Tax and the EV transition

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Glossary

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ICE	Internal combustion engine vehicle
EV	Electric vehicle (EV) – pure battery electric vehicles (BEVs) only, excluding all hybrids
ZEV	Zero emission vehicle
NPV	Net Present Value, a discounted summary of costs and benefits over time
SMMT	Society of Motor Manufacturers and Traders
Business sales – SMMT definition	If the vehicle is registered by a company that operates up to 24 vehicles
Fleet sales – SMMT definition	If the vehicle is registered by a company that operates a fleet of 25 or more vehicles
Private sales – SMMT definition	If the vehicle is being registered primarily for the personal use of a private individual
Fleet market	Business and fleet sales
Private market	Private sales
CBA	Cost Benefit Analysis
Kt	Kilo (10^3) tonnes
Mt	Mega (10^6) tonnes
NOx-eq	NOx equivalent
PM2.5	Fine particulate matter
FTT:Transport	The Future Technology Transformation model for private passenger vehicle purchases

Executive Summary

About this report

The Government has a statutory target to bring all greenhouse gas emissions to net zero by 2050. It is committed to phasing out the sale of cars and vans with a combustion engine (including hybrids) by 2040 and is currently consulting on bringing this forward to 2035. Both the Committee on Climate Change and the National Infrastructure Commission have said that the sales ban should be brought forward to 2030.

The impacts of COVID-19 and the associated economic shutdown have already led to a sharp reduction in vehicle sales in the first half of 2020. Supporting policy aimed at stimulating the industry provides a major opportunity to specifically encourage the uptake of electric vehicles.

In this analysis, we assess the impact of different fiscal policies on future electric vehicles (EV) volumes across the passenger car fleet. In doing so, we provide insight into the potential to deliver an earlier phase-out of combustion engines from sales of new vehicles.

Key findings

1. Without additional policies measures, a 2040 phase-out of ICE sales can be achieved, but a 2035 phase-out cannot. Current policies, up to and including those in the March 2020 budget, are expected to deliver a 50% market share of new sales for pure electric cars by 2030, rising to 84% in 2035 and 97% in 2040.

2. A significant increase in policy measures is required to deliver 95% of new registrations as EVs in 2035, a level which would make an outright ban on the sale of ICEs feasible. Our analysis shows that this range of measures should include:

- a strong differential in Company Car Tax rates between EVs and other vehicle types
- a continued Plug-in Car Grant for EVs
- a reduction in purchase taxes through extension of Enhanced Capital Allowances to lease vehicles and a VAT exemption for EVs.

3. Deployment of new EVs into the fleet market is expected to be more rapid than the private market, due to rapid turnover rates and a stronger set of tax incentives.

4. There are environmental benefits from a more rapid transition. The shift away from ICEs will reduce tailpipe emissions of CO_2, NO_x and particulates on UK roads, by 10.4%, 9.3% and 2.7% respectively over the period 2020-50, compared to the Baseline.

5. Over the period 2020-50[1] we estimate that the cumulative net cost to Government of policies to bring a 2035 phase-out within reach will be £134

[1] The costs and benefits of the transition are measured over a longer time period than the policy measures are in place, in order to capture the continued benefits of vehicles for as long as they are in the fleet.

billion. After applying a discount rate, the cumulative net cost to Government is £95 billion over the same period.

6. This figure does not include the economic impacts of this transition, which would be expected to impact on the net costs. Not including these effects means that the impact, for example, on job creation from vehicle manufacturing or battery production is not assessed.

7. Annual policy costs in this scenario peak at £16.7bn 2032, equivalent to just less than 2% of total government expenditure in 2019.

1 Introduction

1.1 Context

In June 2019, the UK government committed to legally binding targets to bring all greenhouse gas emissions to net zero by 2050. In the transport sector the government is committed to phasing out the sale of vehicles with a combustion engine (including hybrids) by 2040, and is currently consulting on bringing this forward to 2035 (which would be broadly in line with a 2050 net zero target, given the long lifetime of a typical vehicle).

Phase out policies have the potential to be unpopular – particularly if the majority of the population has not already made the switch to zero emission vehicles (ZEVs). In order to make a phase-out politically feasible, EVs will need to dominate sales of new vehicle. Under such a scenario, a phase-out only affects (in the sense of preventing them from taking up their preference) a small number of people who are strongly attached to existing ICE technologies.

To date, the leasing segment of the fleet market has matched the private market in the adoption of electric vehicles – but the April 2020 changes to Company Car Tax (CCT) have substantially bolstered take-up in this market. Further changes to the CCT and the inclusion of other policies (e.g. a VAT exemption) would further increase the attractiveness of EVs for fleets and their drivers (and in some cases the private market), while also helping achieve the governments ambition.

The socio-economic impacts of COVID-19 will lead to a sharp reduction in vehicle sales in 2020. Government support will likely be needed to help return to ‘normal’ levels. The Government should consider how such support can explicitly encourage take-up of EVs to maximise the benefits of such measures.

1.2 Study objectives

In this study, we explore of the following questions:

- **How rapidly are current policies expected to deliver a transition to very high EV shares?**
- **What role is expected to be played by the fleet market?**
- **What policies could be deployed to encourage a more rapid take-up of EVs, and what are the costs and benefits of such policy measures?**

Our analysis applies a tailored technology diffusion model (FTT:Transport) to assess these issues. We then calculate costs and benefits from the transition. The costs include additional government spending or tax revenue forgone by the Government from the implementation of various policies. The benefits include the reduction in emissions; improving air quality and reducing the associated damages. The economic and wider economic benefits (and costs) of the transition are not assessed in this study, however.

Current policies, referred herein as the Baseline, includes all relevant policy changes confirmed in the March 2020 Budget. In the scenarios, additional policy measures start from 2021.

All scenarios, and the Baseline, do not include any effects of COVID-19. Although COVID-19 and the associated economic shutdown have had substantive impacts in the short-term, we expect activity to revert to trend in the coming years, and do not expect it to lead to any structural changes in long-term demand for motor vehicles.

1.3 The structure of this report

Chapter 2 describes the status of the current policies as per the March 2020 budget and how they change in each of the policy scenarios. Chapter 3 presents the impact on EV passenger sale as a percentage of total sales in both the fleet, private and whole market for each scenario. Chapter 4 presents the impact of emissions, covering changes in CO_2, NO_x and PM2.5 emissions. Section 5 presents the Cost Benefit Analysis (CBA) for the Middle and High ambition Scenario and finally Section 6 contains the conclusion, communicating the key findings of this study. Appendix A briefly describes the modelling framework and the relevant model developments used in this project. Appendix B provides further details of the assumptions and data sources for the model developments and Appendix C describes how the policies were introduced into the model.

2 The policy scenarios

2.1 Introduction

The purpose of this analysis is to assess the incremental impacts of policies on the deployment of electric vehicles. To do that, it is necessary to first establish a baseline (i.e. setting out how sales of EVs are expected to evolve under current policies). Additional policies can then be introduced in scenarios to evaluate their marginal impact. In this chapter we describe the measures included in the baseline and scenarios, before presenting the results in Chapter 3.

2.2 The Baseline

The Baseline used in this analysis includes all policies relevant to road transport sector up to and including those announced in the March 2020 budget.

While the short-term impacts of COVID-19 (and the associated shutdown) have been substantially lower vehicle sales in the first half of 2020, the longer-term impacts are unclear. Our analysis does not explicitly account for the impacts of COVID-19; short-term effects are therefore implicitly assumed to be balanced out by a rebound in sales as the economic shutdown ends.

Furthermore, Government support will likely be needed to help the economy bounce back; this presents an opportunity to enable the take-up of EVs.

The policies explicitly included in the Baseline, and therefore able to be altered in the scenarios, are detailed below.

Overview of the policies and how they are modelled in the baseline

Company car tax (CCT) is a tax levied on company cars that are used for business and leisure purposes. In these circumstances, a company car is treated as a ‘benefit in kind’, i.e. a benefit that is given to an employee in lieu of wages. CCT requires the individual that has the company car to pay tax at their prevailing rate of income tax upon a fixed proportion of the vehicle purchase price (which varies based upon the CO_2 emissions per mile of the vehicle) for each year that they hold the vehicle. The proportion varies by vehicle type. The 2018/19 revisions to the CCT regime narrowed the gap in CCT percentages subject to tax between ULEVs and conventional vehicles. This made ULEVs less attractive (relative to ICEs) for purchase, rental, or leasing.

However, starting from April 2020 there was a substantive shift in the CCT rate for ULEVs; they are now subject to a 0% rate for 2020-21, followed by 1 percentage point increase in the subsequent two tax years, before being frozen for an additional two tax years (up to and including 2024-25), at 2%. In our baseline, it has been assumed that the CCT rate for all vehicles (including EVs) will grow at 2 percentage points per annum until the top CCT rate of 37% is reached, in 2042.

