ZEV mandate, cars manufactured in the UK and exported would be excluded from the UK ZEV mandate.

A UK ZEV mandate does not preclude the Government from taking further steps to support domestic car manufacturing as the UK recovers from the COVID-19 pandemic, or from offering support to domestic car manufacturers to accelerate their transition to ZEV manufacturing.

100. Author's calculations. Assumes that ICEs sold in the UK have average emissions of 120 gCO_2/km in 2021, reducing linearly to 100 gCO_2/km in 2035. Tailpipe emissions from ZEVs are assumed to be 0 gCO_2/km, and PHEVs are not modelled.

101. SMMT (accessed 17 July 2020). *Industry topics: UK automotive.* Link

ICE vs ZEV manufacturers

A ZEV mandate will impact differently on traditional ICE manufacturers and new specialist ZEV manufacturers. Traditional ICE manufacturers will rightly be nervous about the prospect of a transition to a new product. A ZEV mandate provides ICE manufacturers with a clear timetable for the transition to ZEVs, whilst a liquid market for ZEV credits and a price cap helps to limit the cost of compliance.

New specialist ZEV manufacturers are likely to be the biggest beneficiaries of the transition to ZEVs, regardless of the policy instrument. Ambitious ZEV policies, accompanied by appropriate industrial policy, would encourage specialist ZEV manufacturers and a ZEV supply chain to locate in the UK. It is no surprise that leading EV manufacturer Tesla is based in California, the first jurisdiction to introduce a ZEV mandate. The UK is already home to specialist electric van manufacturing start-up Arrival, which has received investment from leading global car manufacturers and orders from global package delivery company UPS.[102]

By introducing a ZEV mandate for cars and vans now, the UK will be better-placed to develop other zero-emission vehicles in future, including HGVs, trains, ships and planes. It is notable that California has recently approved plans to introduce a ZEV mandate for medium-duty and large trucks, starting in 2024.[103]

Treatment of vans

This report has primarily focussed on passenger cars, although the Government's proposed phase-out of petrol, diesel and hybrid cars also applies to vans. Smaller vans could be included in a UK ZEV mandate alongside cars, as they are a similar size and cost. For larger vans, the cost of a zero-emission model could be significantly higher than a petrol or diesel equivalent, suggesting that additional support may be required. The UK Government recognised this by providing a higher plug-in van grant of up to £20,000 for the first 200 zero-emission heavier vans sold in the UK.[104] California is introducing a stand-alone ZEV mandate for Heavy Good Vehicles with different parameters to the existing ZEV mandate for cars. The UK Government could consider a similar approach to decarbonising heavier vans.

102. Arrival (https://arrival.com/).

103. Shepardson, D. and Groom, N. Reuters (June 2020). *California passes landmark mandate for zero emission trucks.* Link

104. Ibid (UK Government). *Low-emission vehicles eligible for a plug-in grant.*

6: Conclusion

Transport is the leading contributor to greenhouse gas emissions in the UK, and within transport cars and vans comprise the majority of emissions. The UK Government is forming an ambitious goal to end the sale of new petrol, diesel and hybrid cars and vans by 2035 or earlier. This ambitious goal requires an equally ambitious policy framework.

The Government could achieve this goal by expanding the current grants and tax breaks for buyers of zero-emission vehicles, following the approach of Norway. However, this approach is likely to be expensive, and is likely to over reward customers who can already afford electric vehicles.

Alternatively, the Government could follow the approach pioneered in California and introduce a zero-emission vehicle mandate. A ZEV mandate will help the UK to end the sale of petrol, diesel and hybrid cars and vans whilst allowing the Government to phase out expensive subsidies and preferential tax treatment for ZEVs. This money can be better spent on complementary policies, including EV charging infrastructure and Clean Air Zones.

A ZEV mandate, combined with appropriate industrial strategy, should also attract manufacturers of zero-emission vehicles to locate in the UK, building on the UK's existing car manufacturing industry and existing supply chain for high-value components for electric vehicles.

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