
# Electrifying the UK:

## Ensuring the transportation revolution benefits everyone

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The complete report is available online at europe.edf.org.

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# Executive summary

How can the UK bridge the gap between the affordability of cleaner electric vehicles (EVs) and internal combustion engine (ICE) vehicles?

Environmental Defense Fund Europe (EDFE) and Frontier Economics sought to answer this question in a collaborative report that examines the transition away from fossil fuel vehicles to EVs. Specifically, we looked at how this progression could incorporate all residents of the UK, regardless of income level.

Targeted Government action to make EVs more accessible will help people on lower incomes save money on motoring. For example, the analysis found that if policies result in half of new car sales shifting to electric across all income levels, low- to middle-income households would save roughly £350 million in total every year in fuel and maintenance costs.

## Policy recommendations to drive further progress

The Government must put in place policies that make EVs more affordable and accessible, especially for people on lower incomes.

1) *Continue to reduce the upfront cost of EVs*: Follow the example of rebate and loan programmes in California and Scotland, respectively – as well as continue to run plug-in grants and homecharge schemes in the UK, with a particular focus on lower-income households.
2) *Establish better financing options for EVs*: Put in place robust policies to enhance financing options for and resale value of EVs, such as continuing to reduce emission standards for vehicles and establishing sales mandates.
3) *Ensure better dissemination of information*: Strengthen programmes run by the Office of Low Emission Vehicles to certify car dealerships that have the demonstrated knowledge necessary to sell EVs.

By facilitating the transition to cleaner vehicles and improving the opportunity for lower- and middle-income families to harness important benefits from electric transport, the UK can begin reducing harmful pollution and build a healthier, more equitable transport system.

## Introduction

Tackling pollution from transport has become one of the most fundamental and pressing issues in the UK today.

- Transportation continues to be one of the primary contributors to harmful air quality. Public Health England estimates the monetary cost of air pollution's health impacts will reach £5.3 billion by 2035.
- On-road transport – like cars and lorries – contributes over a quarter (27%) of climate-altering emissions in the UK.

To significantly reduce air pollution and mitigate the effects of climate change, the country urgently needs to phase out combustion engines and ramp up deployment of EVs for the following critical reasons:

- Battery EVs made up only 0.8% of the new cars market in January 2019.
- The market share for EVs in the UK lags behind countries such as China, the Netherlands, Sweden, and Norway.

As the Government considers how to accelerate EV adoption, it is critical to make the transition just and equitable – especially because people on lower incomes are simultaneously more likely to be harmed by high levels of transportation pollution while being least able to afford a clean alternative.

Thoughtful policies can reduce barriers to EV adoption, while ensuring people of all socioeconomic levels are able to access and benefit from a clean transport sector.

## Identifying the problem

Existing market conditions and financing options remain strongly in favour of ICE vehicles, the totality of which slows down EV sales and prevents low- and middle-income people from being able to purchase a clean vehicle. As a result, the number of zero or near-zero emission vehicles on the road in the UK is less than 1 in 200 or 0.6% of total vehicles.

The future resale value of ICE cars is far more favourable than for EVs in part because:

- Those who determine second-hand values have much less data for EVs.
- Between 2015 and 2018, various models of EVs were worth less than half of their upfront purchase price.

The second-hand market is for EVs is underdeveloped, with less than 3% of used vehicles on the market being ultra-low emission vehicles. The low supply limits the ability of lower-income households to access the market, as they are more likely to purchase used vehicles.

- There has not been enough time for the market to mature.
- Second-hand car dealers are not effectively and accurately disseminating information around EVs.
- Higher depreciation rates for EVs make them less attractive to fleet operators, reducing the volume going into the second-hand market.
    - » An extremely low portion of cars in commercial fleets are electric – about 2.1% or 27,500 of 1.3 million newly registered BEVs in the commercial fleet, and 1.2% or 5,200 of 433,000 newly registered electric vans.

There is also a lack of attractive financing options for EVs.

- 0% APR offerings are largely only available for conventional vehicles.
- Aside from the Renault Zoe, the list of vehicles that have an attractive interest rate attached are exclusively ICE vehicles.

All of these factors result in wealthy people buying EVs at higher rates than people on lower incomes.

- Half of all ultra-low emission vehicles (ULEVs) are owned by households in the richest two income deciles, compared with just a quarter of ICE cars.
- Households in the lowest two income deciles made up just 4% of ULEV owners, but more than 10% of ICE vehicle owners.

## Recognising opportunities

Potential cost savings that can be harnessed as a result of a transition to EVs are also significant – providing an opportunity to reduce costs to households across different economic demographics.

Car-owning households in the lowest two income deciles spend around 10% of their income on vehicle running costs, in comparison to the richest two deciles, which spend around 5%.

To illustrate the potential savings from reduced fuel and maintenance costs available to different income groups, two scenarios were modelled.

- *Scenario 1*: The impact of converting half of all new ICE purchases to EVs, spread evenly across all income quintiles:
    - » The bottom 60% of households would save annually £345m per year, and the poorest 20% of households would each on average save £343 per year.
- *Scenario 2*: The impact of converting the same number of sales of new vehicles from ICE to EV, but with sales still disproportionately occurring in wealthier quintiles:
    - » The bottom 60% of households would save annually £227m per year, and the poorest 20% of households would each on average save £252 per year.

### Reducing Upfront Cost for Private Vehicle Owners

There are two key jurisdictional examples that can be seen as potential policy solutions in England and the rest of the UK: Scotland and the State of California.

Scotland has an interest-free EV loan programme.

- The programme offers up to £35,000 for a new fully electric or plug-in hybrid vehicle (as well as a narrow subset of second-hand vehicles), as well as up to £10,000 for a new electric motorcycle or scooter.
- Since the programme was launched in 2015, it has enabled the purchase of 505 EVs, with funding and participation increasing significantly since its inception.
- Though the programme had a relative slow start, the programme has grown exponentially to the point of being expanded due to oversubscription. The initial slow start could be circumvented through better direct education by the government and by dealers at point of sale to encourage greater adoption.

California has an upfront rebate programme for cleaner vehicles to defray the higher point of sale cost of clean vehicles and help to mitigate a key barrier affecting the breadth of the transition.

- The State's Clean Vehicle Rebate Program (CVRP) allows residents, businesses, non-profits, or government entities to receive a point-of-sale rebate – between $1,500 and $5,000, depending on whether the customer purchases a hybrid, a battery electric car, or a fuel cell electric vehicle, with a $2,000 "add-on" for low-income customers.
- Since its inception in March 2010, the state has issued 307,779 rebates, totalling over $693 million in funding.
- A significant portion have been directed specifically to low- and moderate-income customers, with 12,223 rebates going to these income demographics – equating to $49 million, or roughly 1 in 26 of consumers using the rebate programme.
- Despite only 8% of consumers currently using the rebate programme that are considered low- or moderate-income, 13% of issued funding went to these economic segments.
- Over half of low- to middle-income people say they would not have purchased an EV without the programme.

## Glossary of Key Terms

**Internal Combustion Engine (ICE) Vehicle** – an automobile that runs on petrol or diesel.
**Battery Electric Vehicle (BEV)** – A car that runs purely on electricity and whose battery must continually maintain a state of charge in order to operate.[a]
**Plug-in Hybrid (PHEV)** – A car that can run on battery electricity as well as petrol.[b]
**Hybrid electric vehicle (HEV)** - A vehicle that combines a conventional internal combustion engine with an electric propulsion system.
**Ultra-low Emission Vehicle (ULEV)** – ULEVs may include BEVs, PHEVs and/or HEVs. Under the current definition, a vehicle that emits less than 75 grams of carbon dioxide per kilometer traveled.[b]
**Total Cost of Operation (TCO)** – A measurement of the financial implications of vehicle ownership over time, including such metrics as upfront cost, fuel costs, and maintenance costs.[c]

[a] EEA, 2016, *Report No 20/2016*, https://www.eea.europa.eu/publications/electric-vehicles-in-europe
[b] *id.*
[c] Department for Transport, 2018, *The Road to Zero*, p.24

# Introduction

Given the political, climate, and air quality concerns that plague the UK, it is imperative that the country begins to address emissions from its most offending source: transport.

## Air quality

Transportation continues to be one of the primary contributors to harmful air quality. As a result of burning fuel from vehicles, the UK has seen an increase in harmful pollutants such as carbon monoxide, nitrogen oxides, volatile organic compounds, and particulate matter – in addition to secondary pollutants like ozone.[1]

These pollutants have dangerous health effects. According to the European Environment Agency, exposure can affect organs, the nervous system, and blood, and lead to respiratory illnesses, heart attacks, asthma, dizziness and fatigue.[2] Over the long term, more serious health impacts such as cancer and premature death will rise along with transport emissions; in 2015, a report estimated that air pollution was responsible for approximately 64,000 premature deaths across the UK.[3] This is not to mention the monetary cost of these health impacts, estimated by Public Health England to reach £5.3 billion by 2035.[4] Combined with other harmful pollutants from other sectors, as well as the predicted continued rise of emissions if the status quo continues, these negative impacts will only be compounded.

