Greenpeace

The impact of a 2030 ICE phase-out in the UK

Final Report

November 2020

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Contents

Executive Summary

In this analysis, the impact of a more rapid phase out of the sale of internal combustion engine (ICE) cars and vans in the UK has been assessed.

- Two uptake scenarios have been modelled, a baseline consistent with a 2035 phase-out of ICEs (including hybrids and plug-in hybrids), and a central accelerated scenario, which phases out ICEs in 2030. Both have been modelled using ECCo, an EV uptake model which is also used by the UK Department for Transport for policy design. For both scenarios, representative policy environments have been developed to meet each the respective phase out dates. These include: a roll-out of charging infrastructure to provide blanket access by the phase out date; and average new car/van CO_2 targets which gradually decrease to 0 gCO_2/km by the phase out. In the case of a 2030 phase out, a gradual increase in first year Vehicle Excise Duty, banded by CO_2 emissions, was also needed.
- Growth in ultra-low emission vehicle sales is driven almost exclusively by battery electric vehicles, with sales far outstripping those of plug-in hybrids and H_2 fuel cell vehicles during the 2020s. This is a result of a rapid fall in battery costs, making battery electric vehicles a highly cost-competitive proposition. Under a 2030 phase out of ICEs, 90% of the car and van stock is zero-emission by 2040.
- A phase out of ICEs will require a rapid deployment of charging infrastructure. The vast majority of this will be at drivers' homes. But work and public charging is needed for the quarter of drivers without access to off-street parking, as well as to enable BEV to drive long-distance. Under a 2030 phase out of ICEs, by 2030 the UK would require 1.2m work, 240k slow public (3-22kW) and 62k rapid public (>50kW) charge points, as well as 13m home charge points. Between 2020 and 2040, the earlier phase out date requires £7bn more in infrastructure investment versus a 2035 phase out.
- The more rapid transition is expected to create additional economic activity and jobs in the UK; GDP could be up to 0.2% higher, and an additional 32,000 jobs created across the economy in 2030. This is primarily a result of lower demand for imported fossil fuels; the improved efficiency of electric vehicles (and lower tax rates) results in lower overall costs of mobility, and as a result higher consumer spending on electricity (for fuel) and other consumer goods and services.
- The impacts do not play out evenly across the economy. Under the accelerated phase-out, the motor vehicle industry loses jobs more rapidly before 2035 as a result of the more rapid shift away from conventional ICE vehicles. The increase in employment is focussed in (consumer) services, but jobs are also created in the manufacture of both consumer goods and charging infrastructure, as well as the installation of the latter.
- The more rapid transition to low carbon vehicles will lead to a decline in Government tax revenues from car and van owners, driven primarily by a fall in fuel duty revenues. However, the overall economic gains lead to increased revenues elsewhere in the economy, particularly from income

tax, which could lead to government revenues £1.9bn higher in 2030 than in the baseline. Our modelling assumes that this money is channelled back into the economy through tax cuts, although the UK Government could elect to use this money to reduce borrowing, which would slightly reduce the positive economic impacts (to a GDP increase of 0.13% above baseline, and employment 27,000 higher, in 2030).

- If the UK motor vehicle industry, with support from UK Government, can leverage the more rapid transition to improve their competitiveness, there could be substantial potential economic benefits. Securing a greater share of the UK domestic market for new vehicles could increase GDP by 0.6% in 2030 and create a further 63,000 jobs in the same year, as compared to a 2035 phase out. Notably, under such an assumption there would be sufficient additional demand for motor vehicles to almost completely balance out the jobs lost in the sector in 2030 as a result of the more rapid phase out.

1 Introduction

1.1 The policy background

Earlier in 2020, the UK Government undertook a consultation on ending the sale of new petrol, diesel and hybrid cars and van. The Government is currently formally committed to a 2040 phase-out; but the consultation looked at bringing this forward to 2035 “or earlier if a faster transition appears feasible”. The UK Committee on Climate Change’s most recent recommendation is that the phase out should take place by 2032 “at the latest” (CCC 2020). It appears therefore that the UK is likely to introduce a phase out of the sale of internal combustion engine (ICE) cars and vans by 2035 at the latest. Scotland has already committed to phasing out “the need” to buy combustion engine vehicles by 2032.

At the same time, European countries are also announcing (and bringing forward) phase out plans. Norway is committed to phasing out the sale of ICE cars and vans by 2025; Ireland, Sweden and the Netherlands by 2030; while Denmark, Iceland and Slovenia have 2030 targets with some exceptions or conditions; and France and Spain have 2040 as a phase-out date enshrined in legislation.

The primary aim of such legislation is to realise environmental benefits; in particular, the current 2040 phase-out date for sales of ICE cars and vans is not consistent with the UK Government’s commitment to achieving net zero greenhouse gas (GHG) emissions by 2050. Given that the average age of a UK-registered car at scrappage in 2018 was just over 14 years (SMMT 2020) and the equivalent figure for a van was 13 years, the majority of cars and vans sold in 2039 will still be in the stock in 2050.

Previous analysis (Vivid Economics 2018) (Cambridge Econometrics 2015) has shown that the transition to electric cars and vans can have a positive impact upon the UK economy, alongside these environmental benefits.

In addition, a more rapid transition to low-carbon technologies could present the UK’s motor vehicle industry and associated supply chains with an opportunity; to seize ‘first mover’ advantage, and roll-out price competitive electric vehicles more rapidly than European producers, and in doing so secure a greater market share both domestically and in Europe.

1.2 The aim of this study

This analysis explores the impacts of bringing forward the ban on the sale of new internal combustion engine (ICE) cars and vans to 2030. It uses a vehicle choice model (ECCo) and a macroeconomic model (E3ME) to assess impacts on the vehicle fleet, including fuel demand and emissions, and the economy at large.

This analysis is conducted through the construction of scenarios which explore possible future outcomes; initially, through the introduction of policies into the vehicle choice model which lead to large-scale take-up of alternative powertrains consistent with a phase out of sales of ICE cars and vans in 2035 (in the baseline) and 2030 (in the main scenario).

In the macroeconomic modelling, further sensitivities are then evaluated, under which the competitive position of the UK motor vehicle industry is materially affected by the UK being amongst the ‘first movers’ in terms of achieving a rapid transition towards zero-carbon vehicles. The analysis explores the potential economic impact from UK industry taking advantage of such an opportunity to expand its share of the UK motor vehicle or battery market, or the European vehicle market.

1.3 The rest of this report

Chapter 2 sets out the baseline and central scenario used in the analysis, in terms of their impacts upon the sale of cars and vans, and resultant changes to energy demand and emissions. Chapter 3 sets out the economic impacts of these scenarios, and in addition explores additional macroeconomic impacts that could be linked to changes in the UK’s competitiveness. Finally, Chapter 4 sets out conclusions from the analysis.

2 Future demand for cars and vans

In this chapter, we set out the analysis carried out on the future evolution of the car and van stock in the UK under our baseline (which is consistent with a 2035 phase-out of ICEs) and our central accelerated scenario, which introduces policies which deliver take-up trajectories consistent with phasing out ICE cars and vans by 2030.

These scenarios have been developed using ECCo[1], a vehicle uptake model built by Element Energy. ECCo uses a choice model to predict sales of different vehicle powertrains, which are passed to a stock model to track vehicle usage through their lifetime. Parameterisation of consumer behaviour in ECCo is based on a survey of 2,000 new car buyers which quantifies how they weigh up various vehicle attributes, such as purchase price, running costs and range. This enables the sales impact of future vehicle trends, such as higher electric ranges or lower battery costs, to be accurately predicted. As a consequence, ECCo has been found to be a much better predictor of EV uptake to date compared with simple diffusion models or cost comparisons, and is used by the UK Department for Transport for ULEV policy development. Using ECCo therefore ensures the modelling for this work is consistent with that used by the DfT.