The **Plug-in Car Grant** (PICG) is given to purchasers of vehicles, and directly impacts upon purchase prices and leasing costs. PICGs were reduced in 2018, removing entirely the grant on plug-in hybrids and reducing the grant attached to the purchase of a battery electric vehicle to £3,500. In March

2020, the government announced that this grant would be reduced in the same month to £3,000, and stay at this value until 2022, after which we assume in the baseline that it falls to £0.

Before the March 2020 Budget, the **Enhanced Capital Allowance** (ECA) allowed a firm to write off the total cost of a purchased ULEV (i.e. any vehicle which emitted less than 50 gCO_2/km) against their taxable profits in the year of purchase. At the Budget the measure was tightened, and only Zero Emission Vehicles (ZEV) are now eligible for a 100% write-off of the purchase cost. Any ULEVs which emit between 1-50 gCO_2/km can only benefit from an 18% write off, and all other vehicles above 51 gCO_2/km are eligible for the special ECA rate (6%) only. This policy makes pure electric vehicles (EVs) more attractive. In the Baseline we assume that this rate is effective from 2021 and continues throughout the projected period. In line with current policy, in the Baseline leasing companies are currently excluded from claiming ECA for their vehicles.

Value Added Tax (VAT) is a sales tax which applies to all vehicle purchases and leases. In the Baseline, the VAT is assumed to remain at its current rate of 20%.

Establishing the Baseline

The quantitative modelling framework uses historical data on the rate of change in vehicle take-up to project future responses to changing incentives. However, the coming shift to EVs is without recent precedent; as such, we adjusted the quantitative trends that the model was delivering through incorporating a short-term view. This took into account relevant latest data on sales and potential policy impacts (e.g. ensuring conformity with the 2020/21 EU emissions standards).

The calculations and assumptions to introduce each policy into the model are included in 1.11.1.1.1.Appendix C.

2.3 The additional policies modelled

The additional policies modelled are summarised in the table below.

Table 2.1: Summary of Baseline and additional policy measures

Policy instrument	Policy measures			
	Baseline	Low ambition	Middle ambition	High ambition
Company car tax	Increase 2 percentage points per year for all vehicles Remove 4% supplement for Diesel vehicles in 2021 onwards.	BEVs increase by 1 percentage point per year between 2025 and 2032. From 2033, BEVs increase by 2 percentage points per year. Remove 4% supplement for Diesel vehicles from 2021 onwards.	BEVs increase by 1 percentage point per year between 2025 and 2032. From 2033, BEVs increase by 2 percentage points per year. Remove 4% supplement for Diesel vehicles from 2021 onwards.	BEVs remain at a constant rate of 2% between 2025 and 2029. From 2030, BEVs increase by 2 percentage points per year. Remove 4% supplement for Diesel vehicles from 2021 onwards.
Plug-in Car Grant	£3,000 until 2022 and then £0 in 2023	Reduce by £1000 each year after 2022 (£2,000 in 2023, £1,000 in 2024 £0 in 2025)	Continues at £3,000 until 2025, reduces by £1,000 each year until 2028 where it drops to £0	Continues at £3,000 until 2032, then reduces by £1000 each year until 2035 where it drops to £0
Enhanced Capital Allowances	No change from today (First year allowance on purchases only in the fleet market)	First year allowance across whole fleet market from 2021	First year allowance across whole fleet market from 2021	First year allowance across whole fleet market from 2021
VAT	Current rates	No change	No change	VAT exemption for all EV sales in both markets from 2021

Low ambition scenario

In the Low ambition scenario, the CCT rate for EVs increases by 1 percentage point per year from 2025 (after the announced freeze has ended) until 2032, after which the CCT rate for EVs increases by 2 percentage point per year out to 2040. The rate applied to all other vehicles continues to increase by 2 percentage points per year from 2025. By 2030, the CCT rate for all ICE vehicles (excluding diesel economy vehicles which have a lower CO_2 emission factor) reaches the upper limit of 37%, while the rate for EVs is only 8%. In 2030 this difference equates to an increase in the annual lease cost of a petrol luxury vehicle of £4,700 in comparison to an equivalent luxury EV. Thereafter, the gap closes, as the CCT rate for EVs steadily increases, reaching 14% by 2035 and 19% by 2040.

The PICG is held at £3,000 until 2022. In the Baseline it reduces to £0 the year after (2023) but in this scenario it is assumed to be phased out more slowly; reducing by £1000 a year until it reaches £0 in 2025.

From 2021, the ECA is applied to leases within the fleet market, as well as direct purchases. In other words, the ECA policy is applicable to the entire fleet market. The ECA enables firms to write-off 100% of the purchase costs of EVs, while petrol and diesel cars need to be depreciated at either 18% or 6% per year.

Middle ambition scenario

The Middle ambition scenario includes the same policy measures as the previous scenario, with the addition of a further extension to the PICG. The PICG is assumed to continue at £3,000 until 2025, after which it is reduced by £1,000 per year, dropping to £0 in 2028.

High ambition scenario

The high ambition scenario includes a substantial step up in the ambition of the policy measures. The CCT rate for EVs is frozen at 2% between 2025 and 2029, after which it increases by 2 percentage point per year until 2040. All other vehicles increase at the Baseline rate of 2 percentage points per year from 2025. The relative gap in 2030 is thus wider than in the other scenarios. In 2030 the gap equates to an increase in annual lease cost of petrol luxury vehicles of £5,300 in comparison with its EV equivalent.

The PICG is assumed to remain constant for longer than in the Middle ambition scenario, remaining at £3,000 until 2032. The PICG value drops by £1,000 in each subsequent year until it reaches £0 in 2035.

This scenario sees the inclusion of a new policy measure: the removal of the 20% VAT rate from the annual cost of EVs for both the fleet and private market. The VAT rate is not removed from ICE vehicles.

Exogenous changes to policy scenarios

A mid-term view incorporating exogenous improvements to the take-up of EVs in the fleet market was included in each of the policy scenarios. This was informed by CE’s expectations based on the perspective of members of the BVRLA. As in the Baseline, we include incremental increases[2] in the share of EVs in new registrations in the fleet market in each of the policy scenarios.

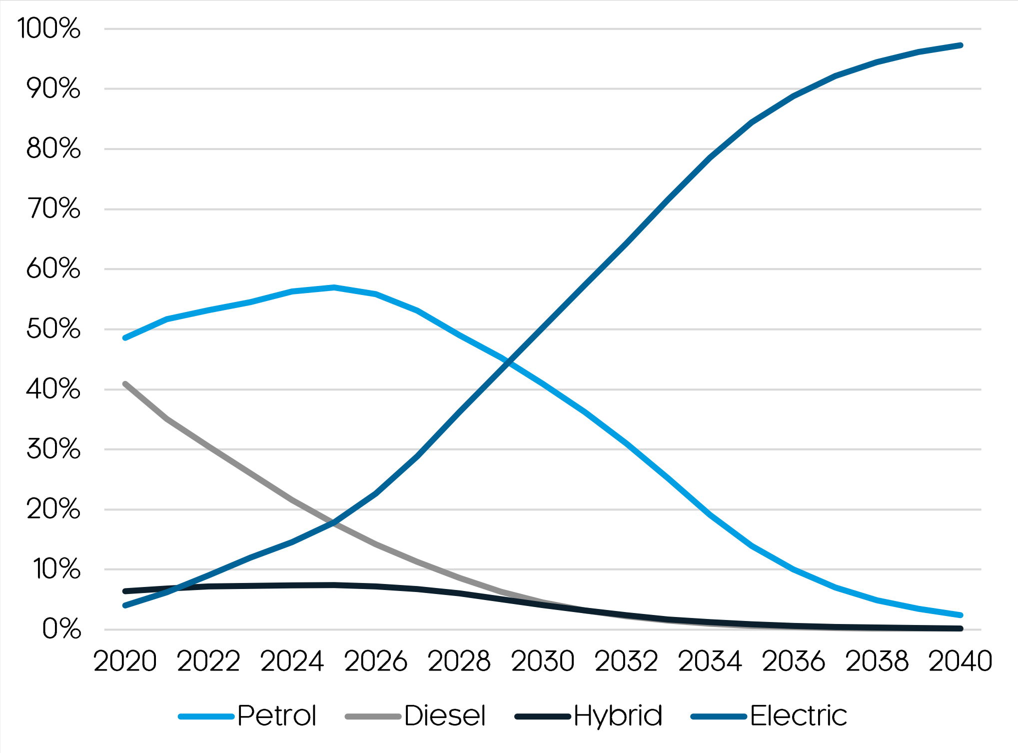
[2] These increases were on average by 3 percentage points each year between 2025 and 2030.