In addition to the need to protect the health of its citizens, the UK Government also has a legal responsibility to improve its air quality. It is one of only a handful of countries that face fines from the European Commission for continuingly high levels of toxic air pollutants. Along with France, Germany, Hungary, Italy, and Romania, the UK has been referred to the European Court of Justice for failing to adequately address harmful pollutants, recognising that levels of nitrogen dioxide remain unacceptably high in most urban areas.[5]

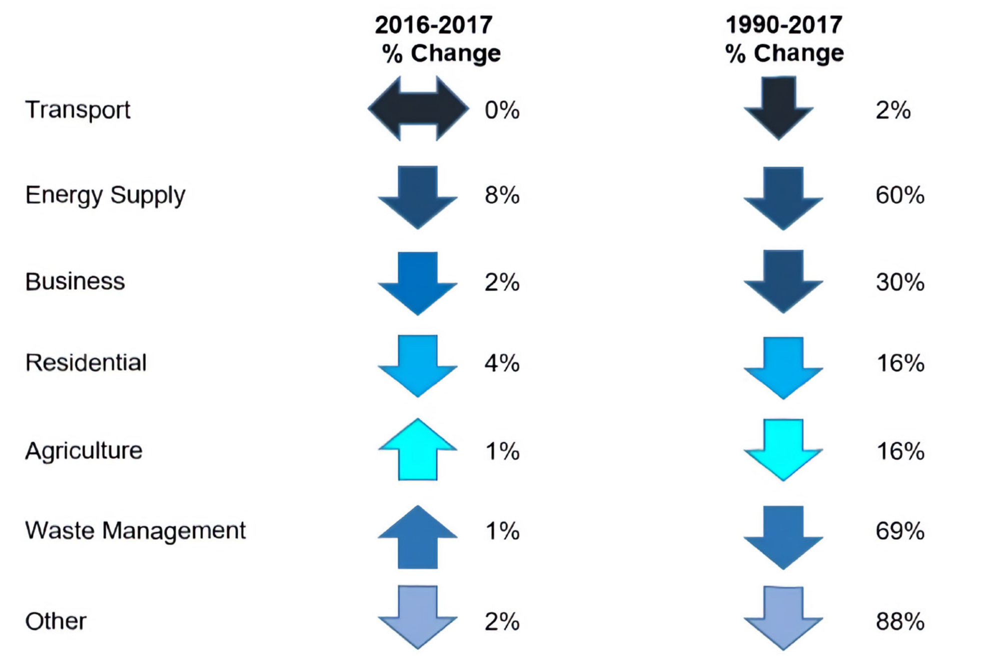
## Climate change

Transport contributes over a quarter of climate-altering emissions in the UK, with the most pollution coming from on-road transport. Indeed, the most recent data from the Department for Business, Energy & Industrial Strategy (BEIS) shows that in 2017, 27 percent of greenhouse gas emissions came from road transport.[6]

Further, emissions from the transport sector have been on the rise. Despite decreasing in the early 2000s, due to lower petrol consumption and improvements in fuel efficiency, emissions have started to rise again since 2013, due in part to increased vehicle kilometres travelled.[7] An additional contributor is the increased reliance on large, petrol-intensive vehicles; smaller, more efficient vehicles sales are down, while a corresponding increase in larger vehicles has led to a 0.8 percent uptick in the average amount of carbon dioxide generated per new car.[8]

FIGURE 1

## Changes in greenhouse gas emissions by sector




Source: Department of Business, Energy & Industrial Strategy, 2017 UK Greenhouse Gas Emissions

## The need for electric vehicles

Enter ultra-low emission vehicles (ULEVs), including, critically, pure battery electric vehicles (BEVs). BEVs have dramatic emissions reduction potential relative to their internal combustion engine (ICE) counterparts, given that they produce no combustion emissions. Even if the power used to source electric vehicles (EVs) is fossil-fuel-based, EVs are less polluting than traditional petrol and diesel vehicles.[9]

In addition, the positive impact on energy security can also be dramatic: the wide-scale use of EVs across the UK can reduce reliance on imported petrol and diesel – a potential cost savings of £5 billion and £10 billion, respectively, based on 2016 spending levels.[10] The combined magnitude of these factors means that action needs to be taken swiftly in order to electrify transport and that the increased prevalence of EVs is needed  to mitigate severe emissions and monetary impacts.

## The need for action

The Government has stated that its aim is "to put the UK at the forefront of the design and manufacturing of zero emission vehicles,"[11] and for all new cars and vans to be zero emission by 2040.[12] Although this is a laudable goal, the timeline is not nearly aggressive enough, given the severity of the air pollution problem. Moreover, sales of zero emission vehicles in the UK are moving slowly, with battery electric vehicles making up only 0.8% of the new cars market in January 2019.[13] Furthermore, the market share for electric vehicles in the UK lags behind countries such as China, the Netherlands, Sweden, and Norway.[14,15]

In order for EVs to capture a tighter hold on the market, policies must be put in place that even the playing field for ICE vehicles and EVs. Of paramount importance is remedying the current disparity in financing options between ICE vehicles and EVs – which remains strongly in favour of the former – and adopting innovative solutions to defraying the still high upfront cost of EVs.

## The need for an equity lens

Lower-income individuals are simultaneously more likely to be harmed by high levels of transportation pollution while being least able to afford a clean alternative.[16] Less attractive financing options mean that currently the wealthiest individuals are best able to afford the upfront cost of a clean energy vehicle.[17]

In order to make the transition to EVs just and equitable, the Government must be mindful of constructing policies that offer opportunities for lower-income and/or disadvantaged communities to benefit from clean transport. This is particularly important given the potential savings that can be realised over the lifetime of the car in terms of fuel cost and maintenance cost reductions.

For example, the recent gilets jaunes movement highlights the need for careful consideration of how policies can impact lower-income individuals. The grassroots protest was against a planned French increase on the fuel tax, which was designed to help fund a country-wide transition to clean energy. The majority of participants in gilets jaunes protests were from cities peripheral to Paris, as well as cities and rural areas across France with lower-income communities. They perceive the fight against the fuel tax as fighting "against a tax system perceived as unfair and unjust."[18]

In order for EVs to capture a tighter hold on the market – including, importantly, for lower-income individuals who are simultaneously more likely to be harmed by high levels of transportation pollution while being least able to afford a clean alternative[19] – policies must be put in place that even the playing field for ICE vehicles and EVs. Of paramount importance is remedying the current disparity in financing options between ICE vehicles and EVs – which remains strongly in favour of the former – and adopting innovative solutions to defraying the still high upfront cost of EVs.

In order to present a fully-formed picture of the current landscape, and evaluate how to remedy the still-present lack of incentives to allow for robust enough penetration of EVs, the main body of this paper will be divided into three parts:

1) exploration of current barriers and opportunities for the promulgation of EVs;
2) examples of policies and incentives that can aid in overcoming existing hurdles to the development of the market for clean transportation; and
3) a set of policy recommendations that should be followed in order to achieve EV targets and improve air quality.

CHAPTER 1

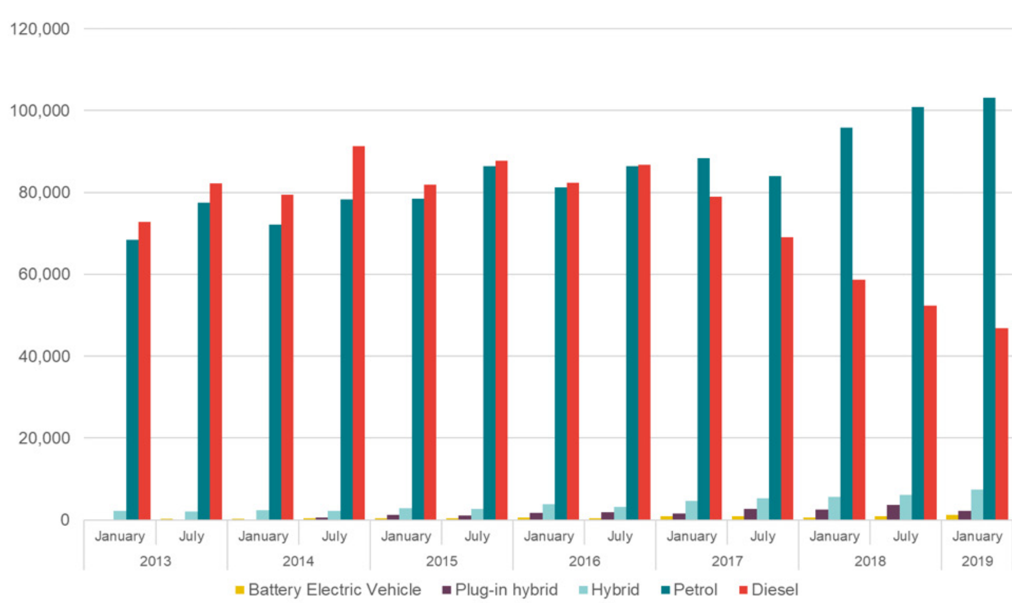
# Identifying the problem

While the benefits of EVs are well-documented, their hold on the vehicle market remains tenuous at best. While there were an estimated 31.2 million cars licensed in the United Kingdom as of 2018, only 185,000 of those were classified as ULEVs– that is, either fully electric vehicles or those emitting less than 75 grams of carbon dioxide per kilometre travelled. Put another way, the number of zero or near-zero emission vehicles on the road in the UK is less than 1 in 200 or 0.6% of total vehicles.[20] As depicted in Figure 2, though the share of ULEVs relative to their ICE counterparts has grown significantly since 2014, there is a lot of ground to make up – especially given the magnitude of emissions from the transportation sector and the stated desire of the UK government to be a world environmental leader.