2.1 The policies assumed in the scenarios

An earlier ICE phase out will require policy changes to accelerate zero-emission vehicle adoption

In both the baseline and the central policy scenario, a set of model inputs have been developed to represent realistic policy environments required to meet each of the phase out goals. These are shown in Table 2.1.

Table 2.1 ECCo model inputs for each uptake scenario

Input	2035 ICE Phase-out	2030 ICE Phase-out
Powertrain bans	ICEs/HEVs/PHEVs removed from sale in 2035	ICEs/HEVs/PHEVs removed from sale in 2030
Access to charging	Gradually increases to 100% by 2035	Gradually increases to 100% by 2030
Plug-in Car Grant	Zero emission vehicles are eligible for a grant until 2023 if their price is less than £50,000: 2020: 35% of car purchase price, capped at £3,000 2021: 35% of car purchase price, capped at £1,500 2022: 35% of car purchase price, capped at £750	
Car Vehicle Excise Duty	Kept at current levels	First year VED, banded by CO2, increases by 20% a year from 2025
Average new car CO2 target	95 gCO2/km in 2021 Decreasing linearly to 0 gCO2/km by 2035	95 gCO2/km in 2021 Decreasing linearly to 0 gCO2/km by 2030
Plug-in Van Grant	2020: 20% of purchase price, capped at £8,000 for vans that emit <75 gCO2/km and have a >10 mile electric range 2021-2022: As above but grant is capped at £4,000 2023-2030: As above, but capped at £1,000 for zero emission vans only	

[1] http://www.element-energy.co.uk/sectors/low-carbon-transport/project-case-studies/

Van Vehicle Excise Duty	Kept at current levels	First year VED, banded by car CO2 levels, applied from 2023 onwards and increases by 20% a year from 2025
Average new van CO2 target	147 gCO2/km in 2020 Decreasing linearly to 0 gCO2 per km by 2035	147 gCO2/km in 2020 Decreasing linearly to 0 gCO2 per km by 2030

In the baseline, which achieves a 2035 ICE phase out from sales, a mass roll-out of charging infrastructure is required to ensure that all consumers have access to charging by 2035. In addition, new targets for average new car and van CO_2 emissions, similar to the EU's CO_2 performance standards[2], are assumed, and these gradually decrease to 0 gCO_2/km by 2035. Where these targets are on course to be missed, it is assumed that vehicle OEMs adjust pricing to encourage uptake of low emission vehicles, and to discourage take up of vehicles with high emissions.

In the 2030 ICE phase out scenario, roll-out of charging infrastructure must be more rapid, in order to achieve blanket access by 2030, and the date for a target of 0 gCO_2/km for average new cars and vans is brought forward as well. In addition, it is assumed that first-year Vehicle Excise Duty is gradually increased from 2025. As this is banded by CO_2, it acts to discourage sales of higher emission cars and vans.

Under both scenarios, continued support for zero-emission vans is necessary, with the plug-in van grant in place until 2030, although at a reduced amount of £1,000 per vehicle, and limited to zero-emission powertrains from 2023.

2.2 The trajectory of new sales in the scenarios

A rapid fall in battery costs will drive rapid uptake of BEVs in the early 2020s

Figure 2.1 and Figure 2.2 show the predicted sales of each powertrain under the two ICE phase out scenarios. In both scenarios, rapid uptake of BEVs is observed in the early 2020s. This is despite a gradual phase out of the Plug-in Car Grant, and is driven by a rapid fall in battery costs which affords higher ranges and lower cost vehicles[3]. Even under the 2035 ICE Phase Out, ultra-low emission vehicles account for 45% of new sales in 2025. However, without the measures introduced to achieve the 2030 ICE Phase Out, this early momentum fades and the rate of growth slows down under a 2035 ICE Phase Out.

[2] Regulation (EU) 2019/631 https://ec.europa.eu/clima/policies/transport/vehicles/regulation_en

[3] Battery cost assumptions based on forecast from Bloomberg New Energy Finance: https://about.bnef.com/blog/behind-scenes-take-lithium-ion-battery-prices/

Figure 2.1 Powertrain share of new cars and vans 2020-2040, under a 2035 ICE phase out baseline

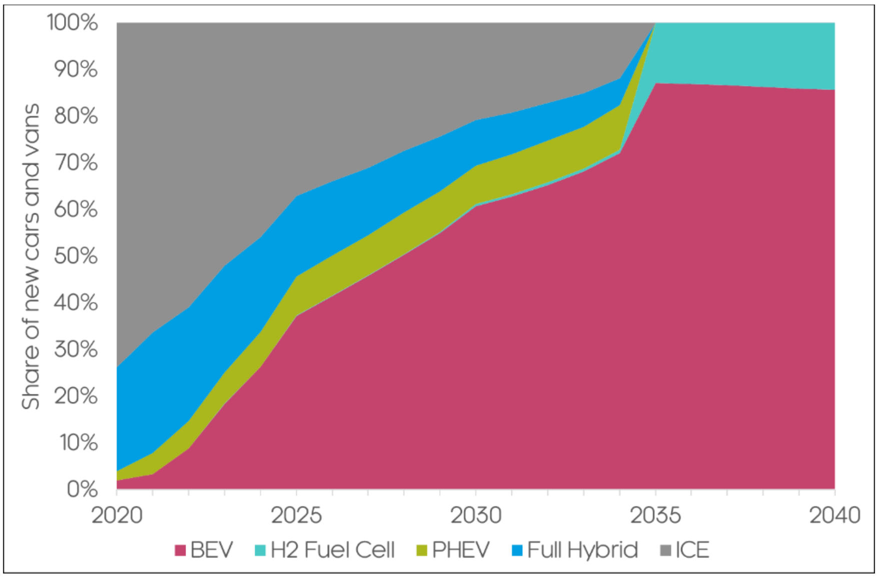
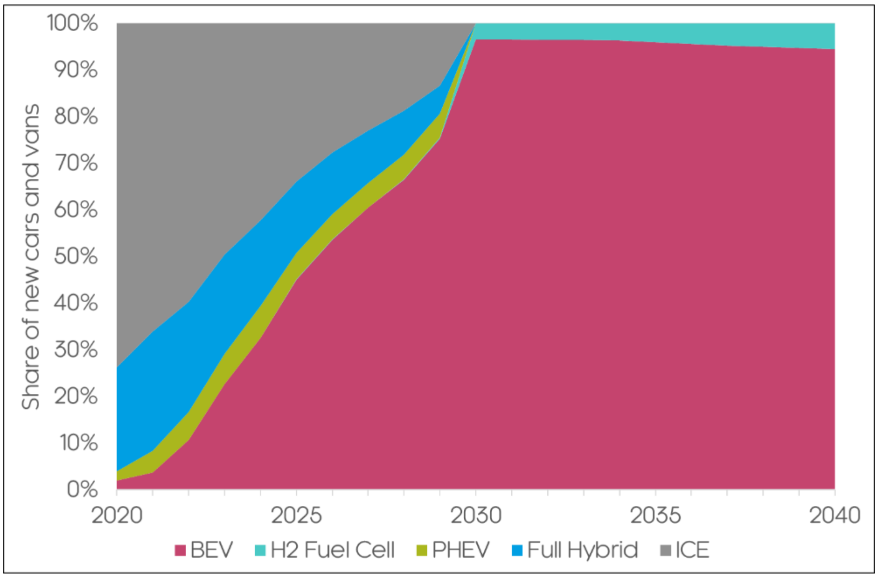


Figure 2.2 Powertrain share of new cars and vans 2020-2040, under the 2030 ICE Phase Out scenario



PHEV uptake remains low in both scenarios, peaking at just under 10% of new sales in 2028 under the 2035 ICE Phase Out. This is largely because as battery prices fall, PHEVs are unable to match the competitiveness of battery electric vehicles on a total cost of ownership basis.