3 Impacts on new passenger car registrations

3.1 New vehicle registrations by powertrain in the Baseline

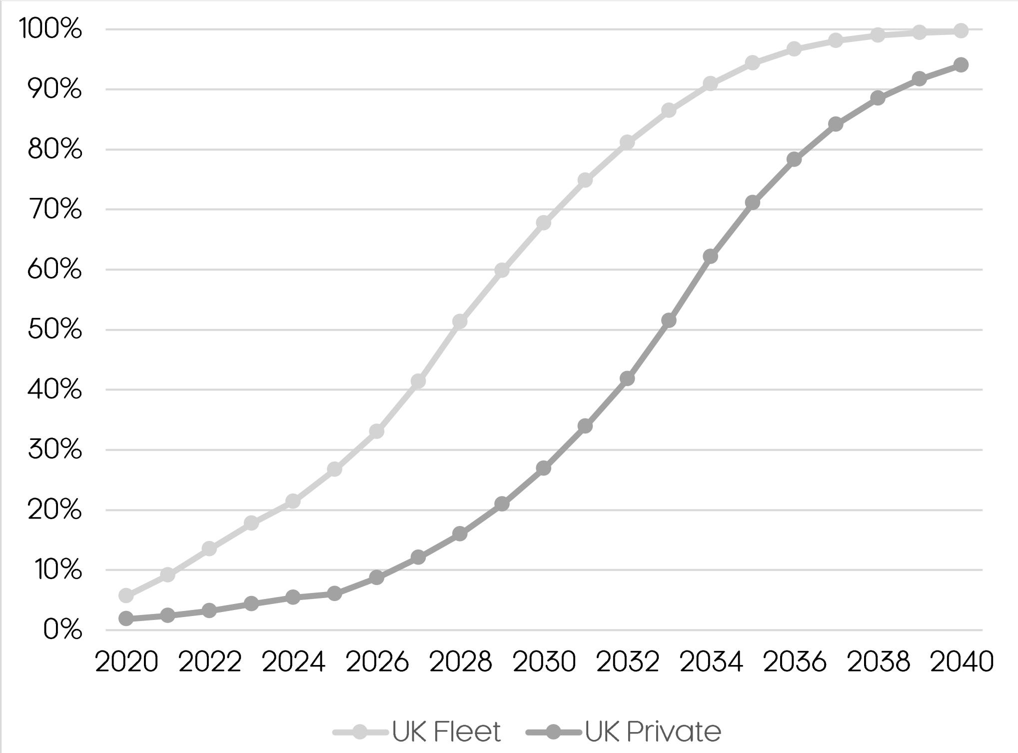
Figure 3.1 shows the evolution of new vehicle registrations by powertrain in the Baseline, which includes the policies announced in the March 2020 budget. In this trajectory diesel vehicles continue to decline as initially consumers prefer petrol vehicles. Petrol vehicles peak at 57% of registrations in 2025 before EVs start to dominate.

Figure 3.1: New registration shares by powertrain in the Baseline



The take-up of EVs in the fleet market is more rapid than in the private market. In 2030, 68% of new registrations in the fleet market are EVs, whilst they are only 27% of registrations in the private market. This equates to 50% in the whole (combined) market. By 2035, 84% of registrations across the whole market are EVs (94% fleet, 71% private) and by 2038 the share of EVs in registrations rises to 95% (99% fleet, 89% private). It is at this level (95%) that we believe a ban on the sale of non-ULEVs becomes politically acceptable.

Figure 3.2: New registration shares of EVs in different markets in the Baseline



3.2 New vehicle registrations by powertrain in the policy scenarios

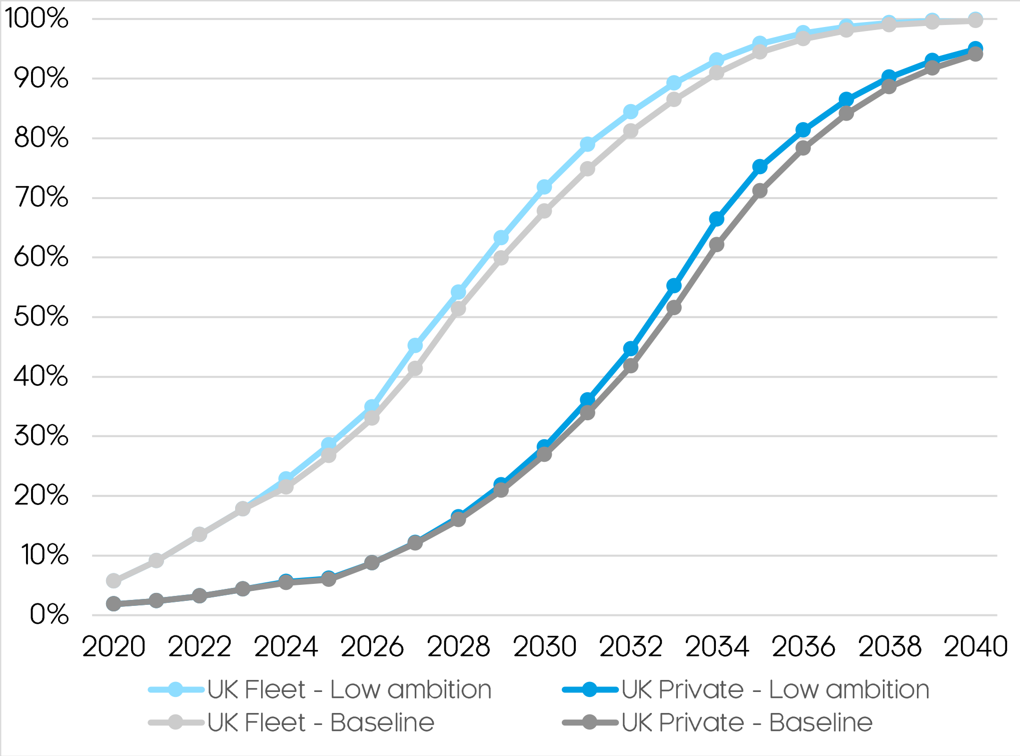
Low ambition

In the Low ambition scenario, compared to the Baseline, there are three key policy differences. These differences are:

- A 1 percentage point per annum increase in the CCT rate for EVs between 2025 and 2032. Starting in 2033, the CCT rate for EVs increases by 2 percentage point per annum. The CCT rate change reduces the annual leasing cost of EV vehicles in the fleet market.
- The PICG is phased out over 2023-25 instead of an immediate removal in 2023. This reduces the cost of EVs in both the fleet and private market in 2023-25; but as this is phased out the cost of EVs returns to baseline level in both markets.
- The ECA is introduced into the leasing segment of the fleet market, whereas in the Baseline it is only applicable to purchases within the fleet market. This reduces the cost of EVs in the fleet market.

This results in minor increases in the share of EVs in new registrations compared to the Baseline. In 2030, the share of EVs in new registrations in the whole market increases by 3 percentage points to 53% (72% fleet, 28% private). In 2035, the share of EVs in new registrations in the whole market increases by 3 percentage points from 84% in the baseline to 87% in this scenario (96% fleet, 75% private). However, by 2038 the outcomes converge, as most policy measure differences in this scenario are removed, and the share of EV registrations in the baseline reaches high levels, thereby offering little additional incentive to lease EVs.

Figure 3.3: New registration shares of EVs in different markets in the Low ambition scenario

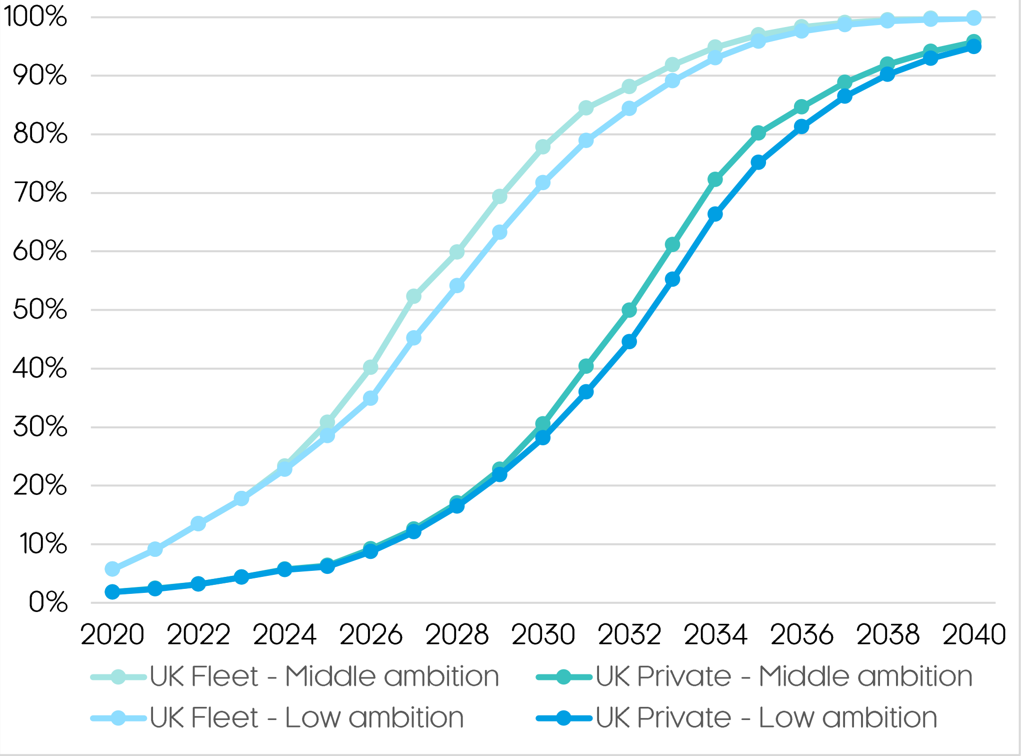


Middle ambition

The Middle ambition scenario includes a further extension to the PICG. The CCT and ECA remain as in the Low ambition scenario. In the Middle ambition scenario, the PICG is extended to 2025 and phased out over 2026-28. This keeps the cost of EVs lower, and therefore makes them more attractive, in both the fleet and private market.