There are many potential reasons for this failure of EVs to take hold in the UK vehicle market, namely: underdevelopment of the second-hand market as a result of less attractive financing options for EVs and a failure of information being passed from dealerships to potential buyers; and a disproportionate amount of sales occurring among higher-income individuals. This section will address each of these areas in turn.

FIGURE 2

## New car sales by propulsion type: 2013 - 2019



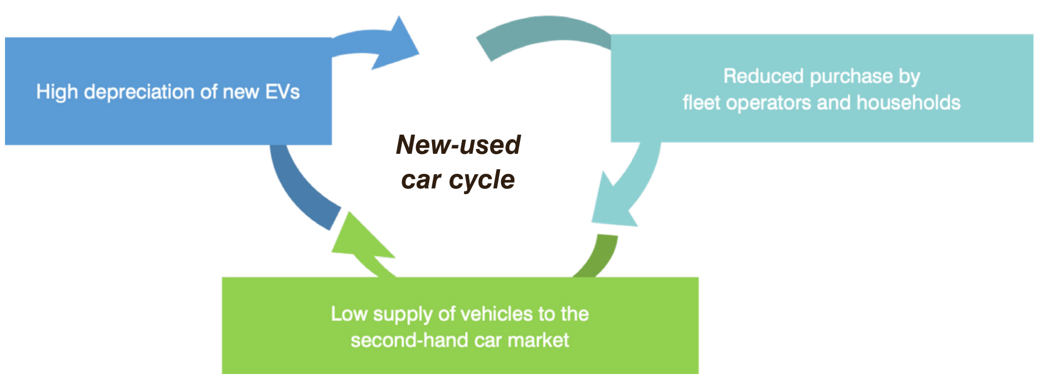

Source: SMMT Data, 2019

## A. Disparity of Financing and Resale Options

Despite the lower fuel costs and maintenance costs of EVs compared to ICE vehicles, the future resale value of EVs is far less favourable in large part because those who determine second hand values have much less data for these vehicles when compared to ICE cars – as EVs have been sold in considerable numbers for less than a decade and there has not been enough time for the second-hand market to mature. As a result, EV purchasers, with a few exceptions, are able to capture a much lower percentage of the upfront cost paid, which diminishes overall cost savings that would otherwise be captured with the purchase of an EV. Put another way, the higher the share of the sale price that can be recovered when the car is sold (the less the value depreciates), the lower the cost is to the owner of operating that vehicle. For example:

- The Renault Zoe, after having been purchased in 2015 for £15,498 was worth less than half of the upfront purchase price in 2018 – valued at a mere £6,190, or 40% of the initial price.
- The value of a Nissan Leaf purchased for £27,835 fell by 55%, worth only £10,355 in 2018.
- The KIA Soul EV lost 51% of its £25,400 value between 2015 and 2018, ending up with a worth of £12,400.[21]

Higher depreciation rates for EVs raises the overall cost of new EVs compared with ICE vehicles, and makes them even less accessible to middle and lower-income families – due to the fact that the rapid depreciation effectively makes the car more expensive. Though there are some EVs that do hold their value to a higher degree, these are largely expensive "premium" vehicles with longer battery ranges like Teslas – which are, again, out of reach for the majority of consumers. It also, importantly, reduces the interest from large-scale purchasers of new vehicles (fleet operators), which then reduces volumes going into the second-hand car market – again likely artificially raising the price of a second-hand vehicle. It should be noted that recent data suggests the average price of certain second-hand EVs are more than a petrol or diesel car.[22] However, this does not necessarily reflect on the steep depreciation that is typical of EVs, given their significantly higher upfront cost due to there not being appropriate economies of scale and a general lack of education among those responsible for selling vehicles, and drives home the point that both new and used EVs are out of reach for many consumers. Additionally, the higher average cost of these vehicles is a symptom of a mismatch between low supply and high demand – another factor that reduces the number of used EVs that are available. In short, uncertainty in the market, which is rapidly changing, is potentially resulting in lower adoption, because consumers have little insight into how their vehicle will depreciate over time – the end result being scant supply in the second-hand market.



In addition, there are few if any EVs that are offered a 0% APR financing rate. Aside from the Renault Zoe,[23] the list of vehicles that have an attractive interest rate attached are exclusively ICE vehicles. As a result of this drastic devaluation and less attractive financing options, there are two potential – and important – consequences. First, buyers will be more reticent to purchase EVs – including light-duty fleet operators that can have a significant impact in growing the number of EV purchases across the UK and driving the market forward. Second, because of these reduced sales from the high depreciation represented in Figures 3 and 4, the second-hand market is much less developed for EVs.

FIGURE 3

## Operating costs of different types of vehicle

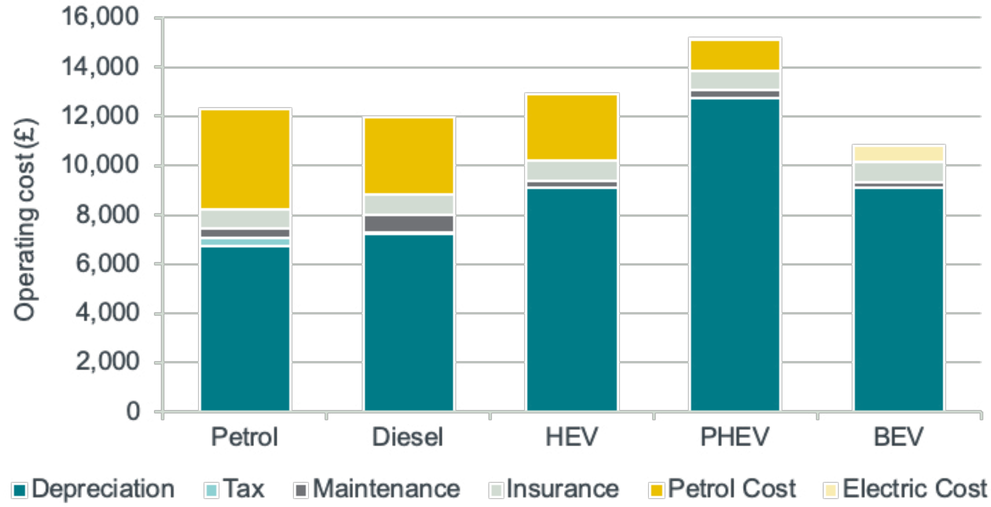
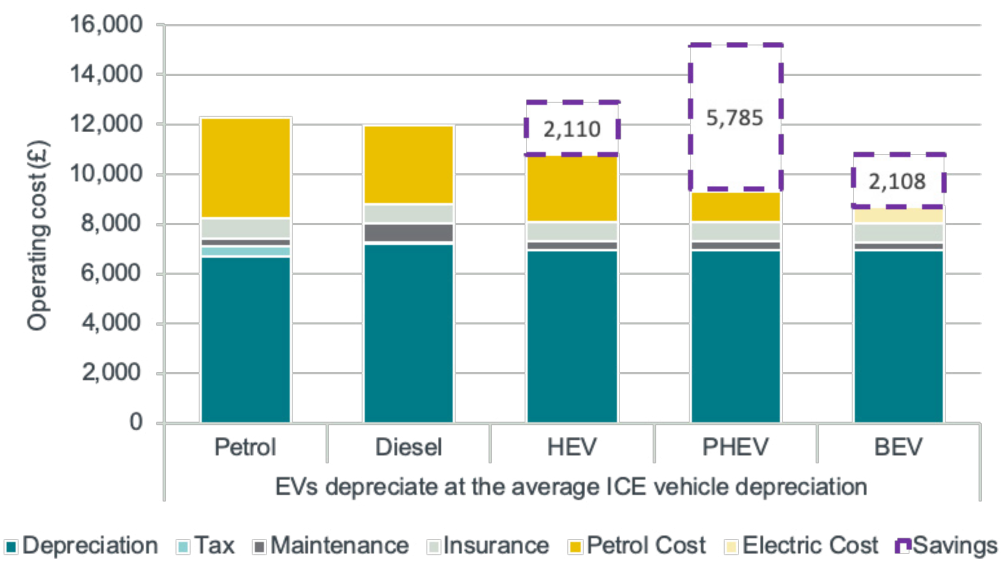



FIGURE 4

## Operating costs of different types of vehicles if depreciation for EVs fell to the same as petrol/diesel average




Source: Total cost of ownership and market share for hybrid and electric vehicles in the UK, US and Japan, Palmer et al., 0218; Frontier calculations. The dotted lines denote current levels of depreciation for EVs above the diesel/petrol average.