ECCo also predicts lower H_2 fuel cell vehicle adoption in 2030 ICE Phase Out as the price of fuel cells remains high at point of phase out, and the H_2 market does not have time to mature. In both scenarios, H_2 fuel cell vehicle sales come primarily from the van sector, driven by the small number of van users with very high daily mileage requirements.

2.3 The evolution of the vehicle stock in the scenarios

Under a 2030 ICE Phase Out, 90% of the car and van stock will be zero-emission by 2040

Figure 2.3 and Figure 2.4 show how the car and van stock evolves under the baseline and the accelerated phase out scenarios. Under a 2030 ICE Phase Out, there are 6.5m more zero-emission cars and vans by 2040, compared with the 2035 ICE phase out in the baseline. In the scenario, over 90% of the stock is zero-emission by 2040.

Figure 2.3: Number of cars and vans in the stock by powertrain 2020-40, under a 2035 ICE phase out baseline

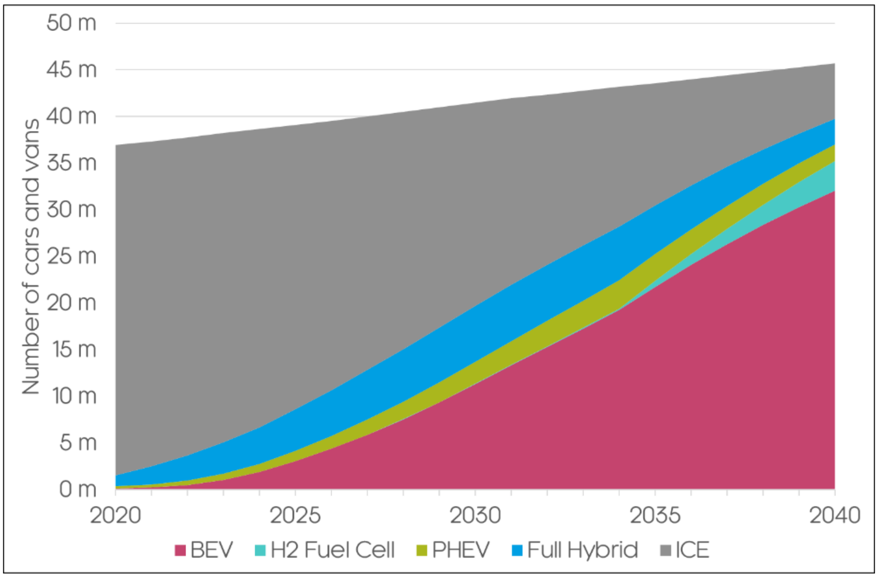
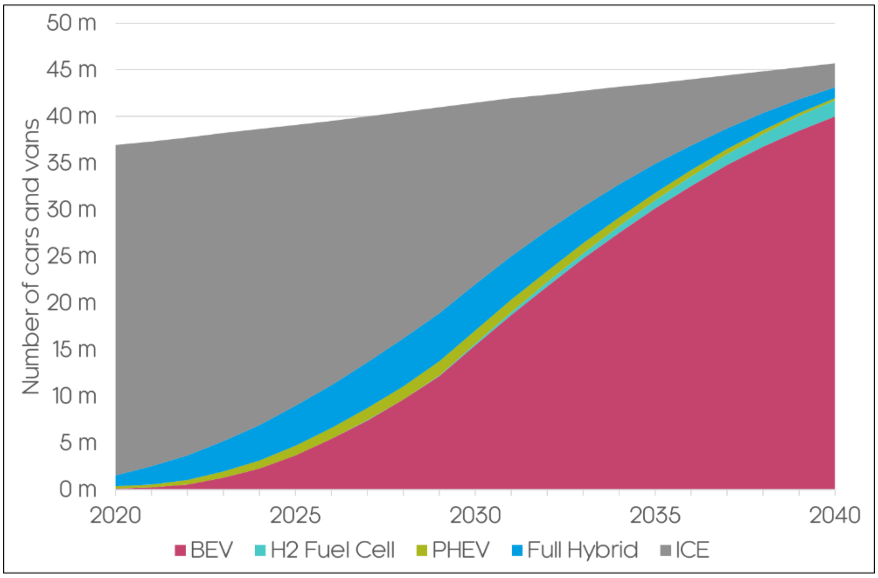


Figure 2.4: Number of cars and vans in the stock by powertrain 2020-40, under the 2030 ICE phase out scenario



In both the scenario and the baseline, the overall stock size has been aligned with DfT's Road Traffic Forecasts (Department for Transport 2018). This predicts continued growth in vehicle kilometres travelled, driven by population growth. However, in order to meet emissions targets, it is likely that a decrease in car and van ownership will be necessary. This will lead to a decrease in the total number of vehicles on the road. This has not been modelled here to ensure consistency with the Government's current projections.

2.4 Fuel and electricity consumption

A 2030 ICE Phase Out will lead to cars and vans achieving net-zero energy consumption by 2040

Figure 2.5 shows the decrease in petrol and diesel consumption from the car and van stock out to 2040. Both scenarios see a dramatic decrease compared with today, driven primarily by the transition to electric vehicles, but also an improvement in the fuel efficiency of new petrol and diesel cars and vans. Under a 2030 ICE phase out, petrol and diesel consumption is 56% lower (by volume) in 2040, compared with a baseline of a 2035 ICE phase out.

Figure 2.5: Petrol and diesel consumption from car and van stock

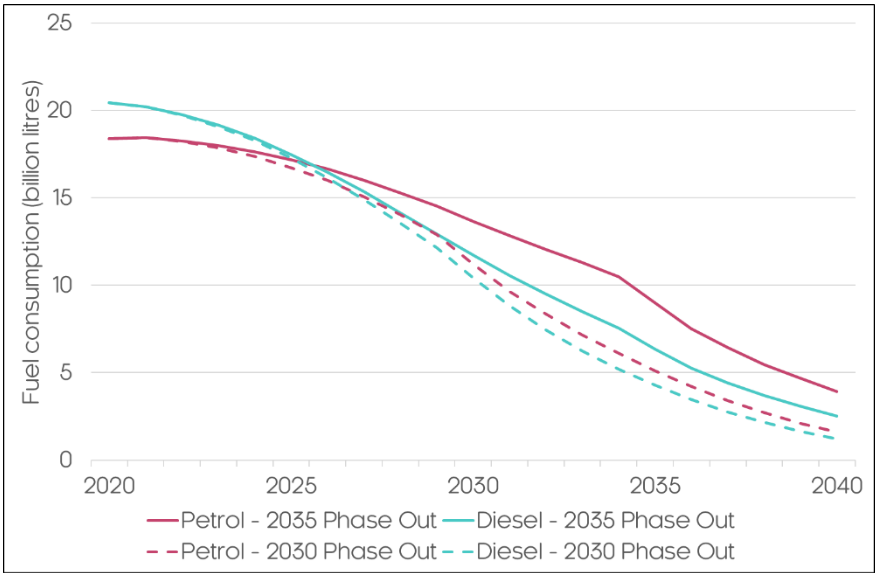
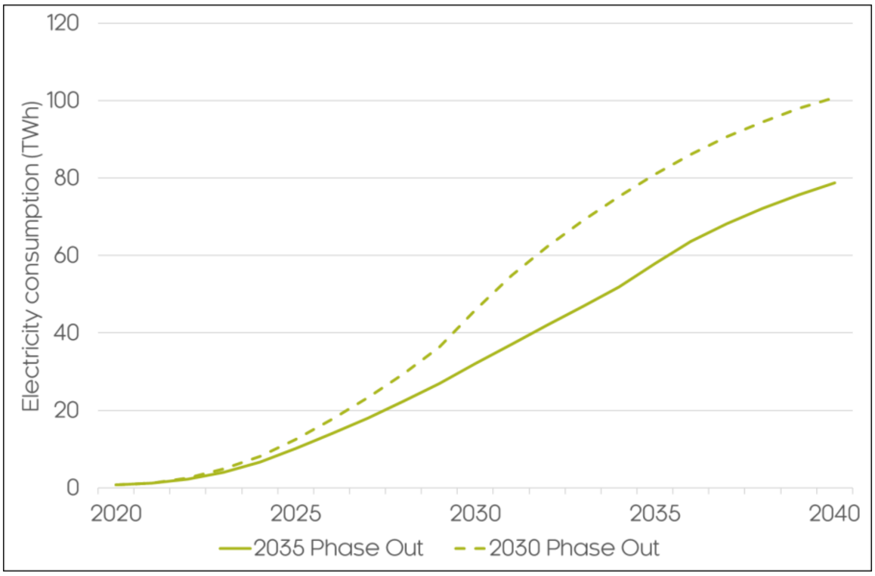