Compared to Low ambition scenario, this results in 5 percentage point increase in the share of EVs in new registrations – up to 58% in the whole market in 2030 (78% fleet 31% private). In 2035, the share of EVs in new registrations in the whole market is 90% (97% fleet, 80% private), up 3 percentage points from the Low ambition scenario. The share of EVs in new registrations in the whole market reach 95% in 2037, one-year earlier than in the Low ambition scenario.

Figure 3.4: New registration shares of EVs in different markets in the Middle ambition scenario



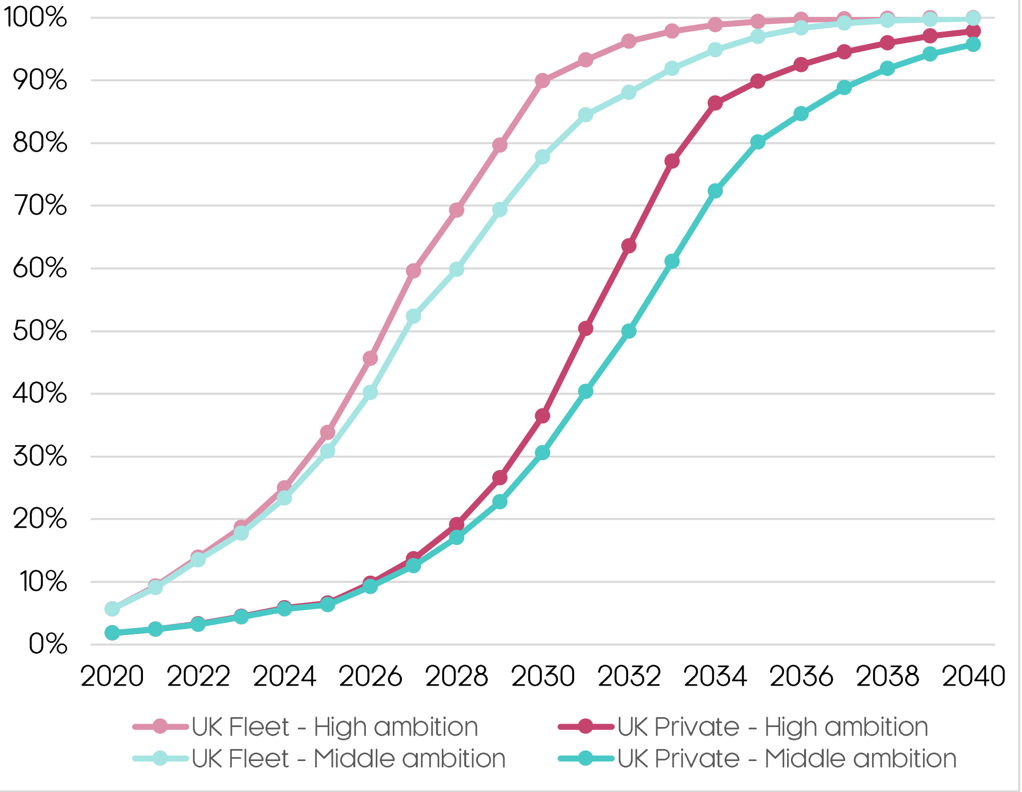
High ambition

The High ambition scenario has the largest policy 'asks' of any modelled. Apart from the ECA, which is unchanged compared to the previous two scenarios, all other policies increase in ambition.

- CCT rate for EVs are frozen between 2025 and 2029, remaining at 2%, after which they increase by 2 percentage points per annum until 2040. This means that there remains a substantial gap in the tax applied to EVs compared to other vehicles throughout the period.
- The PICG is extended to 2032 and phased out over 2033-35. As in the other scenarios, the PICG affects costs of EVs in the fleet and private market.
- From 2021, VAT on EVs in both markets is removed. This reduces the annual costs of vehicles in both markets.

The policies in this scenario accelerate the take-up of EVs in comparison to the Middle ambition scenario. In 2030, EVs are 67% of new registrations across the whole market (90% fleet, 36% private), an increase of 9 percentage points compared to the Middle ambition scenario. In 2035, EVs reach 95% of new registrations in the whole market (99% fleet, 90% private), two years earlier than in the Middle ambition scenario. This level is sufficient to support the government proposal of a total ban on new ICEs sales in 2035. After 2035, the rate of take-up flattens, as technology laggards are slow to adopt EVs.

Figure 3.5: New registration shares of EVs in different markets in the High ambition scenario



4 Impact on emissions

4.1 Emissions in the baseline

In the Baseline emissions of CO_2, NO_x and PM2.5 exhaust emissions[3] all fall over time. This is the result of two baseline trends; first, the increasing prevalence of zero-emission vehicles, and second, increasing fuel efficiency of ICE vehicles. The latter effect can be particularly pronounced when there are specific emission standards which mandate such improvements (e.g. the EU CO2 emissions standards for 2020/21 and beyond).

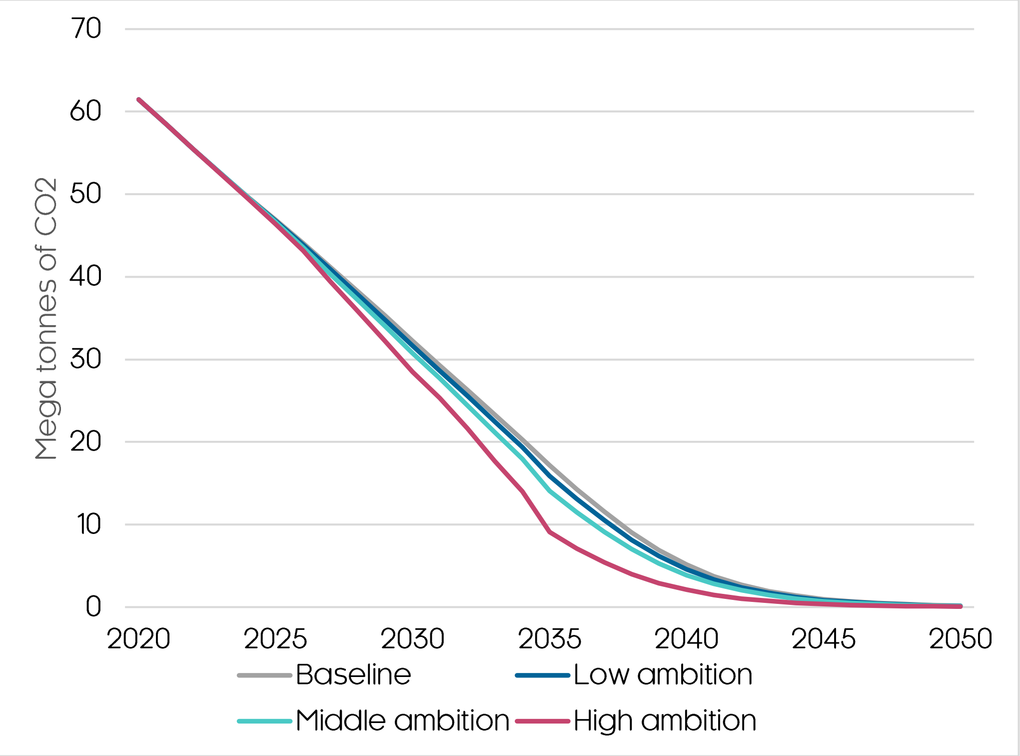
Note that the charts in this section show changes in emissions out to 2050. Although additional policies are not modelled past 2040, the scenarios will continue to benefit from reduced emissions due to the higher prevalence of EVs in the vehicle parc, until the point at which all of the Baseline vehicle stock is EVs.

4.2 Changes in emissions in the policy scenarios

CO_2 emissions

Over the period 2020-50, emissions are 12Mt CO_2 lower in the Low ambition scenario compared to the Baseline, equivalent to 1.8% of total CO_2 emissions over this period in the Baseline. Over the same period, emissions are reduced by 30Mt CO_2 emissions in the Middle ambition scenario compared to Baseline, equivalent to 4.3% of total emissions. Finally, in the High ambition scenario emissions are 72Mt CO_2 lower, equivalent to 10.4% of total CO_2 emissions in the Baseline.