Additionally, a lack of education among car dealers is negatively impacting the health of the second-hand market. Because sales staff might feel less comfortable with explaining the positive attributes of EVs or in their understanding of EV technology, they are less likely to "talk up" EVs – therefore virtually ensuring customers are not exposed nor do they adequately consider the cost and environmental benefits inherent in the purchase of a clean vehicle. In the end, these elements combine to create a vicious circle – because dealers are not effectively and accurately disseminating information, and customers are buying fewer EVs, demand and economies of scale may decrease as a result, artificially increasing the already high up-front cost of both new and used vehicles.[24]

The combination of these factors leads to a stark picture on the prevalence of used ICE and ULEV sales:

TABLE 1

## Used car and ULE sales

2016–2018

| Year | Used car sales | Used ULE car sales |
|---|---|---|
| 2016 | 8,200,084 | 170,936 |
| 2017 | 8,113,020 | 174,589 |
| 2018 | 7,945,040 | 188,187 |

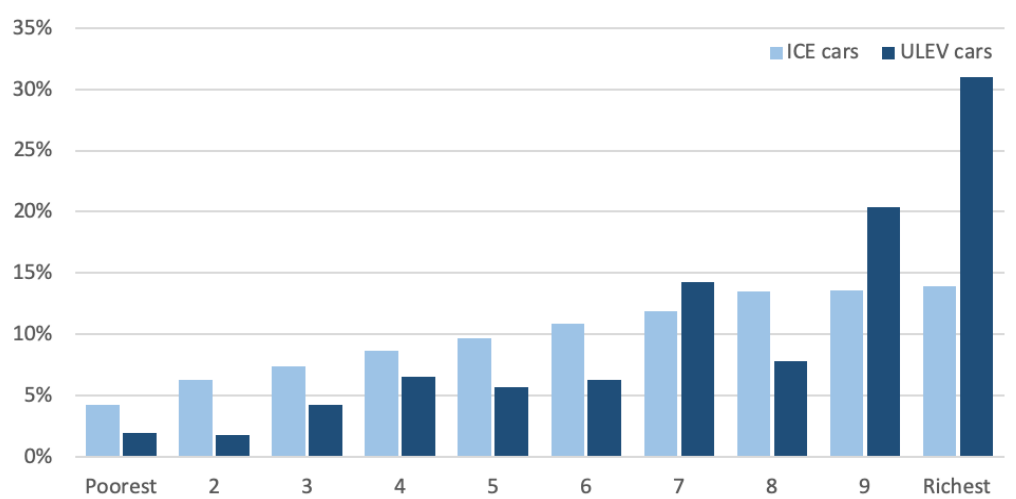
Source: Frontier Economics analysis based on SMMT press releases

To date, likely due to still high upfront cost and less than ideal financing options, ULEV sales disproportionately occur among wealthy individuals in the UK, and are largely purchased as a second vehicle. A recent analysis of recent UK households show that in both 2015-16 and 2016-17, more than 60% of households who own a ULEV also own an ICE vehicle. In addition, though wealthier households are more likely to own personal vehicles in general, that skew is even more pronounced for ULEVs, as shown in Figure 4.

FIGURE 5

## Distribution of ICE and ULEVs owned, by income decile

2015/16 & 2016/17 data




Source: Frontier Economics analysis of Living Costs and Food Survey data, 2015/16 and 2016/17 waves combined. Data are demographically weighted to the UK population. Income deciles are based on total household income after taxes and transfers, adjusted for household size.

More specifically, more than half of all ULEVs are owned by households in the richest two income deciles, compared with just 25% of ICE cars. On the flip side, households in the lowest two deciles made up just 4% of ULEV owners, but more than 10% of ICE vehicle owners.

Further, lower income households are much less likely to purchase new vehicles, likely because of the high upfront purchase price; this is only exacerbated by the higher price of ULEVs: the most popular ICE vehicle in the UK, the Ford Fiesta, retails starting at £15,420, while the nearest vehicle in terms of size, the Renault Zoe, starts at £21,220 before the grant as described below, and excluding battery hire.[25]

TABLE 2

## Details of Plug-In Grant

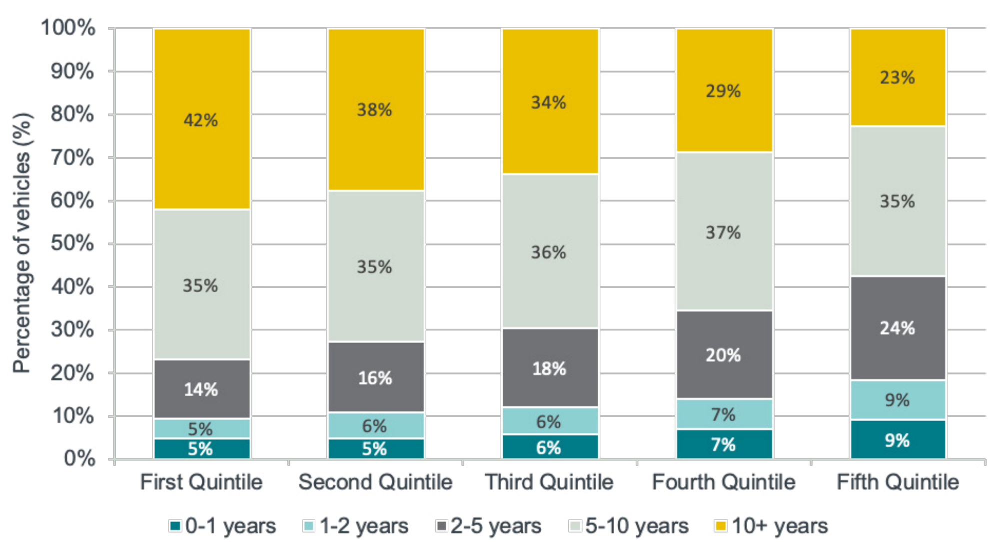
| Category of ULEV (cars) | Current value of grant (from October 2018) | Previous value (from March 2016) | Initial value (from January 2011) |
|---|---|---|---|
| CO2 emissions of <50g/km and zero emission range of 70+ miles | 35% of the purchase price up to a maximum of £3,500 | 35% of the price up to £4,500 | All plug in cars eligible for up to 25% of the purchase price up to £5,000 (must be <75g/km CO2 with range 70+ miles for full EVs or 10+ miles for PHEVS) |
| CO2 emissions of <50g/km and zero emission range of 10-69 miles | None | 35% of the price up to £2,500 (cars costing more than £60,000 not eligible) | |
| CO2 emissions of 50 to 75g/km and zero emission range of 20+ miles | None | 35% of the price up to £2,500 (cars costing more than £60,000 not eligible) | |

Source: Frontier Economics analysis of National Travel Survey

As shown in Figure 8, approximately 18% of cars owned by the wealthiest quintile are less than 2 years old, while only 10-11% of vehicles owned by the lowest two quintiles are less than 2 years old. Instead, more than 75% of cars in the lowest, poorest quintile are more than 5 years old – signalling that second-hand vehicles are an important source for vehicles among this demographic. Given the low percentage of used ULEVs currently on the market – only 2.3%, well below the 6.2% of new cars that are ultra-low emission – it is logical that this disparity of access will only be exacerbated for EVs.