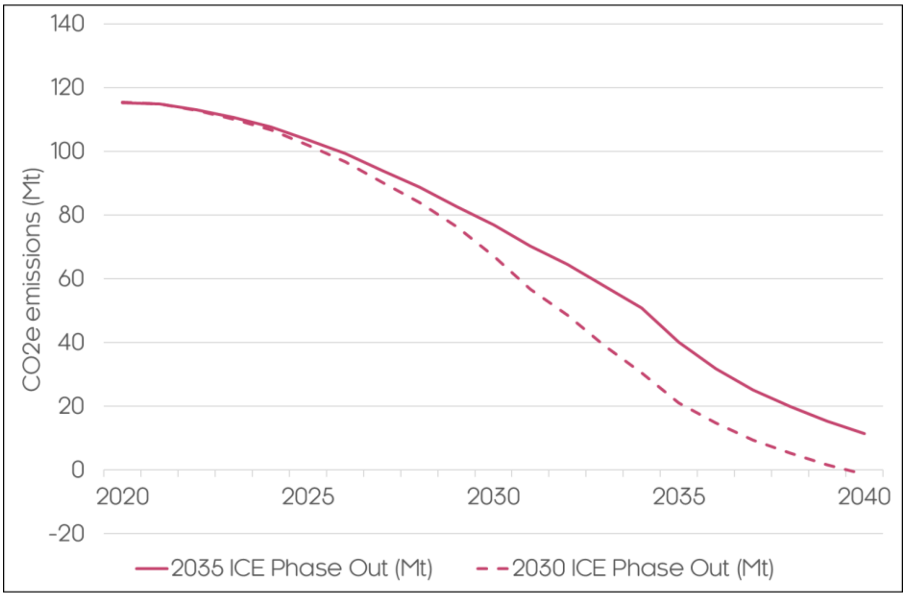
Figure 2.6 shows the increase in electricity consumption from the growing stock of plug-in electric vehicles. With a 2030 ICE phase out, electric cars and vans are projected to consume 100 TWh in 2040, equivalent to 29% of current UK electricity consumption.

Figure 2.6: Electricity consumption from plug-in cars and vans



In both scenarios, the share of driving that PHEVs carry out under electric power (the so-called “utility factor”) has been aligned with recent findings from Transport & Environment which show real world CO_2 emissions are considerably higher than official type-approval values would suggest (Transport & Environment 2020). This is largely because PHEVs are charged less often than is assumed in the type-approval process. Due to the limited stock penetration of PHEVs in these scenarios, their impact on overall energy consumption is low. But it remains important to recognise that although PHEVs have the potential to reduce emissions, this risks being undermined by how consumers choose to use them.

Figure 2.7: Overall well-to-wheel CO_2e emissions from the car and van stock



The transition from petrol and diesel will lead to a substantial decrease in emissions from the light duty vehicle sector (see Figure 2.7). But under a 2030 ICE phase out, the car and van stock achieves net-zero emissions by 2040, and leads to cumulative emissions savings of 191 Mt during 2020-40, compared with a 2035 ICE phase out (a 13% reduction). Net-zero is achieved whilst petrol and diesel vehicles remain in the stock because it is assumed that the carbon intensity of the electricity grid becomes negative in 2033, owing to the presence of biomass generation paired with carbon capture and storage technology [4,5,6,7]. This is aligned with National Grid's latest Future Energy Scenarios.

2.5 Deployment of charging infrastructure

A 2030 ICE phase out would require a faster roll-out of charging infrastructure in the 2020s, although mostly at home

The mass uptake of plug-in electric vehicles will require a widespread roll-out of charging infrastructure. Figure 2.8 and Figure 2.9 compare the projected number of charge points needed to satisfy the vehicle stock in the baseline and the 2030 phase out scenario. The vast majority of this infrastructure is deployed at drivers' homes. However, work and public charging is also needed to provide for the quarter of car and van owners who do not have access to off-street parking[8], as well as to enable BEVs drivers to carry out long-distance journeys. Workplace charging is also needed to serve cars and vans which are kept overnight at depots.

[4] Petrol and diesel well-to-tank emissions from (LowCVP 2020)

[5] Petrol and diesel tank-to-wheel emissions factors from (BEIS 2020)

[6] Electricity carbon intensity from (National Grid 2020) System Transformation scenario

[7] 8.6% transmission and distribution losses have been assumed, based on (BEIS 2020)

[8] (Department for Transport 2019), NTS0908, Where is vehicle parked overnight, England