Figure 4.1: Reduction in CO_2 exhaust emissions



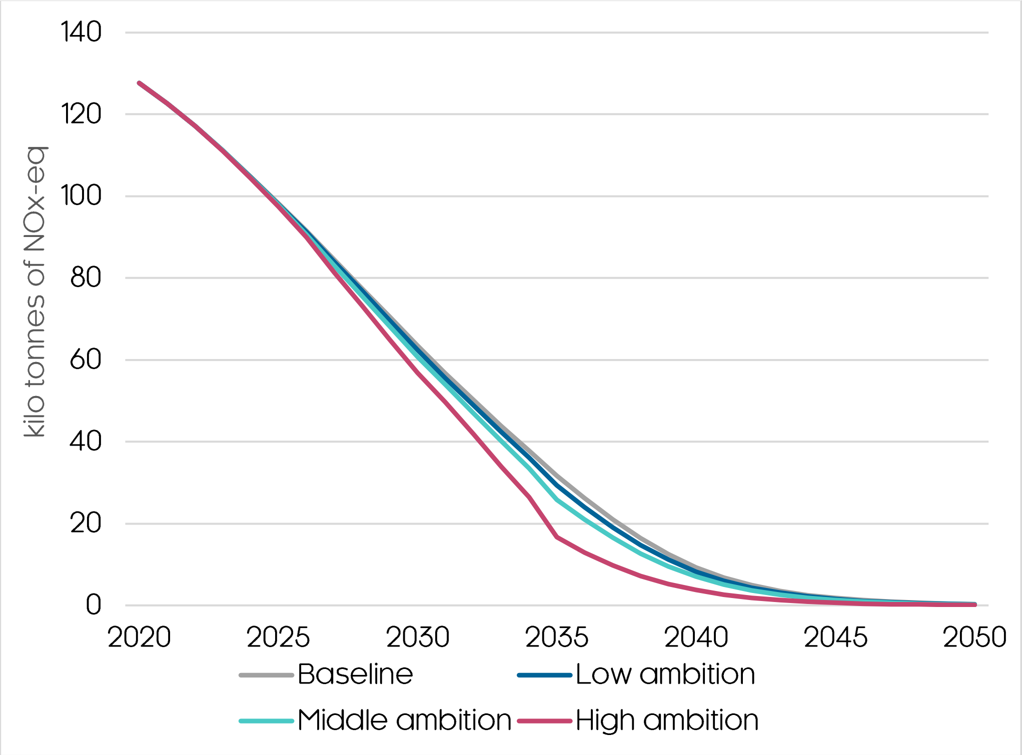
[3] The quantification of emissions in this project focus solely on exhaust emissions, and not emissions that can arise from other elements of road transportation (e.g. tyre wear) or downstream emission (e.g. vehicle manufacturing)

NO_x emissions

Over 2020-50, emissions are 23 kilo tonnes (kt) of NO_x-equivalent (eq) lower in the Low ambition scenario compared to the Baseline, equivalent to 1.6% of total NO_x emissions over the period in the Baseline. Over the same period, emissions are 54kt NO_x-eq lower in the Middle ambition scenario compared to the Baseline, equivalent to 3.9% of total NO_x emissions in the Baseline. In the High ambition scenario, emissions are 130kt NO_x-eq lower compared to the Baseline, equivalent to 9.3% of total NO_x emissions in the Baseline.

As with CO_2 emission, the NO_x emission reduction over the projected period are restricted by efficiency improvements and EV take-up in the Baseline.

Figure 4.2: Reduction in NO_x exhaust emissions

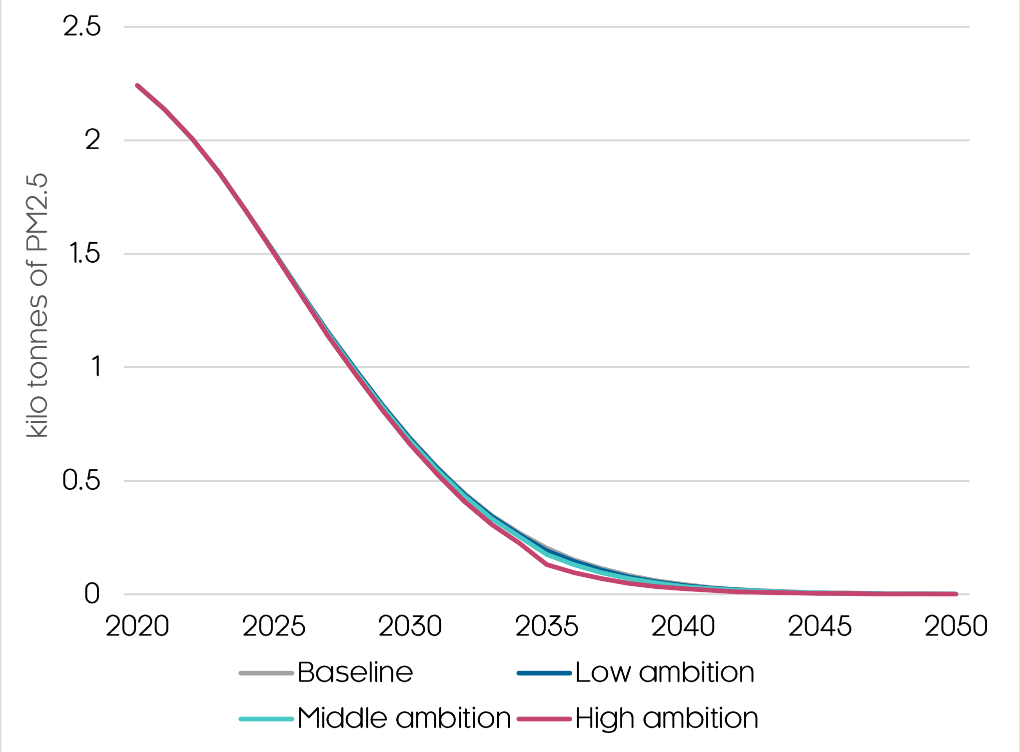


PM2.5 emissions

Over the period 2020-50, emissions are 0.1kt PM2.5 lower in the Low ambition scenario compared to the Baseline, equivalent to 0.5% of total PM2.5 emissions in the Baseline. Over the same period, emissions are 0.21kt PM2.5 lower in Middle ambition scenario compared to the Baseline, equivalent to 1.1%. In the High ambition scenario, emissions are 0.5kt PM2.5 lower to the Baseline, equivalent to 2.7% of total PM2.5 emissions in the Baseline.

The overall reductions in PM2.5 emissions in the policy scenarios compared to Baseline is low due to the fact that before the EV roll-out gathers pace there is already a shift towards petrol vehicles (see Figure 3.1). Petrol vehicles produce much lower volumes of PM2.5 emission compared to their diesel counterparts. Therefore, as EVs are chosen over petrol vehicles, the improvement in PM2.5 emissions is less pronounced.

Figure 4.3: Reductions in PM2.5 exhaust emissions



5 Cost benefit analysis of policy scenarios

Cost benefit analysis (CBA) is a tool to help policy makers evaluate the relative merits of policies on an equivalent basis. They weigh up the monetised costs against the monetised benefits to show relative returns. They are subject to extensive critique, including the importance of chosen methodology for monetisation, their use of discounting and the lack of treatment of uncertainty, amongst other factors[4]. In that light, such an approach should be considered with caution. Given the current Government's commitment to achieving net zero in 2050, and an ICE phase out, the key question to policy makers is probably not *whether* such a thing should be achieved, but *how* it might be achieved, and what will it cost the government to deliver it.

The benefits initially occur in non-monetary units (e.g. reduced air pollution). Carbon emissions and air quality (NO_x and PM2.5 emissions) have been monetised based on values from the HM Treasury Green Book and DEFRA, respectively. However, there is substantial uncertainty surrounding the impact of reduced particulates on air quality, and the valuation of improved air quality, which is reflected in the large lower and upper sensitivity bounds of the coefficients provided by DEFRA. The central estimates have been used in this report.

In addition, the economic impacts of this transition are out of scope in this analysis. Not including these effects means that the impact, for example, on job creation from vehicle manufacturing or battery production is not included.

The CBA of the Middle ambition and High ambition scenario are presented below. The policy is costed based upon the costs of each policy 'per vehicle' multiplied by the difference in sales (by powertrain and vehicle size) between the relevant scenario and Baseline. Thus, all costs and benefit are assessed relative to the Baseline.

The incremental impact on EV sales of each individual policy is not reported. It is not possible to calculate the individual impacts in isolation, because the policies have a combined (and non-linear) effect on the sales of EVs. A given policy would have a bigger impact on EV deployments if it is the 'first' policy, compared to if it is the 'last' policy implemented in the model.

There are two important concepts that aid the interpretation of the results in this analysis:

- Discounted vs. non-discounted: Discounting captures the logic that people care more about the present than they do the future. A person would prefer to receive £1 today, to receiving £1 tomorrow. This time preference is captured by the discount rate. The cost of policies in a scenario are discounted so that expenditure in the future is given a lower weight than expenditure today.

[4] See, for example, Ackerman, F., (2008) *Critique of Cost-Benefit Analysis, and Alternative Approaches to Decision-Making*

- Annual vs. cumulative: Annual costs are a snapshot of policy cost in a given year, irrespective of the cost in the previous year or the subsequent year. Cumulative costs are the summation of costs in each year throughout the period.