FIGURE 6

## Age of vehicles owned by income quintile, UK

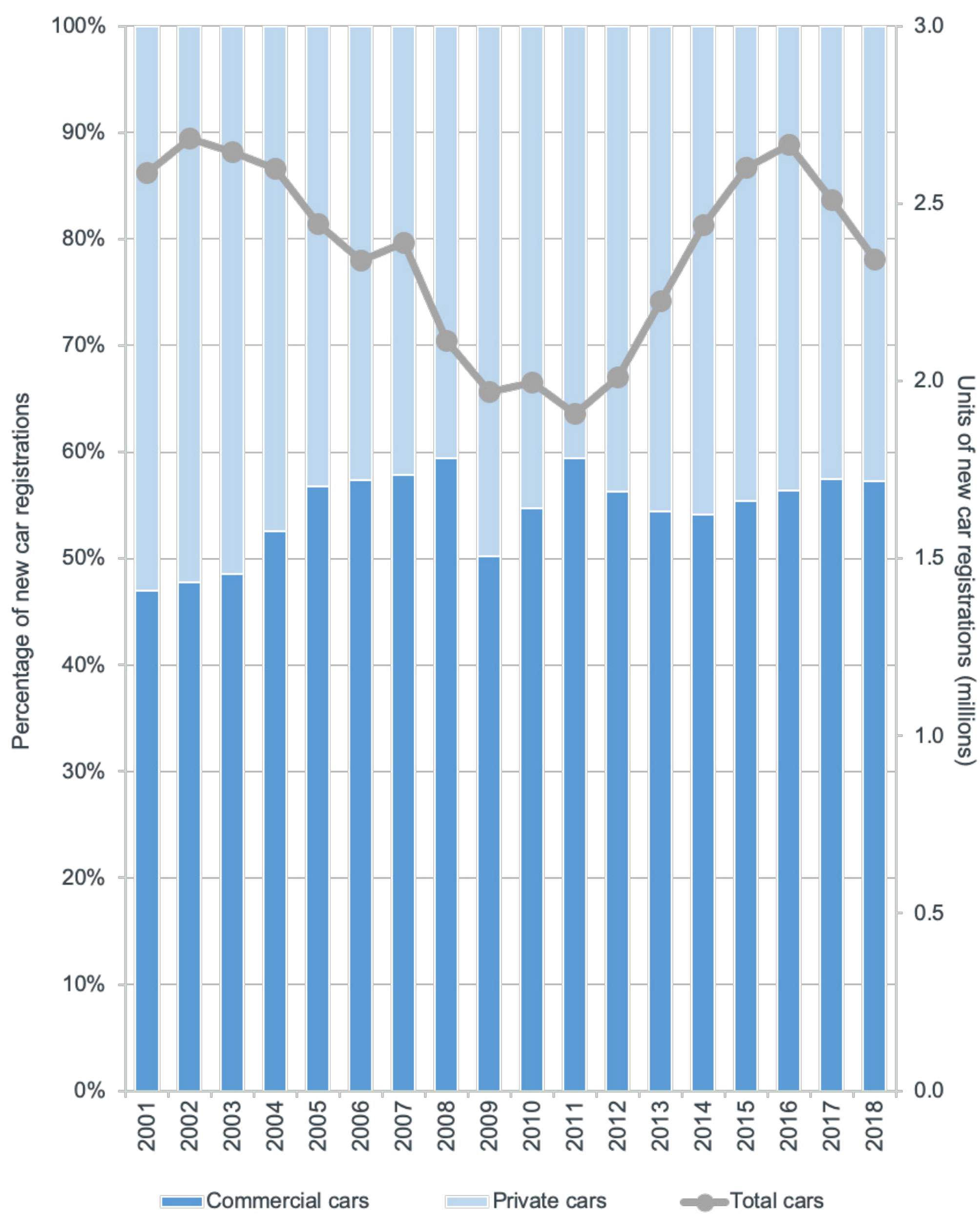


This troubling pattern is also evident among commercial fleet operators – in the UK, commercial fleets dominate the new car market, thus being an important funnel into the second-hand market. By the numbers, 57.3% of new car registrations in the UK are by companies for their commercial fleet – with these vehicles moving relatively quickly to the second-hand market – a significant portion within a year.[26] However, an extremely low portion of cars in commercial fleets are electric – about 2.1% or 27,500 of 1.3 million newly registered light-duty vehicles in the commercial fleet, and 1.2% or 5,200 of 433,000 newly registered vans.[27]

FIGURE 7

## New car registrations over time, by fleet / private

2001-2018




Source: DfT Vehicle Licensing Statistics

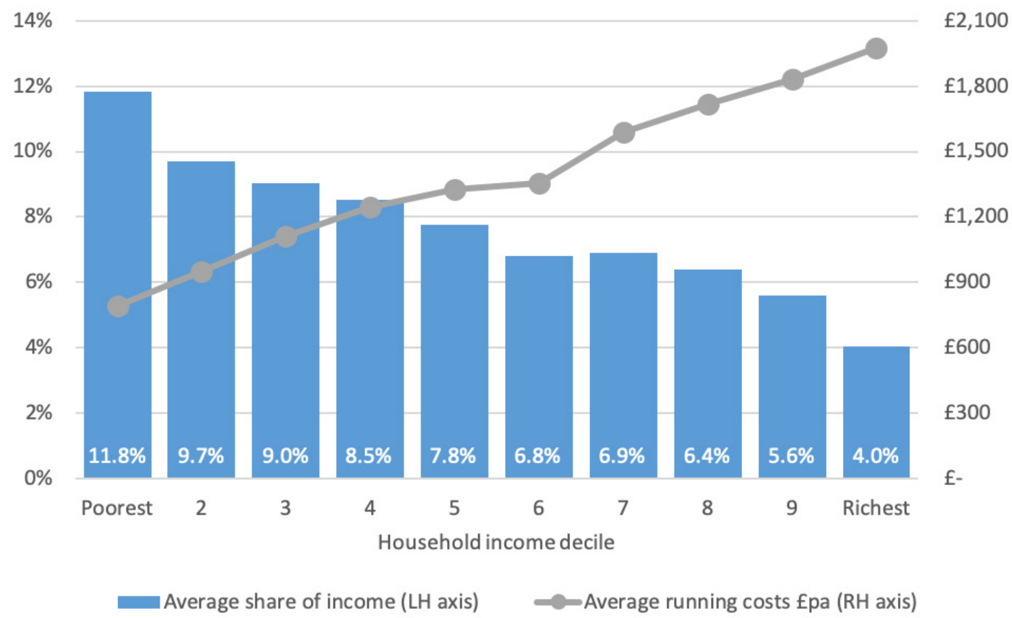
CHAPTER 2

# Recognising opportunities

As discussed in the introduction, it is well-documented that the environmental and health benefits of EVs are significant. Because they produce no tailpipe emissions, they offer a clean alternative to polluting vehicles – and, even when the predominant source of the electricity being used to power EVs is from fossil fuels, still come out ahead in terms of fuel emissions.[28] However, the potential cost savings that can be harnessed as a result of a transition to EVs are also significant – providing an opportunity to reduce costs to households across different economic demographics.

FIGURE 8

## Average spend on vehicle running costs for car-owning households, by decile group




Frontier Economics analysis of Living Costs and Food Survey data, 2015/16 and 2016/17 waves combined.

To illustrate the potential savings available to difference income groups, two scenarios were modelled[29] – the first assumes that half of new vehicle purchases in every income quintile are EVs (as opposed to the current skew towards new EV purchases in the wealthiest quintiles), while the second continues to assume that sales will continue to disproportionately occur in wealthier quintiles, but that sales of EVs will go up across all income levels.

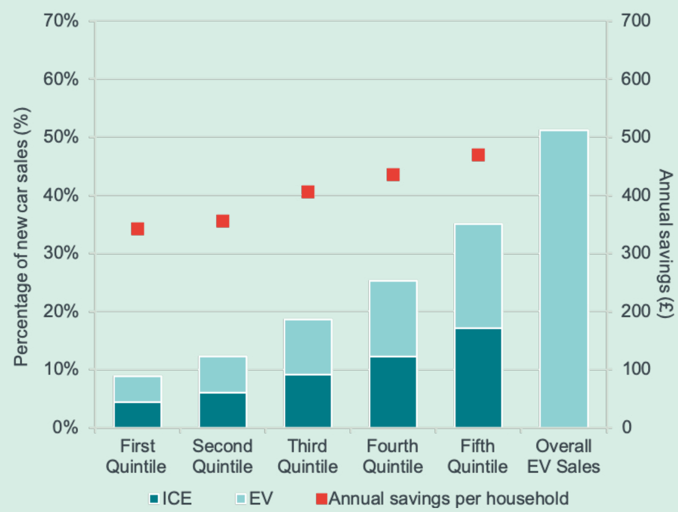
These two scenarios clearly show that there are savings in the order of millions of pounds on an annual basis across all quintiles, and hundreds of pounds per household, as illustrated in the graphs below:

FIGURE 9

## Scenarios showing potential cost savings

### Scenario 1: 50% of new ICE car purchases in each income group are converted to EVs

- **Total annual cost savings of £354m per year for the bottom 60% of households by income:**
    - **£307 million per year on fuel savings** based on average per-mile costs of ICE and EVs and average distances driven per income group
    - **£47m million per year on non-fuel savings** based on EVs costing an average of 23% less to service and maintain than a conventional ICE vehicle.
- Average cost savings in the poorest quintile of **£343 per household per year**
- 52% of new sales are EVs in this scenario – meeting government targets that at least half of new cars are EV by 2030