Figure 2.8: Number of charge points required with 2035 ICE Phase Out

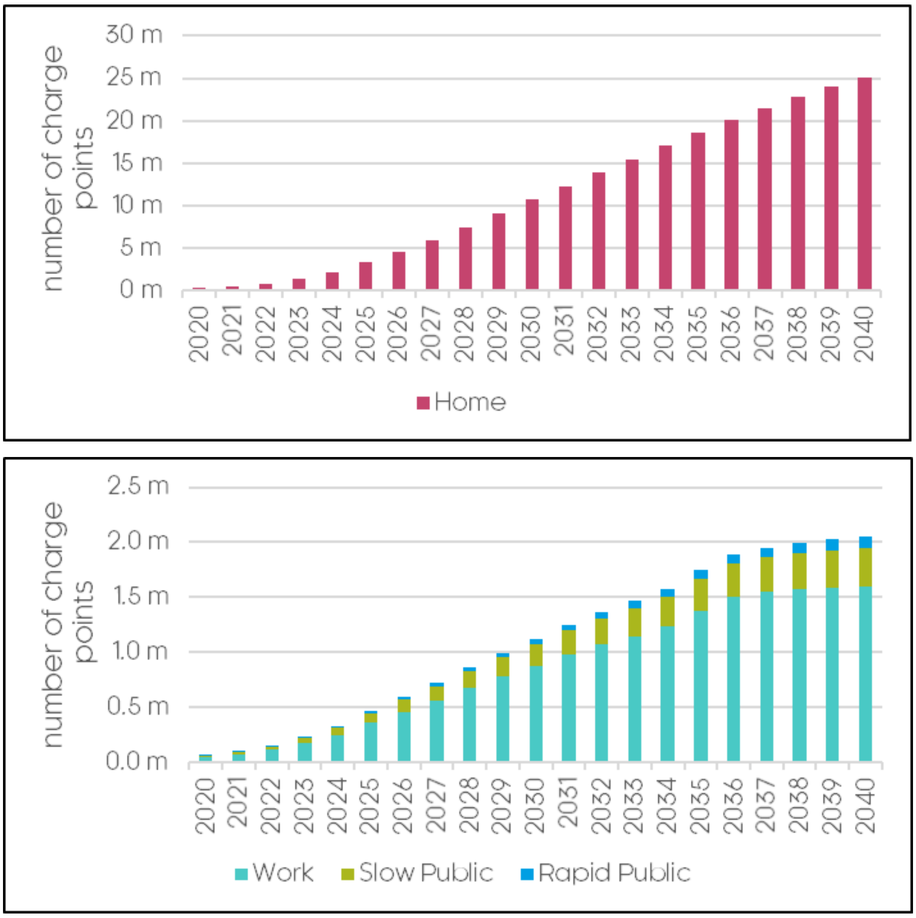
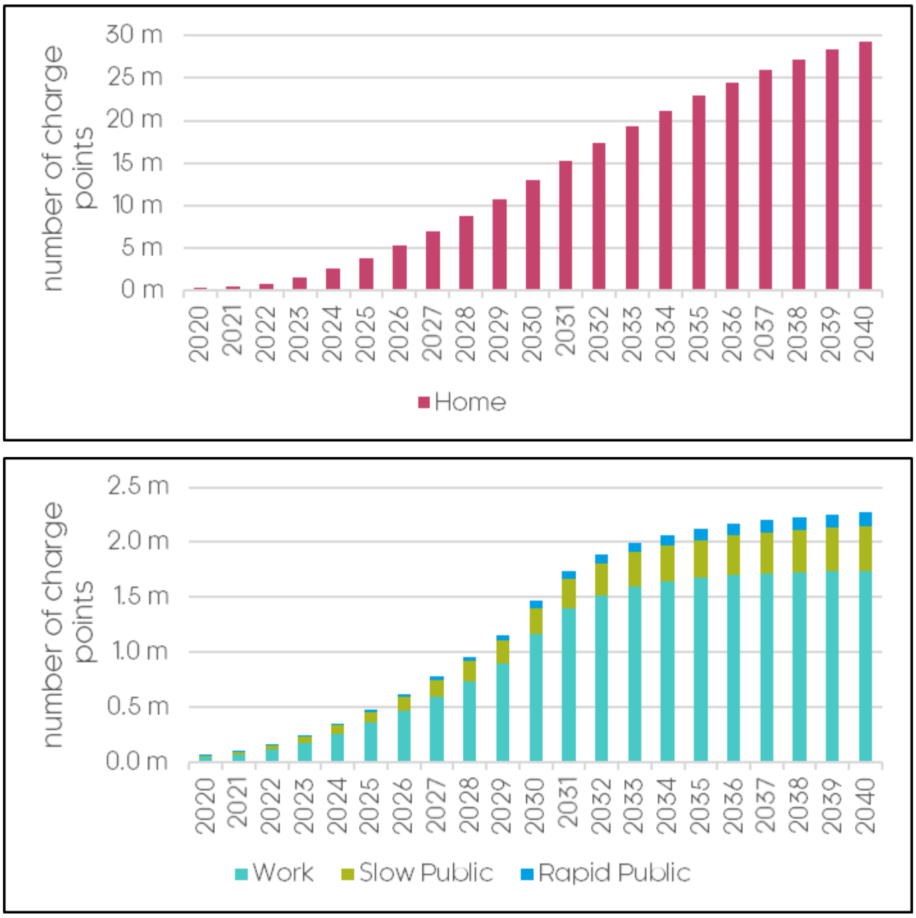


Figure 2.9: Number of charge points required with 2030 ICE Phase Out



A 2030 ICE phase out would require a faster roll-out of charging infrastructure through the 2020s. This is both to meet demand, as well as to provide certainty to consumers that they will have ready access to charging when needed. By 2030, the UK would require 1.2m work, 240k slow public (3-22kW) and 62k rapid public (≥50kW) charge points, as well as 13m home charge points.

Figure 2.10: Annual charging infrastructure investment cost under 2035 ICE Phase Out

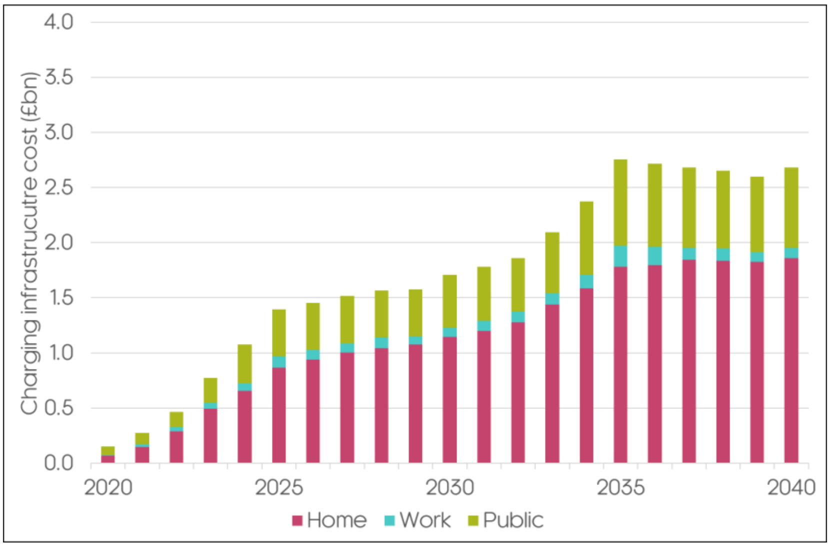
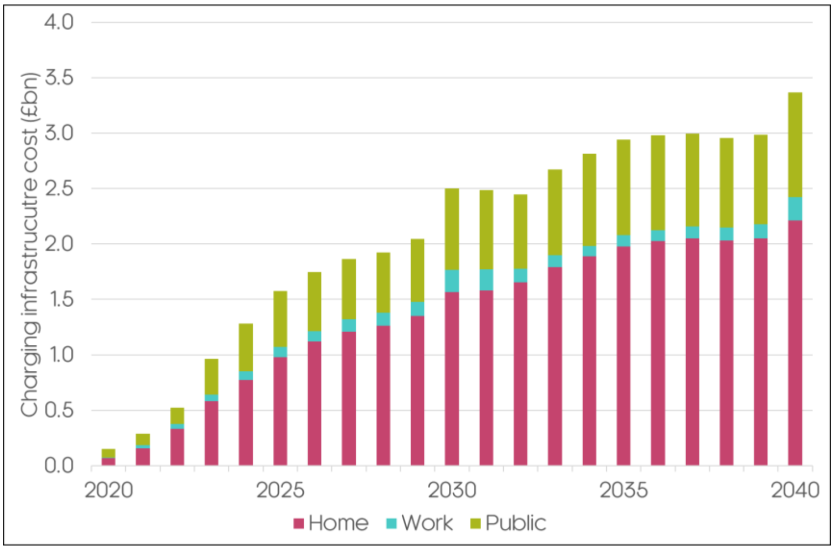


Figure 2.11: Annual charging infrastructure investment cost under 2030 ICE Phase Out



The earlier phase out date requires £7bn more in infrastructure investment out to 2040 versus a 2035 phase out (see Figure 2.10 and Figure 2.11). Under a more rapid phase out, a substantial volume of infrastructure is required in the year of the phase out (2030) in order to meet demand, and because this infrastructure is expected to have a 10-year lifespan, a similar increase in investment is seen in 2040 in order to replace this infrastructure.