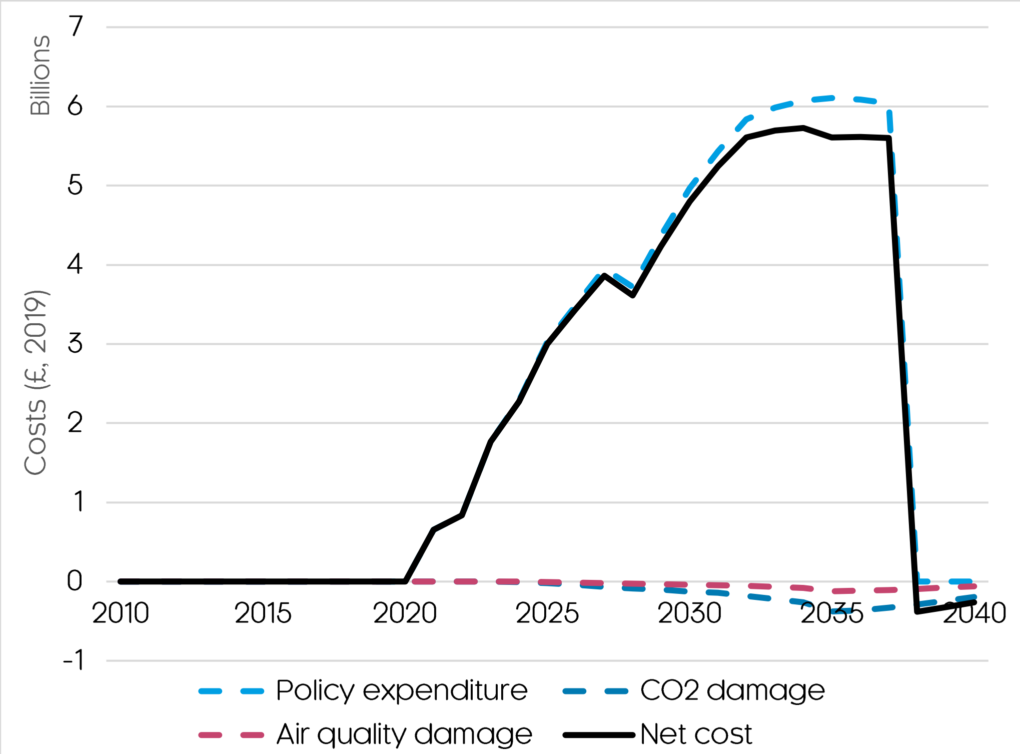
5.1 The net cost of policy in the scenarios

Cost Benefit Analysis is presented here only for the Middle and High ambition scenarios. The policies implemented in the Low and Middle ambition scenarios were very similar, with only a temporary extension of the PICG grant the difference, and a minimal difference in the take-up of EVs; therefore the costs of the Low ambition scenario can be assumed to be broadly similar to those of the Middle ambition scenario presented directly below.

Middle ambition

Once the benefits of improved air quality and CO_2 damage have been included, the net cumulative undiscounted cost of the Middle ambition scenario over the period 2020-50 is £66 bn. This is represented by area under the black line in Figure 5.1 below[5]. When this value is discounted, at the standard Green Book discount rate of 3.5%[6], the net cumulative discounted cost over the same period is £45 bn.

Figure 5.1: Annual undiscounted CBA in Middle ambition scenario relative to baseline



[5]The chart ends at 2040, since the policies have already reduced to zero, but policy is costed up until 2050 because there are still minor benefits from a reduction in emission damages as the vehicle stock tends to 100% EVs.

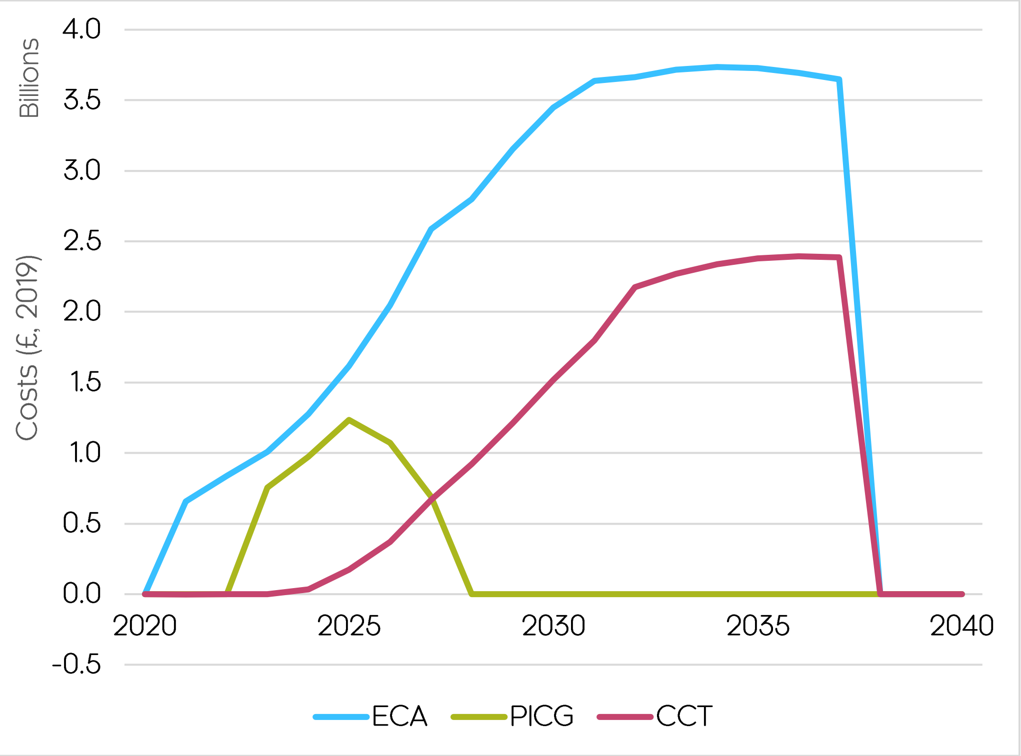
[6] The official rate as per the HMT Green Book.

In 2037, the share of EVs in new registrations in the whole market reaches 95%. We consider this to be an accepatable position from which the government can impose an ICE ban, thus reducing the need for policies which incentivise take-up. Therefore from 2037, we assume that the costs of all supporting policies fall to £0; at this stage, policies to support EVs are simply encouraging (or otherwise) the owning and running of motor vehicles, rather than explicitly supporting EVs.

The majority of the policy cost comes from the ECA. The ECA allows fleet operators to write-off 100% of the purchase cost of EVs for tax purposes; as a result, as the demand for EVs grows, the government receive less tax revenue (an increase in their costs).

The second largest contributor to policy costs is the CCT. This has been done to capture the potential changes the government may implement as EVs become established as the dominate vehicle choice. After 2032, EVs achieve 90% of sales in the fleet market. By then we expect a sufficient amount of supply, infrastructure and preferences to continue the demand for EVs even when the CCT rates begin to rise. In other words, the policy ceases to be about incentivising EV take-up and the rates can begin to converge to those of ICEs. The individual undiscounted annual cost of each policy is shown in Figure 5.2.

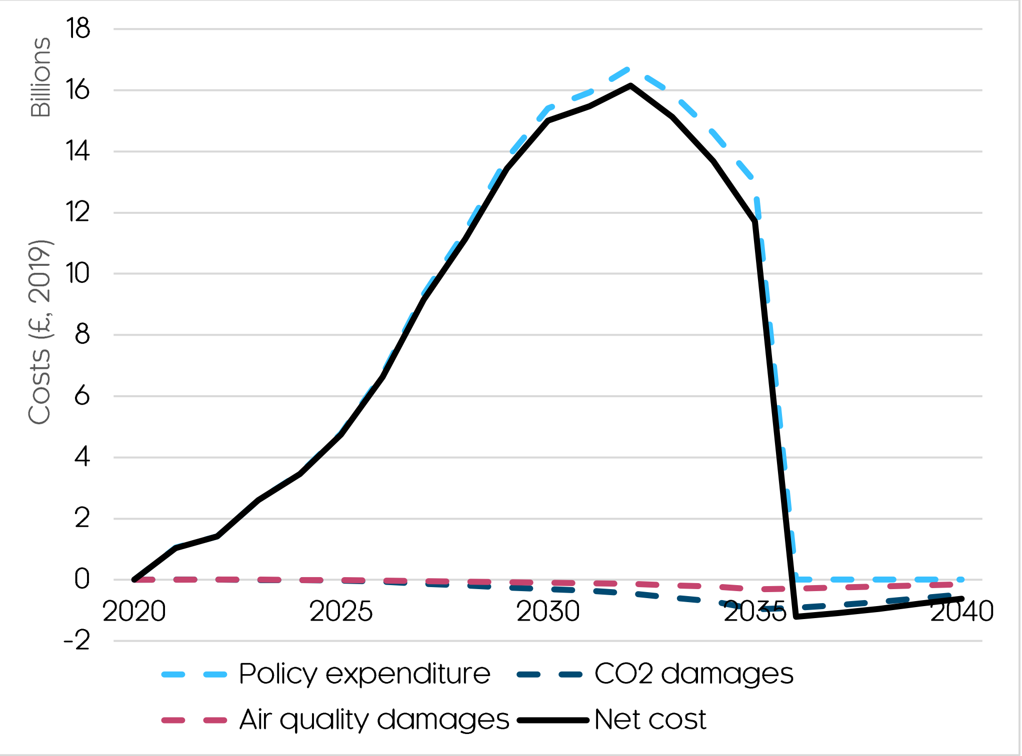
Figure 5.2: Annual undiscounted cost of Middle ambition policies relative to baseline



High ambition

The cost of the High ambition scenario is over twice as much as the Middle ambition scenario. The net cumulative undiscounted cost of this scenario over the period 2020-50 is £134 bn (including the improvements in air quality and CO_2 emissions). When discounting is applied the expected cumualtive net cost is £95 bn.