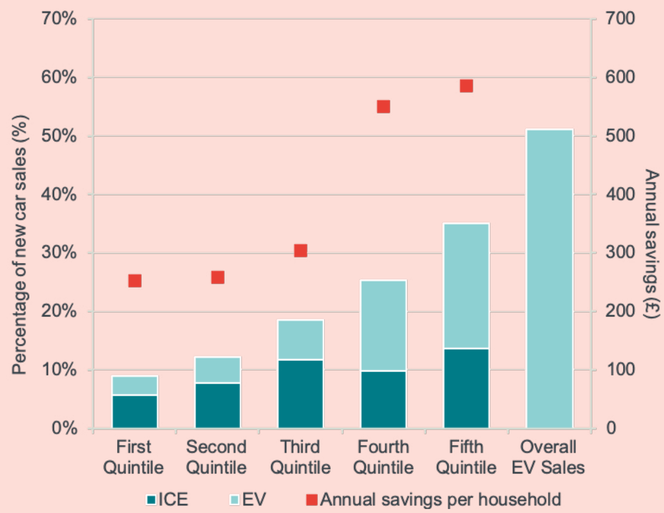

(Figure continued overleaf)

FIGURE 9 (CONTINUED)

## Scenarios showing potential cost savings

### Scenario 2: EVs are still more likely to be bought by richer households but take-up rises everywhere

- **Total annual cost savings of £261m per year for the bottom 60% of households by income:**
  - **£227 million per year on fuel savings** based on average per-mile costs of ICE and EVs and average distances driven per income group
  - **£35m million per year on non-fuel savings** based on EVs costing an average of 23% less to service and maintain than a conventional ICE vehicle.
- Average cost savings in the poorest quintile of **£252 per household per year**
- 51% of new sales are EVs in this scenario – meeting government targets that at least half of new cars are EV by 2030




Acknowledging the environmental and total cost of ownership savings inherent in the purchase of an EV relative to an ICE vehicle, there are a number of programmes aiming to provide financial support and increase uptake of clean vehicles across the board.

## A. Increasing Fleet Uptake

In the UK, there are several initiatives to ensure that small and larger commercial fleets can overcome the upfront cost associated with greening their vehicles and maximise environmental benefits, though none are comprehensive or ambitious enough to revolutionise the market. This is particularly true given the benefit in kind increase that actively disincentivises fleet managers from purchasing EVs.[30] Nevertheless, the measures are as follows:

- Financial Support for Chargepoints
  The Future of Mobility Minister has provided policy support for taxi drivers by expanding infrastructure funding for ultra-low emission vehicles across the country. To date, 17 local authorities across the UK – including Greater Manchester, Brighton and Hove, Leicester, and the North East, have received more than £6 million in funding. This money will be used to install 300 rapid chargepoints and 46 fast chargepoints, which can support 800 ultra-low emission black cabs and upwards of 3,000 ultra-low emission private fleet vehicles.[31]

- Studying Impact on the Distribution Grid

  Backed by energy regulator Ofgem and multiple private energy companies, London and the South East will conduct the world's largest commercial EV trial, Optimise Prime, this year. A three-year endeavour, the project will utilise Internet of Things (IoT) technology to track the charging activity of 3,000 commercial vehicles in order to understand the potential issues of a large-scale uptake of fleet vehicles – such as the impact of increased power usage on the distribution network – and presumably measure the environmental benefit of EVs. This is in addition to National Grid's analysis overlaying the transmission power network and strategic road network.[32]

- Defraying High Upfront Cost

  Businesses buying ULEVs – those vehicles that emit less than 75 grams of carbon dioxide per kilometre – or zero-emission vans are entitled to a capital allowance of 100% of the vehicle's value during the first year of ownership.[33]

- Loans for Businesses

  Transport Scotland has two programmes designed to benefit businesses. The agency has teamed up with Energy Saving Trust to provide interest-free loans, up to £120,000, in order to enable Scottish businesses to acquire greener and more efficient transport alternatives.[34] In addition to covering fleet purchases of EVs, plug-in hybrid vehicles, motorcycles, and scooters, the Scottish Government will also provide up to £50,000 towards purchases of fully electric or hybrid heavy goods vehicles, and vehicle efficiency devices. This includes such technologies as telematics systems that can map and record where a car is, how quickly it is driving, and, importantly, energy usage, state of charge, and battery health – all important metrics to how well-integrated these vehicles are. As well, Transport Scotland and Energy Saving Trust are providing interest-free loans up to £120,000 for taxi drivers that are willing to replace their conventional vehicles with ultra-low emission and electric taxis.[35]

## B. Reducing Upfront Cost for Private Vehicle Owners

There are two key jurisdictional examples that can be seen as potential policy solutions in England and the rest of the UK: Scotland and the State of California.

### 1. Scottish Interest-Free Loan

As part of Scotland's commitment to phase out petrol and diesel cars by 2032,[36] and similar to its scheme for taxi drivers, Transport Scotland rolled out an interest-free EV loan programme. Administered by the Energy Saving Trust, the programme offers up to £35,000 for a new fully electric or plug-in hybrid vehicle (as well as narrow subset of second-hand vehicles), as well as up to £10,000 for a new electric motorcycle or scooter. Further, on top of the £500 grant already offered by OLEV, Energy Saving Trust will provide £300 towards the cost of a 32A home charge point installation.[37] Since the programme was launched in 2015, it has enabled the purchase of 505 electric vehicles, with funding and participation increasing significantly since its inception. In 2015-16, approximately £4 million was offered[38] (or £0.74 per capita); this rose to £7.8 million in 2016-2017[39] and 2017-18, respectively (about £1.44 per capita), and had to be shut down in the latter year due to being oversubscribed[40]; finally in 2018-19, Transport Scotland has increased funding to about £20 million[41] (or £3.70 per capita). It should be noted that there are certain restrictions on this loan – second-hand/used vehicles are not eligible for the loan unless they are less than 12 months old, and have put in less than 6,000 miles; those who desire to make use of the loan cannot already own a pure or hybrid electric vehicle; and the list price must be less than £60,000.

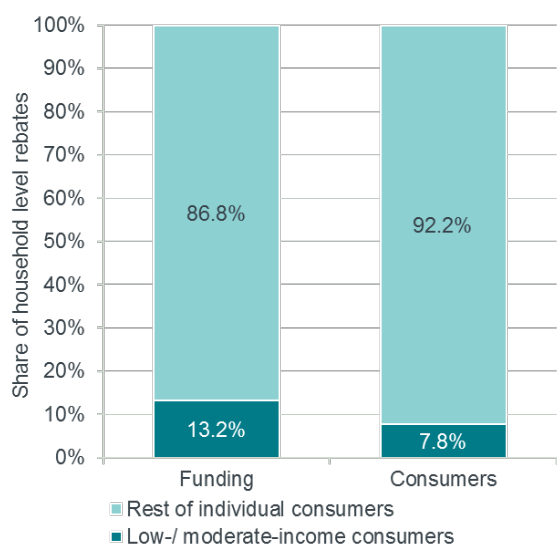
Additionally, while this scheme could be a significant and valuable to increase sales of EVs – and therefore is something that should be replicated more widely – awareness and funding needs to be higher in order to ensure more uptake of EVs. Though the Scottish EV no-interest loan has seen much greater participation in the last two years, the relatively slow start (only 500 customers were in the first two years of the programme) could be circumvented through better direct education by the government and at point of sale to encourage greater adoption.

2. **California Rebate Programs**

The brainchild of the California Air Resources Board (CARB), and run by the Center for Sustainable Energy (CSE), the Clean Vehicle Rebate Program (CVRP) allows residents, businesses, non-profits, or government entities to receive a point-of-sale rebate – between $1,500 and $5,000, depending on whether the customer purchases a hybrid, a battery electric car, or a fuel cell electric vehicle, with a $2,000 "add-on" for low-income customers – in order to defray the higher upfront cost of clean vehicles and help to mitigate a key barrier affecting the breadth of the transition. Recognising the relative capabilities of different income brackets and businesses to spend capital on clean vehicles, the CVRP amount is not flat across the board. In addition to having an income cap of $150,000 for single tax filers and $204,000 for head-of-household filers (with the exception of fuel cell electric vehicles), California provides $2,000 more per vehicle for households with incomes less than or equal to 300% of the federal poverty level.[42] Since its inception in March 2010, the programme has proved to be an enormous success, underscoring that under the right circumstances, uptake of EVs the mitigation of upfront cost can be significant. More specifically, the state has issued 307,779 rebates, totalling over $693 million in funding. Importantly, a significant portion have been directed specifically to low and moderate income customers, with 12,223 rebates going to these income demographics – equating $49 million, or roughly 1 in 26 of consumers using the rebate programme.[43] The programme, part of legislation designed to specifically benefit low-income communities hardest hit by pollution from transportation, is demonstrably achieving those goals. Despite only 8% of consumers currently using the rebate programme that are considered low or moderate-income, 13% of issued funding went to these economic segments.