Public charging makes up a relatively small number of charge points in the total infrastructure requirement. Public charging by its nature is accessible to all, and so each charge point will serve multiple EVs. However, it contributes a disproportionate amount to the total infrastructure cost, due to the higher cost of installation, and in the case of high-powered rapid charging, higher hardware and network connection costs. Consequently, in both scenarios, public charging accounts for c30% of total infrastructure investment costs.

2.6 Net Government revenues

The transition to lower carbon vehicles will reduce Government tax revenues from cars and vans

The transition to more efficient and lower carbon vehicles will lead to a substantial decline in net Government revenues from car and van owners (see Figure 2.12 and Figure 2.13). This is primarily the result of a fall in fuel duty revenue, with a drop in fuel VAT and Vehicle Excise Duty also contributing.

The 2030 ICE phase out marginally accelerates this revenue decline, reducing cumulative net revenue between 2020-2040 by £34bn (5.5%) relative to the 2035 phase out in the baseline.

In both scenarios, this lost revenue could be replaced though a technology neutral vehicle tax. The net revenue loss between 2020 and 2040 is equivalent to £774/yr per vehicle under the 2030 ICE phase out scenario. This would be equivalent to a road user tax of 8.6p per mile driven.

Figure 2.12: Net Government revenue from cars and vans under a 2035 ICE Phase Out

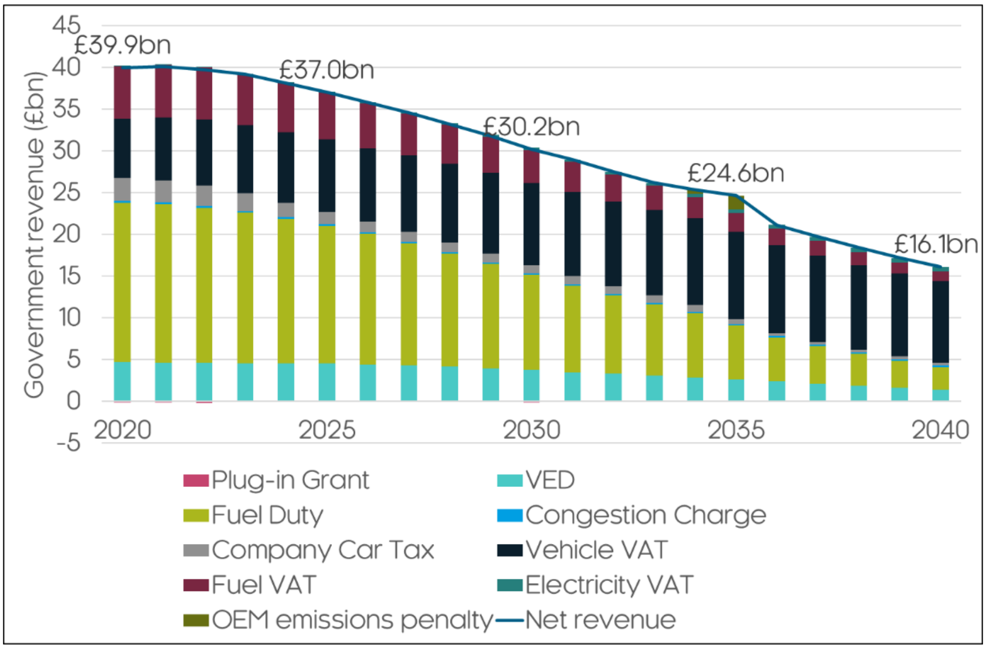


Figure 2.13: Net Government revenue from cars and vans under a 2030 ICE Phase Out

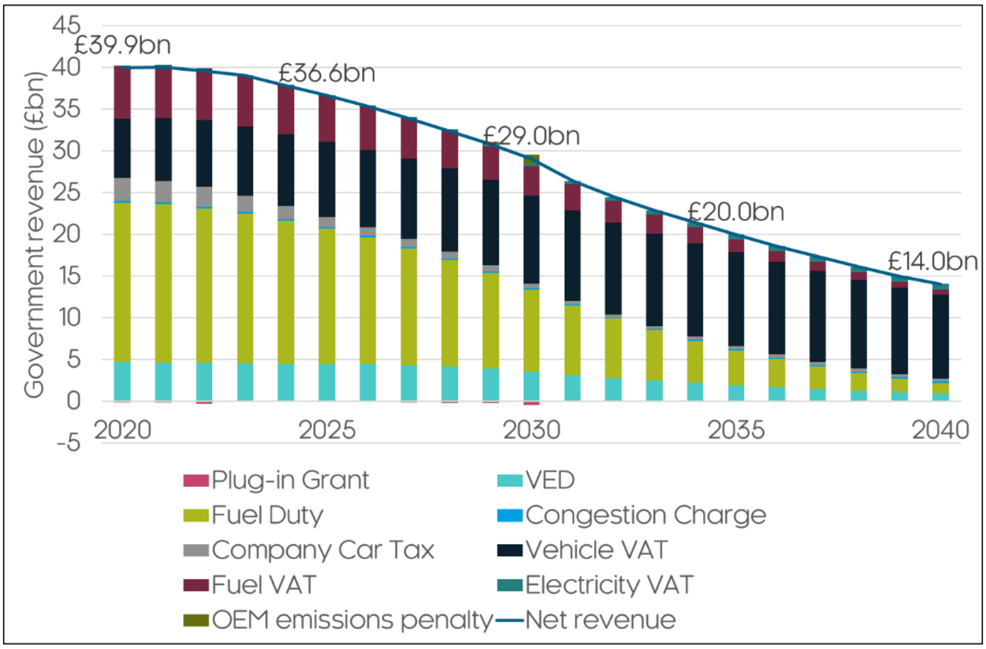


Table 2.2: 2040 net Government revenue loss versus 2020, per vehicle and per mile driven

	2035 ICE Phase Out	2030 ICE Phase Out
Per vehicle	£729 / yr	£774 / yr
Per mile	8.1p / mile	8.6p / mile

Alternatively, this lost revenue could be offset through higher tax revenues from other sectors. This is discussed further in Chapter 3.

3 The socio-economic impacts of an accelerated phase-out

In this chapter, we evaluate, using a macroeconomic model (E3ME), the impacts of an accelerated phase-out consistent with the main scenario outlined in the previous chapter i.e. 2030 phaseout compared to baseline phaseout in 2035. We then explore how those socioeconomic outcomes might change if the accelerated rollout of electric vehicles alters the competitiveness of the UK's motor vehicles industry, in particular vis-à-vis Europe, allowing it to expand its market share either in the domestic UK market, into Europe via exports, or in terms of the nascent vehicle battery industry.

The economic analysis is conducted using the outputs of the ECCo model, as outlined in Chapter 2, as inputs to the E3ME model. The E3ME baseline is aligned with the 2035 phase out baseline used in ECCo, and the central scenario, a 2030 phase out, is similar aligned. Through this process, it is possible to quantify how the changes to motor vehicle and fuel demand will impact across the UK economy as a whole.

3.1 The impact of a more rapid deployment of zero-emission vehicles

The economic modelling suggests that an accelerated phaseout of ICE vehicle sales could provide a small net increase to activity across the UK economy. The impact is largest between 2030 and 2035 where the difference in vehicle sales is largest as a result of the accelerated phaseout. The scale of the economic impacts then falls slightly by 2040 as ICE sales are phased out in both scenarios, but is still positive as the earlier accelerated phaseout has a persistent effect on the fuel consumption of the vehicle fleet as a whole (as there remain more zero-emission vehicles in the fleet). A summary of the main economic indicators in presented in Table 3.1.