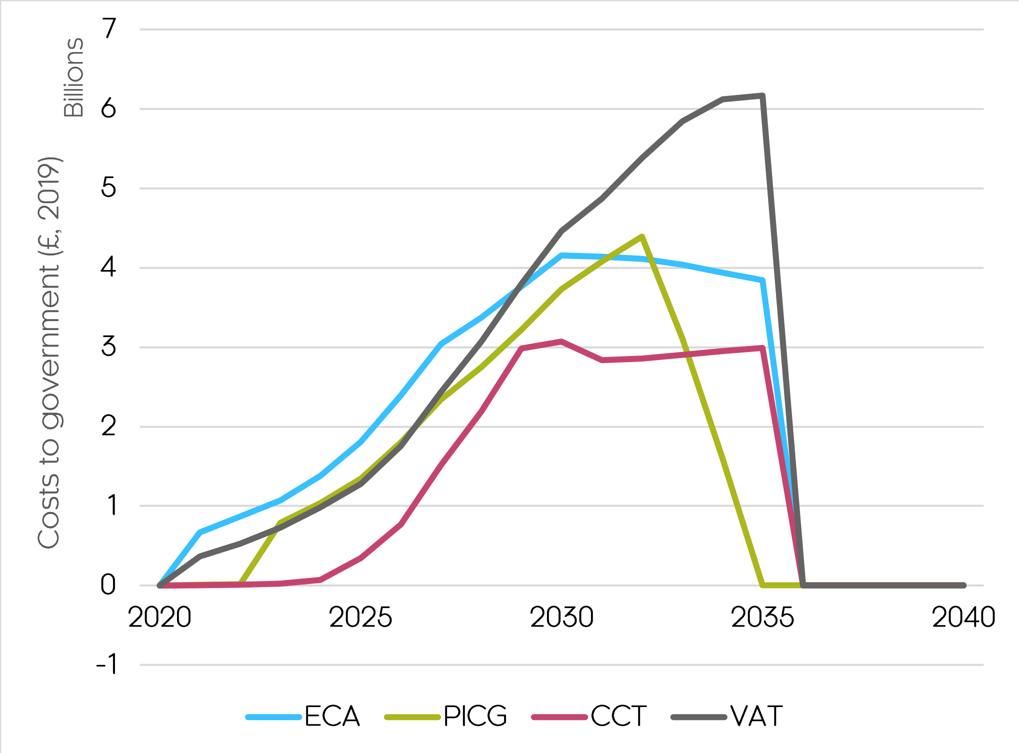
Figure 5.3: Annual undiscounted CBA in High ambition scenario relative to baseline



In the High ambition scenario, we assume that sales of ICEs are banned from 2035, so from 2036 onwards policy costs fall to £0, as incentive policies are no longer necessary.

The introduction of the VAT exemption is the most expensive policy, partly because it is a measure which affects all EV sales across both the private and fleet markets.

Figure 5.4: Annual undiscounted cost of High ambition policies relative to baseline



6 Conclusions

In this analysis, we have set out the potential trajectory of EV registrations under current policy, and how more ambitious policy could influence the take-up of EVs, and bring forward the date by which the Government could realistically propose a complete ban on the sale of new ICE vehicles.

The Government has a statutory target to reduce greenhouse gas emissions such that they are net zero by 2050. This will require the complete removal of tailpipe emissions from passenger cars across the entire fleet by the same year. The Government is committed to phasing out the sale of cars and vans with combustion engines (including hybrids) by 2040 and is currently consulting on bringing this forward to 2035. Both the Committee on Climate Change and the National Infrastructure Commission have said that the sales ban should be brought forward to 2030.

The impacts of COVID-19 and the associated economic shutdown have already led to a sharp reduction in vehicle sales in the first half of 2020. Supporting policy aiming to stimulate the industry provides a major opportunity to specifically encourage the uptake of electric vehicles.

Recent changes to company car tax mean that the economics have now tipped sharply in favour of EVs in this market company car market, and the fleet market is expected to lead the private market going forwards in all scenarios analysed.

Current policies look set to deliver a transition whereby 95% of registrations in 2038 are EVs. At this level, we believe that an outright ban on the sale of new ICE (and hybrid) vehicles is politically feasible. Achieving a more rapid transition, in line with stated Government aims, requires strong incentives to overcome the slow rate of changing consumer preferences, given the relatively slow rate of vehicle parc renewal outside of the fleet market.

Our analysis shows that such a transition is possible but comes at a considerable fiscal cost. In our ‘high ambition’ scenario EVs reach 95% of new registrations in 2035, making a phase-out in this year possible. This scenario relies on a range of supporting policies, including maintaining a strong differential in CCT rates between EVs and other vehicle types, a long-term commitment to the plug-in car grant for EVs, a reduction in purchase taxes through extension of the Enhanced Capital Allowances to lease vehicles and a VAT exemption for EVs. As in all our scenarios, the fleet sector would lead the way - 90% of fleet sales in 2030 would be EVs, and 99% by 2035.

The net cumulative discounted cost to government is £95 bn (including the improvements in air quality and CO2 emissions) over the period 2020-50. Annual policy costs (i.e. just the reduced revenues to government, not including monetised benefits) peak at £16.7bn in 2032, which is equivalent to just less than 2% of total government expenditure in 2019.

Appendix A Modelling framework

The requirements

To address the research questions in the previous chapter the quantitative tools needed to meet specific requirements:

- To provide a way of modelling future vehicle take-up by powertrain given different costs for different vehicle types
- To allow the use of policy levers which affect costs, and therefore leasing and purchasing decisions
- Separate fleet and private markets, so that take-up in the two markets could be tracked on the basis of market-specific policies.

FTT:Transport

The modelling framework which meets the requirements of this project was centred around an existing model that Cambridge Econometrics has licensed use of, the FTT:Transport model. This model, developed by Mercure and Lam (2018)[7], projects future shares of the total passenger car market by vehicle type, ranging from conventional ICEs to electric vehicles.

The drivers of technology take-up

The diffusion of technology depends upon four key components:

- **Purchase decisions:** The model mimics the decisions of households by making pairwise cost comparison between available technologies. The pairwise comparisons of technologies, which is conceptually similar to a binary logit model, is carried out for each technology. Households make investment decisions on the basis of comparing technology costs, given a distribution of costs (explained in more detail below). Costs of technologies are calculated on the basis of the Levelised Cost of Transportation (LCOT)[8].
- **Distribution and reduction of costs:** Purchasers in the model are heterogenous, i.e. they face different operating costs/use cases and have different preferences, which is captured by a distributed LCOT curve. The inclusion of a distribution curve means that even though the 'average' economics of tip in favour of one technology, it cannot go from a position of low market penetration to high penetration in a short period of time (i.e. not all purchasers will immediately invest in the lowest-cost technology). In contrast with models which assume that users have homogenous preferences, i.e. that all users experience the same costs and all invest in the lowest cost technology, FTT:Transport's distribution curves mean that only a certain proportion of the population experience a lower cost when 'average' costs are lower, due to their use case and specific preferences.

[7] Mercure, J.-F., Lam, A., Billington, S. & Pollitt, H. Integrated assessment modelling as a positive science: private passenger road transport policies to meet a climate target well below 2 degrees C. Preprint at https://arxiv.org/abs/1702.04133 (2018).

[8] The Levelized Cost of Transportation (LCOT) combines all relevant cost components (capital cost, operating and maintenance cost, fuel costs, taxes, and subsidies, plus a discount rate) of the vehicle into one single metric.

For example, in innovation theory the population is split into different consumer groups, early adopters, majority, and laggards. Early adopters have a high preference for new technology and are willing to accept higher costs in order to own it. Due to the presence of distributed LCOT, and cost reductions as global take-up of technologies increases, the model produces S-shaped deployment curves.

- **Government policy:** The LCOT of each vehicle type can be influenced by government policy, to aid the penetration of certain vehicles types into the stock through market-based instruments (taxes/subsidies), and/or restrict vehicle types from being purchased (regulation).
- **Current market shares:** The current share of technology in the market influences future take-up. It models the behaviour that purchasers' decisions are influenced by what is available on the market (e.g. what is available in the showroom) and what the most popular technology is (i.e. technology with the highest market share). These conditions help attract future purchases of the same technology creating "path dependence".