FIGURE 10

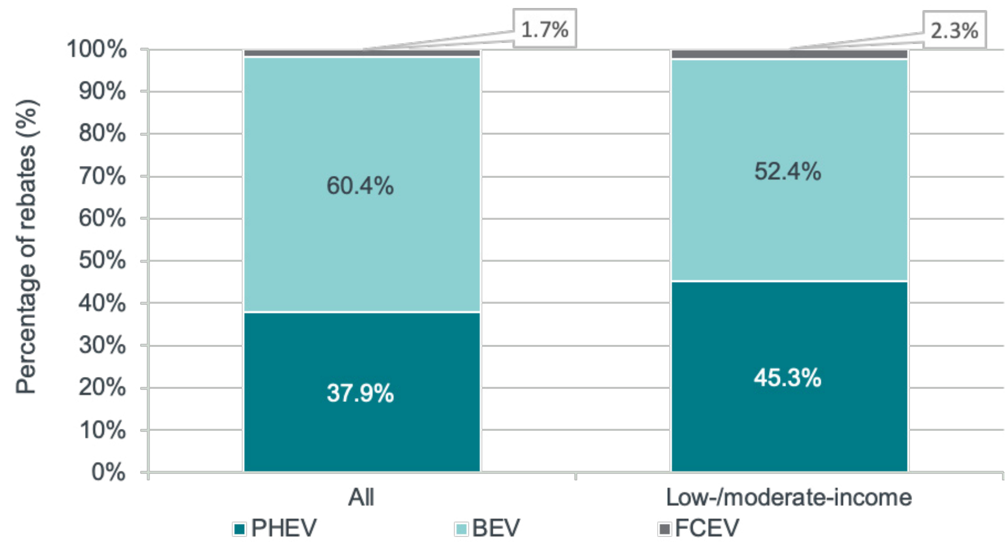
## CVRP statistics of funding and consumer profiles since the introduction of the income criteria in 2016




Source: California CVRP, 'CBRP Rebate Statistics'

FIGURE 11

## Types of EV CVRP funding is used for, by income group

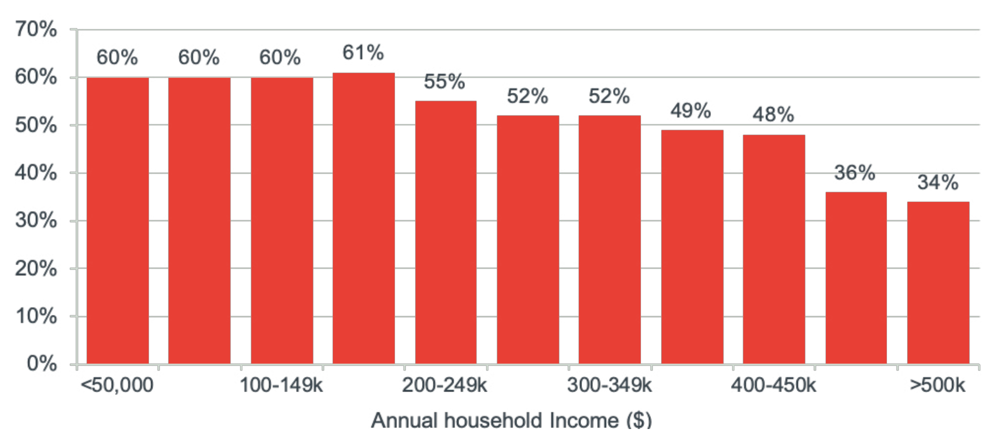



Source: California CVRP, 'CBRP Rebate Statistics'

Though the number of rebates in itself does not indicate that the reduction in upfront cost influenced purchasing decisions, surveys do show that the uptake of vehicles occurring in the wake of the CVRP was not mere coincidence. From a survey of nearly 20,000 respondents conducted by the CVRP, a significant proportion of individuals felt that the rebate was "extremely important" to their decision to purchase an EV; a negligible amount of respondents, on the other hand felt the rebate was unimportant to their decision.[44] Critically, survey-takers from disadvantaged communities were substantially more inclined, as shown in figures 13 and 14, to find the CVRP important in positively impacting their ability to purchase a clean vehicle – relative to those individuals in higher income brackets.[45]

FIGURE 12

## Share of respondents who say they would not have purchased an EV without the CVRP, by household income group




Source: Center for Sustainable Energy, 2016, CVRP Income Cap Analysis: Informing Policy Discussions, https://cleanvehiclerebate.org/sites/default/files/attachments/2016-08%20CVRP%20income%20cap%20analysis.pdf

CHAPTER 3

# Policy recommendations to drive further progress

Though the examples in Scotland and California provide a baseline for successful policy, they must be expanded and added to in order to ensure Britain is able to meet a more ambitious 2030 timeline by which to phase out ICE vehicles, and that benefits are equitably distributed to benefit those communities disproportionately impacted by harmful pollution. These can be distilled into three categories:

1) Expanding and strengthening programmes to reduce the high upfront cost of vehicles;

2 Exploring financing options that are, in the short term, on par with ICE vehicles and ultimately make them even more attractive than ICE vehicles; and

3) Ensuring via broader accreditation schemes that car dealerships are operating from the same baseline of information and encouraging purchases of clean vehicles through accurate and consistent dissemination of EV benefits and available opportunities to make them more affordable.

## A. Continuing to Reduce the Upfront Cost of EVs

The Government must leverage the progress made on defraying the upfront cost of EVs, as demonstrated by rebate and loan programmes in California and Scotland, respectively – as well as continuing to run plug-in grants and homecharge schemes in the UK, at least until EVs reach cost parity with their ICE counterparts. In those two jurisdictions, despite a slow start, uptake has quickly increased and participation has evolved to the point where funds have risen significantly to meet the demand. As well, there is evidence to support the idea that these programmes positively influence purchasing decisions, particularly for low-income consumers. As such, they are a critical means of growing the market and ensuring that it grows in an equitable way. Interest-free loan programmes and higher upfront rebates, policies that exist in Scotland and California, respectively, should be considered and improved upon as the UK moves towards a clean transportation future. In addition, to avoid the slow start that those programmes saw, it would be prudent for the UK – especially given the recent announcement to offer a limited amount of interest-free loans in England[46] – to ensure that these programmes come with targeted, robust education. It is likely, for instance, that the Scottish loan programme could have been even more successful in the first two years of its existence had the programme been more widely known. Widespread education that adequately disseminates accurate information is critical – in other words, distribution of complete information that ensures everyone has access through a variety of different media, languages, and potentially emphasis on different attributes of EVs depending on what is of most importance to a particular socio-economic demographic.

As well, it is important to ensure that those who are disproportionately impacted by harmful pollution from transportation have an equal opportunity to benefit from vehicle electrification.

As such, any rebates and interest-free loans should be geared towards those same communities. Much as the CVRP has enhanced benefits for lower income communities, the Scottish interest-free loan should be structured in such a way that lower-income individuals that would otherwise not be able to afford an EV are given a greater ability to do so. Moreover, much as the CVRP requires proof of income and gives more benefit to taxpayers that show they are below 300% of the established poverty level, the Scottish loan programme could set out a particular percentage of loans for individuals who demonstrate a certain socioeconomic disadvantage. Finally, both interest-free loans and the CVRP programme should change restrictions in order to allow second-hand vehicles to be eligible; though the second-hand market is not yet adequately developed, it likely will be in the near future – because those vehicles might still be out of reach for some individuals living in severely impacted communities, driving that market forward will only benefit from monetary assistance.

## B. Establishing Better Financing Options for EVs

As discussed in the report, there is a significant discrepancy between financing options for EVs and ICE vehicles. In order to increase uptake across all consumer groups, and build a robust second-hand market, financing options and resale value must become commensurate for clean and traditional vehicles. It is clear that low interest rates and higher resale values are important means of inspiring purchases, as evidenced in part by the fact that ICE vehicles are still sold at higher rates, despite the total cost of ownership benefits that come from purchase of an EV. As such, ensuring through legislation or other incentives that financing options are commensurate is critical. This may even be more important for fleets, who are largely responsible for building the secondary market; if these companies are not funneling EVs into that market, then the likelihood that it will grow appreciably becomes significantly less likely.

As such, until the secondary market is robust enough to guarantee that affordability of the upfront cost of EVs is possible, we will continue to see electric vehicle sales concentrated in the upper economic tiers – people for whom financing options and resale value is far less important in purchasing decisions. Requiring similar financing packages and preventing resale values from being set artificially low as a result of uncertainty over EV technology will be critical to ensuring and the continued presence of EVs on the market.

As well, ensuring that robust policies are put in place to grow the market will be important – including, potentially, an EV sales mandate to better enable manufacturer supply that is commensurate with demand, explained more fully in Annex 1. Without adequate recognition that increasing numbers of EVs will be needed to meet targets – as well as discrete, effective policies to achieve the number of clean vehicles required, including continuing to reduce emission standards for vehicles – it is an inevitability that financing options will continue to stall market growth.