Table 3.1: Main Macroeconomic impacts from a 2030 phaseout

	2025	2030	2035	2040
	Difference relative to a 2035 ICE phaseout			
GDP (%)	0.0%	0.2%	0.2%	0.2%
Employment (000s)	3	32	48	27

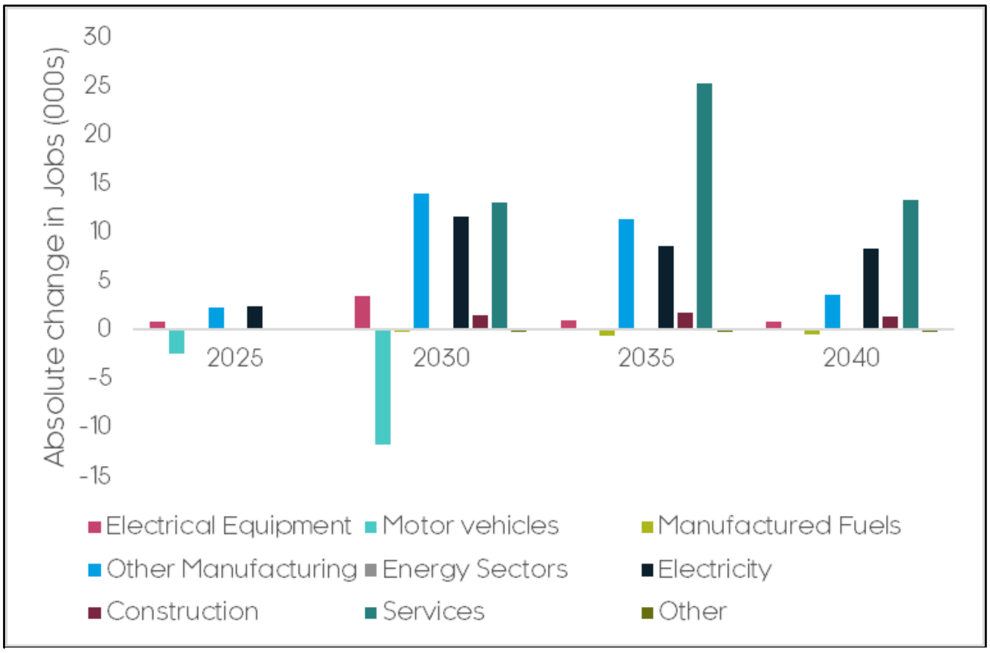
The main driver of the economic impact is the shift away from fossil fuels and towards other goods and services. The reduction in fossil fuel expenditure shifts consumer spending away from oil products, where most of the value is realised outside of the UK, and towards electricity as a substitute fuel, in the first instance. The majority of UK-consumed electricity is domestically generated, creating jobs and activity domestically. In addition, the amount spent on electricity is less than the cost of the fossil fuel foregone (as a result of a number of factors including greater efficiency in electric motors and lower tax rates on electricity); this frees up consumer expenditure to be spent on other consumer goods and services, of which a substantial proportion is delivered domestically and therefore creating further economic activity.

The accelerated ICE phaseout does lead to an increase in vehicle prices, putting downward pressure on consumer spending and real incomes, but this is more than offset by the saving in fuel expenditure.

Sectoral impacts

While the net economic benefits of the accelerated phaseout are positive, the impact are not evenly distributed and there are clear winners and losers.

Figure 3.1: Employment impact by aggregate sector



Notes: Other sectors includes Energy sectors, Construction and Electrical equipment

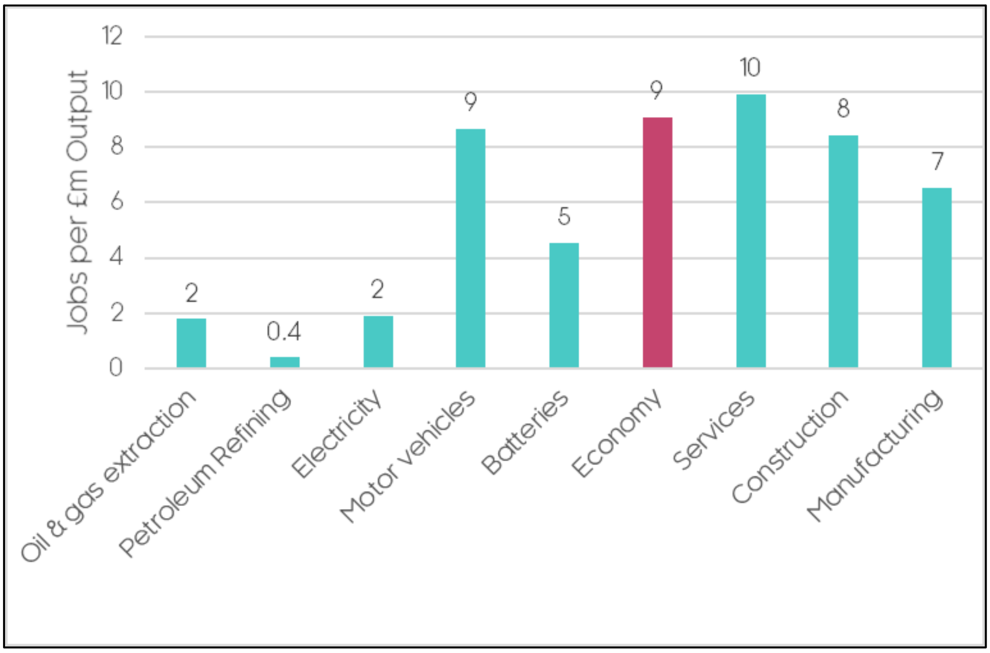
Figure 3.1 shows the employment impacts by sector. The largest increase in employment across the period to 2040 comes in the service sectors. The benefits to service sector employment arise through the additional domestic economic activity as consumer shift expenditure away from imported fossil fuels. As such, within the service sectors, the largest increases are in consumer facing services such as accommodation, food and retail services.

The next largest increase in employment is in other manufacturing sectors, and in fact in 2030 it is this sector which dominates. This is a result of supply chain effects from shifts in consumer spending in sectors such as food & drink, as well as manufacturing related to additional investment in electricity generation and charging infrastructure; in 2030 in particular the latter two effects are strong (as can be seen in Figure 2.11, there is a substantial increase in investment in charging in infrastructure in this year, while demand for electricity is expanding rapidly and requires the manufacture of components for new capacity).

The largest reduction in jobs in the scenario is in the motor vehicles sector. This reflects the loss of traditional manufacturing jobs in engine production. Some of these lost jobs are replaced with battery manufacturing jobs, captured within the electrical equipment sector. However, there is a net loss of jobs relating to motor vehicles as battery production is a less labour-intensive activity, as shown in Figure 3.2.

Among other sectors, the energy supply sector sees a small net increase in jobs as electricity production offsets those lost in fossil fuel production. This is despite the overall spending on energy for road transport falling. The net increase in jobs is because the electricity sector is both more labour intensive and has higher domestic content than fossil fuel production. There is also a modest increase in construction jobs to deliver the accelerated investment in charging infrastructure.