Core model functionalities required

Central to this analysis is the impact of policies on the fleet market and how those influence investment decisions. In total, there are three core functionalities essential to this project:

- **Separate markets:** There are two markets that distinguish the types of consumers and therefore the associated policies; a UK private market made of vehicles primarily for personal use by private individuals, and the UK fleet and business market, consisting of companies that operate a fleet of 25 or more vehicles and companies that operate up to 24 vehicles, respectively.
- **Leases vs. purchases**: The decision making module captures the dynamics of the UK markets; in both the fleet and the private market, decisions are based on leasing behaviour, reflecting the fact that 91% of purchases in the private car market are based on a form of financing[9], which removes the constraint of higher capital costs.
- **Links between markets**: We assume that once fleet leasing contracts finish the vehicle enters the 2nd hand private market. This ensures that network effects are adequately captured (more EVs in the stock help to influence behaviour in the next period).

[9] Finance & Leasing Association. Facts and figures, Accessed here: https://www.fla.org.uk/media/facts-and-figures/

Dimensions

The FTT:Transport includes seven different vehicle technology types and two to three different engine sizes: 25 different vehicle options in total (Table A.1). Note, that for the purpose of this project Electric vehicles represent pure Battery Electric Vehicles (BEV) and Hybrid vehicles represent both Hybrid Electric Vehicles (HEV) and Plug-in Hybrid Electric Vehicles (PHEV).

Table A.1: Vehicle types captured in FTT:Transport

Technology type	Engine size
Petrol	Econ, Mid, Lux
Advanced Petrol	Econ, Mid, Lux
Diesel	Econ, Mid, Lux
Advanced diesel	Econ, Mid, Lux
CNG	Econ, Mid, Lux
Hybrid	Econ, Mid, Lux
Electric	Econ, Mid, Lux
Bikes	Econ, Lux

The model covers 61 countries, including the UK, up to 2050. The model calculates the market share of each technology and engine size to meet a projection of private LDV passenger-km (i.e. the total demand for passenger car transport) in each country. Once the market share is determined, the model calculates the associated fuel demand and exhaust emissions.

Emissions

FTT:Transport includes tailpipe emissions factors for CO_2, NO_x and PM2.5. In addition to the tailpipe emissions, to carry out the CBA it was necessary to source and calculate the equivalent costs related to these emissions, using damage coefficients for NO_x and PM2.5 from DEFRA (2019)[10] and the social cost of carbon for CO_2 from the HM Treasury Green Book.

The assumptions and data sources for the model's core functionalities and emissions can be found in Appendix B below.

[10] Ricardo. Air Quality damage cost update (2019).

Appendix B Model development assumptions and data sources

Introduction of UK fleet market

Method overview and assumptions

The UK fleet market was added to the model. Each market in FTT:Transport requires three exogenous assumptions; transport demand (vehicle kilometres (v-km)), sales and historic stock. Therefore, the base data for the UK (whole market) was split out. In projection years, it is assumed that the split in the last year of history (2018) is constant for the whole projected period. This assumption was supported by the fact that historic shares observed in the data experienced little change.

Table B.1: Historical share of stock

	2012	2013	2014	2015	2016	2017	2018
Private	92%	91%	91%	91%	91%	91%	91%
Fleet	8%	9%	9%	9%	9%	9%	9%

Table B.2: Historical share of sales

	2012	2013	2014	2015	2016	2017	2018
Private	44%	46%	46%	45%	44%	42%	43%
Fleet	56%	54%	54%	55%	56%	58%	57%

Table B.3: Historical share of transport demand

	2012	2013	2014	2015	2016	2017	2018
Private	n/a	n/a	n/a	n/a	81%	81%	81%
Fleet	n/a	n/a	n/a	n/a	19%	19%	19%

Data sources

Historical share of stock was available from Department for Transport (DfT) ‘Licensed cars at the end of year by keepership (private and company): Table VEH0202’.

Historical share of sales was sourced from DfT ‘Cars registered for the first time by keepership (private and company): Table VEH0252.

Historical transport demand (v-km) by market segment was estimated by multiplying the historical stock by the annual mileage from DfT National Travel Survey: ‘Annual mileage of cars by ownership and trip purpose: Table NTS0901’.

Leases vs. purchases

Method over and assumptions

In both markets it is assumed private and fleet consumers do not purchase vehicles but instead decided to lease them. This is to represent the most common form of vehicle acquisition in the UK; 91% of private passenger vehicles are either leased or purchased on finance deals. Two assumptions have been introduced into the cost calculations to mimic this behaviour.

- Leasing fee
- Length of contract

To determine the leasing fee (cost) first a scaling factor was derived based on the ratio between quoted purchases price and their corresponding leasing fee of archetype vehicles. The average scaling factor across the different vehicle prices was 0.016. This was then applied to the purchase prices available in FTT:Transport and multiplied by 12 to reflect the equivalent annual payments referred to as the annual leasing cost. The leasing fee included maintenance costs. The leasing fee is assumed to remain constant throughout the length of the contract.

The average length of a leasing contract is between 39-40 months. As the model solves annually, a three-year contract was assumed. This means that the cost calculation assumes three years of ownership before vehicles are sold into the second-hand market.

Data sources

Quoted purchase prices and corresponding leasing fee was made available from GKL Leasing (a member of the BVRLA) Contract Hire Quotation created on 16/12/19.

The length of contract was sourced from the BVRLA's Quarterly Leasing Survey (Q2, 2019).

Including NOx and PM2.5 emissions and damage coefficients

Method overview and assumptions

The first step was to define the weighted average PM2.5 and NO_x emission factors for each technology type in the current fleet. This was estimated by multiplying the vehicle age cohort by the specific emission factor. For example, if 1,000 vehicles were 5-year-olds in 2012, 1,000 vehicles were new sales in 2007. And if the emission factor (Euro 4) was 0.001 in 2007, then 1,000 vehicles out of the current stock will have this emission factor. This process was done for each vehicle age group and then summed together. Once the average weighted emissions factors were calculated these were entered into the model to estimate the PM2.5 and NO_x emissions for the entire fleet in the Baseline. The historical values outputted by the model were then calibrated using real historical data from the DfT on exhaust emissions. The calibration factor (different between historical and estimated data) was then used for the projected period.

Data sources

Historical emission factors by technology types was source from the EMEP/EEA air pollutant emissions inventory guidebook 2016 (EEA, 2018).

Real historical emissions for NOx and PM2.5 were sourced from DfT 'Air pollutant emissions by transport mode: United Kingdom, from 1990-2017: Table ENV0301'.

Damage coefficients and social cost of carbon

Method overview and assumptions

The damage coefficients and social cost of carbon express the monetary cost associated with a particular unit of emissions. The price base of the costs was updated to 2019 constant prices then multiplied to the emissions calculated by the model.

Data sources

PM2.5 and NOx damage coefficients were sourced from Ricardo's report for Defra 'Air Quality damage cost update' (2019).

The social cost of carbon and GDP deflator were sourced from HM Treasury's 'Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal'[11].

[11] Accessed here: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

Appendix C Policy assumptions

This Appendix includes the calculations and assumption in order to model the different policies in this project.

Company Car Tax

The CCT rates were used to calculate the value of the tax due for each vehicle (v).

$$CCT\ value_v = CCT\ rate_v * Personal\ Tax\ Rate * Lease\ cost_v$$

The CCT rate was multiplied by the personal tax rate and the lease cost of the vehicle. The personal tax rate was assumed to be at the lower rate (20%) for economy vehicles and the higher rate (40%) for medium and luxury vehicles. The CCT value was implemented as an additional cost to the price of the vehicle and was included in each year of the leasing contract.

Enhanced Capital Allowances

The ECA enables a firm to write-off the costs of purchases against their profits. The extent to which this saving is passed on to the consumers depends on the firm. We have assumed that 50% of the write-off is passed through to consumers. To include the ECA for the leasing segment in this market a reduction factor is needed in order to scale down the potential saving as to represent the policy being included for only a proportion of the entire fleet market. The assumption was the share of company fleet leased vehicles (1.8 million[12]) in the entire fleet (2.7 million[13]) equivalent to 68%.

$$ECA\ value_v = ECA\ rate_v * Lease\ cost_v * Pass\ on\ rate * Share\ of\ leases\ in\ fleet\ market$$

VAT

The inclusion of VAT exclusions involves netting out the VAT value in the lease cost of EV vehicles in both markets. First the VAT value is calculated at the prevailing VAT rate of 20%:

$$VAT\ value_v = \frac{Lease\ \mathrm{cost}_{\mathrm{EV}}}{1 + VAT\ rate}$$

The value of the VAT is subtracted from the annual lease cost of EV vehicles throughout the lease contract in the fleet market and private market.

[12] Company True Business and Fleet Cars (excluding purchases) (estimated by the BVRLA from SMMT/MVRIS/BVRLA numbers)

[13] All Cars registered to Companies (DfT/DVLA)