## C. Ensuring Better Dissemination of Information

Finally, in order to better ensure that potential EV purchasers are armed with the correct information, it is imperative that salespeople are trained adequately and prepared to disseminate that information to the broadest extent possible. The National Franchised Dealers Association (NFDA) has already launched the Electric Vehicle Approved programme after a successful pilot, giving accreditation to businesses that met a set of standards demonstrating a firm knowledge of EVs, their benefits, and associated technology, and show a commitment to selling these vehicles. Backed by the Office of Low Emission Vehicles and Energy Saving Trust, these EV accreditations are given out to individual dealership locations after an audit by the Energy Saving Trust. If this programme is going to aid in the mass electrification of vehicles, which it has the potential to do, the accreditation must become mandatory, rather than just an incentive, so that all dealers are certified and able to sell EVs in the quantities that needed to accomplish cleaner air throughout England.

# Conclusion

As vehicles are one of the predominant sources of harmful emissions in the UK, it is imperative that this country incentivise the uptake of EVs and ULEVs, with a particular emphasis on ensuring equity of access to these vehicles. Currently, the secondary market for EVs is severely underdeveloped, which means that despite the total cost of ownership being cheaper for many, these vehicles are still out of reach for most consumers. In order to remedy this, the UK must ensure more vehicles are made available by suppliers and ensure preferential financing options available for ICE are also available for low-emission vehicles. It must also widen the scope of programmemes intended to defray the upfront cost of clean vehicles to encompass the whole of the country, such as adapting successful policies already in place in Scotland. Finally, there is a need expand and standardise accreditation programmes for dealerships, so that customers will be able to visit any dealer across the UK and know that they will get correct information about the technology, total cost savings, rebates and available incentives, with appropriate help on how to evaluate and limit higher upfront capital costs.

# Annex I

For the sake of completeness, Frontier and EDFE compiled recommendations that go beyond ensuring parity of financing options between electric vehicles and internal combustion engine vehicles. Additional policies that can help increase the uptake of EVs are as follows:

## Vehicle-grid integration (VGI) and vehicle-to-grid (VtoG) policies

VGI and VtoG models enable EV batteries to be aggregated and integrated with the energy system to provide flexibility services to the electricity system: modulating the amount and times EVs are charged will help to relieve 'stress points' on the grid and improve the efficiency of the electricity system. VtoG, a subset of VGI, goes beyond management of the energy used to power EVs, and transmits back to the grid.

Though EV users who participate in VtoG programmes may be less able to charge at any time of the day, those who participate in these services can be remunerated through revenue or allocated credits which could help to further reduce the total cost of owning an EV. Vehicle models capable of this service are currently available and programmes are being piloted in California,[47] Europe,[48] and Asia.[49]

One study found that EVs in China are being considered as a future capacity option: a forecast of 100 million EVs in China by 2030 will provide 5 Terawatt-hours of additional storage.[50] Through the use of smart charging, battery swaps and 'retied' batteries, EVs could be used as a solution to periods in which renewable energy faces supply shortages, thus securing the energy market. This in turn may incentivise indigenous companies to actively participate in the full EV supply chain.

However, the VGI and VtoG models may run counter to the 'Mobility-as-a-Service' (i.e. ride-sharing and carpooling) model, which may have vehicles spending a greater number of hours on the road, and thus less predictable charging schedules. This potential barrier will likely decrease as battery capacity and recharging technology continue to improve.[51]

## Improved incentives for manufacturers to drive EV uptake

Manufacturers in Europe face strict compliance with European emission targets that have been structured to incentivise the electrification of fleets (i.e., through penalties and fines faced by vehicles that do not meet emission standards). Though vehicles have become more and more efficient in order to adequately comply, emission standards are not yet strict enough to incentivise the levels of EVs that are needed. Indeed, a consequence of this improved fuel economy is that consumer have preferred to purchase 'bigger' cars, increasing the number of SUVs being sold.[52]

According to one expert, the average profit margin in Europe for an ICE vehicle is 8%, while margins for both PHEVs and BEVs are negative. This could change in the near-term: with improved technological advancements that reduce assembly and battery cost, forecasting shows that though PHEVs will continue to remain unprofitable well into the 2020s, BEVs should break even in early 2020 and begin to compete with ICE vehicles by 2025.[53]

In the near-term, tighter emissions targets will help to improve manufacturer incentives to electrify the fleet: the less strict CO2 regulations are, the more manufacturers have an incentive to continue improving the efficiency of ICE vehicles and the less they are incentivised to accelerate fleet electrification, due to the difference in obtainable margins.

Additionally and critically, there is significant evidence that a lack of supply on the manufacturer side is artificially constraining demand, preventing the economies of scale necessary to effectively drive down the purchase price of EVs – as well as preventing significant expansion of the second-hand market. In order to provide a solution to this programme, California, along with a handful of states dedicated to decarbonising transport, has in place a zero-emission vehicle (ZEV) mandate requiring manufacturers to sell a certain number of clean vehicles per year.[54] Policies like these have already been adopted in other countries[55] and can also be a model for the UK in order to remedy a problem that is a clear stumbling block towards making EVs a more feasible and reliable purchase choice and provide car dealers with the certainty necessary to successfully market these vehicles to would-be EV purchasers.

## Breaking down the barrier of range anxiety

In order to combat the perception of all too many potential EV drivers that there won't be sufficient charging infrastructure to enable being able to drive from point A to point B, policies must ensure adequate charge points in order to begin to change consumer perceptions surrounding range anxiety and start to overcome this key barrier to adoption.

The availability of charging infrastructure stands out as a key driving factor in EV uptake among consumers: an International Council on Clean Transportation (ICCT) study observed a strong correlation between EV sales share and the number of public charging points per million residents.[56] Indeed, San Jose, California, a leading EV market, has the highest charging availability per capita.[57]

This causality goes both ways: with more EVs comes greater need for charging, which reinforces consumer confidence in purchasing an EV.

Government willingness to invest in charging infrastructure sends a strong signal of policy commitment to EV industry and potential enables EV uptake. For example, China announced a target to provide 4.8 million charging points by 2020, nearly a 1:1 ratio with China's target for number of EVs – further cementing their commitment to cleaning their transport sector.[58]

Further, charging locations need to be strategic and need to be  ositioned to make them easily accessible.  Too often, EV charge points are located in parking lot corners, and are thus only accessible to one vehicle at a time or not at all (by virtue of the fact that they are blocked by other parked vehicles). Academic research[59] has highlighted key features of charging infrastructure that help to provide positive influences on owning an EV and decrease range anxiety, including:

- Moving charging locations where others are less likely to park, thus avoiding a situation in which an ICE vehicle is taking up a space that would otherwise be used by an EV to charge;
- Increasing "EV only" parking spaces;
- Putting in more "octopus" chargers (that is, charging stations with multiple ports) that allow more than one vehicle to charge at a time; and
- Installation of chargers indicating when an EV is fully charged and ensuring that regulations permit fully-charged EVs left in public charge points can be unplugged by other users seeking to charge their EV.

Further, it could be critical to greater adoption of EVs in more rural areas and for people renting flats in multi-unit dwellings to ensure access to chargepoints.  For these individuals, there may be the multi-pronged issue of high costs of chargers and inadequate numbers of chargepoints – meaning that the

Government should continue to operate homecharge schemes and ensure installation of more public chargers to bridge the gap.

# Annex II

The following lays out the approach used to model the household savings that can be realised from a switch to EVs.

## Total sales

- Using SMMT data, Frontier Economics integrated the number of new car registrations (sales) for the year 2018.
- To allocate the share of new car sales by quintile, Frontier took the National Travel Survey (NTS) data (2012 – 2016) and identified the share of cars owned that are less than one year old by quintile. This gives a proxy for the share of new cars by income group which is applied to the 2018 sales data.
- We also used the NTS data to identify the current distribution of ICE and alternative fuel vehicles (AFVs) by quintile. The data does not separate EVs and other AFVs but we assume for the illustrative scenarios that all AFVs are EVs.
- For the different scenarios described on page 16, we then identified how many more EVs would be sold in each quintile compared with our current estimate in order to meet the scenario (e.g. the share of new cars by quintile that are EVs).

## Cost savings per household

- Using the NTS data (2012 – 2016) we found the average annual mileage driven per vehicle for each income quintile group. We assume that a household switching from an ICE to an EV will continue to drive the same number of miles.
- We drew on the evidence from the Palmer et al. (2018) study referenced on page 10 to calculate the net difference in fuel-based running costs (lower petrol and diesel costs but higher electricity costs) of an EV compared with an ICE vehicle per mile. We then multiplied this saving by the average mileage per quintile to estimate a household-level saving on fuel costs for those who switch in the different scenarios.
- Also drawing on the Palmer et al. study, we assume the other difference in running costs from the switch comes from a lower annual average maintenance cost but that in the longer-term tax and insurance costs are likely to be similar for ICE and EVs. We draw on evidence on the size of the maintenance savings and add this to the estimated fuel cost savings.[60,61]

- The addition of the fuel cost savings and the non-fuel cost savings is multiplied by the difference in volume of EVs sold to each income quintile to provide the total savings for each income quintile for the given scenario.
- The average savings per household per income quintile group is calculated by dividing the total savings per income quintile by the total volume of new car sales per income quintile group, as determined in the baseline.

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