Figure 3.2: Labour intensity of output by key sectors

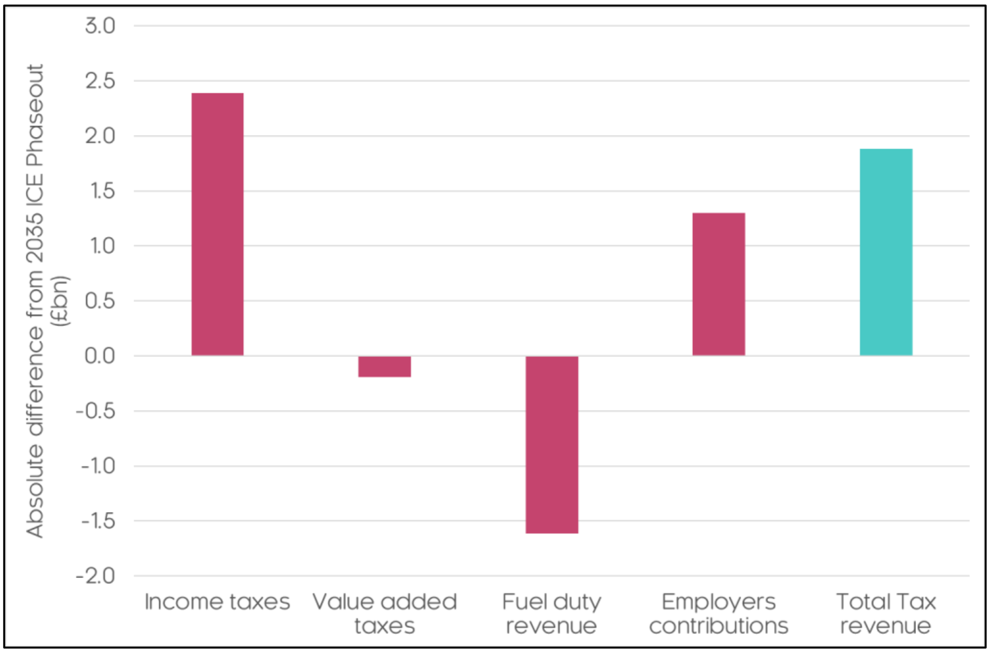


Government revenues

The accelerated phaseout of ICE sales leads to a more rapid reduction in expenditure on petrol and diesel, which generate substantial revenues for the government through fuel duty and VAT. The modelling shows that an accelerated phaseout would reduce revenues associated with fuel duty by around £1.6bn in 2030 compared to the 2035 phase out in the baseline.

VAT revenues also fall due to the reduction in fuel consumption, although this is partially offset by consumers shifting expenditure to electricity and other consumer goods and services which are subject to VAT. The reason that VAT is not fully compensated through other expenditure is due to the reduced VAT rate on some goods and services, most notably electricity which is only taxed at 5% rather than the standard rate of 20%. As fuel is fully rated, a shift in expenditure away from fossil fuels and towards these other activities leads to a reduction in the average VAT rate linked to this consumption.

Figure 3.3: Government tax revenues in 2030 £bn



However, the reduction in VAT and Fuel duty is offset by higher income taxes and employers' contributions driven by the increase in employment and in turn aggregate wages across the economy. The increase in income taxes alone is worth £2.4bn in additional revenues in 2030; overall, government revenues are estimated to be £1.9bn higher as a result of the more rapid phase out.

In the economic modelling outlined earlier in this section, it is assumed that this additional government revenue is redistributed via cuts to income tax rates; however, the government could instead choose alternative uses for these funds, including paying down existing debt. If the revenues are used in this way, the economic impacts are reduced slightly; GDP is 0.13% above baseline, and employment 27,000 higher, in 2030.

3.2 The potential impacts if changes in competitiveness are realised

The central modelling assumes that the UK's motor industry broadly maintains its competitiveness vis-à-vis the European market under a more rapid phaseout but it seems reasonable to think that there could be substantial changes in competitiveness if industry can extract an advantage from taking (or sharing) the lead in the transition to low-carbon vehicles

We have explored how the economic impacts might change if first-mover advantage can be exploited;

- If the UK motor vehicle industry can capture a larger share of the domestic market for cars and vans
- If the UK industry can capture a larger share of the European market
- If the UK can capture a larger share of the nascent battery market, for example through the development of a UK-based 'Gigafactory'.

Below the potential economic effects of each of these are considered in turn; of course, if more than one could be leveraged, that would lead to the accumulation of even greater benefits.

Higher share of domestic production

To assess the potential impact of a higher share of domestic production of motor vehicles, we modelled a sensitivity in which by 2040 the UK's domestic production of motor vehicles, relative to total domestic demand, increases from the current share of 34% to 42%. Essentially, it is assumed that UK producers are able to meet a greater share of the UK's demand for motor vehicles, based on the premise that the UK is demanding more EVs (as a share of overall demand) than other European countries, and therefore domestic production is able to more rapidly focus on the manufacture of such vehicles.

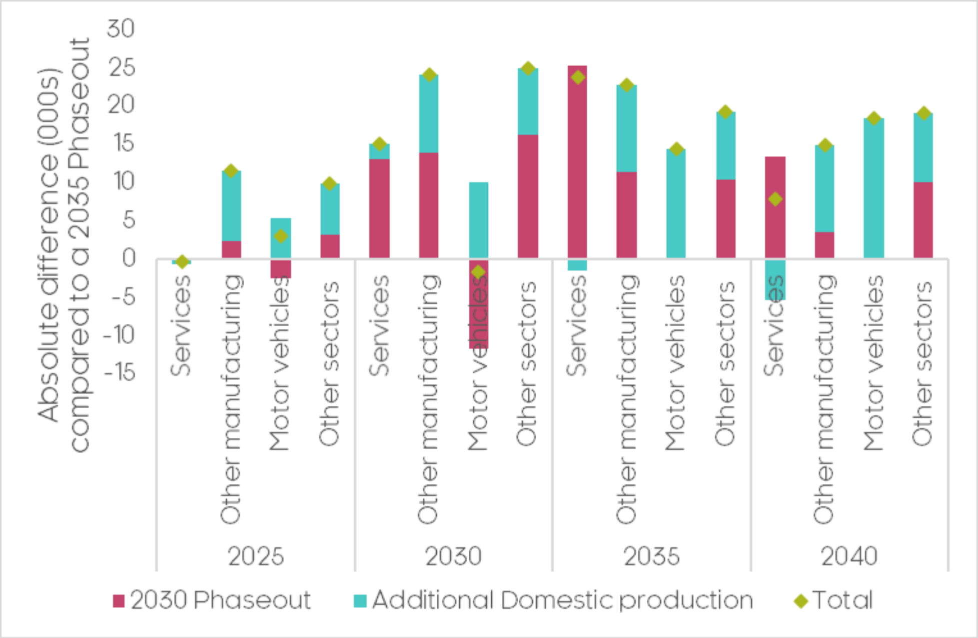
The modelling suggests that the potential benefits of such an improvement could be substantial (see Table 3.2), equivalent to an additional 0.5 percentage points on GDP by 2035 (above the 0.2% increase in the central scenario), and up to 81,000 additional jobs in the same year compared to a 2035 phase out without such an improvement.

Table 3.2: Motor vehicle domestic production sensitivity

		2025	2030	2035	2040
		Difference relative to a 2035 ICE phaseout			
GDP (%)	Baseline	0.0%	0.2%	0.2%	0.2%
	Additional domestic production	0.2%	0.6%	0.7%	0.9%
Employment (000s)	Baseline	3	32	48	27
	Additional domestic production	20	63	81	61

If the UK was able to leverage the accelerated phaseout to expand domestic production, it could offset most of the job losses in motor vehicle production from the shift to EV production (see Figure 3.4). The greater demand for domestically produced vehicles results in a need for more workers in this industry, even though conventional internal combustion engines are no longer produced in the sector.

Figure 3.4: Additional Employment impact by aggregate sector for motor vehicle production sensitivity



Notes: Other sectors includes Energy sectors, Construction and Electrical equipment

Capturing more of the EU domestic market

If the uptake of EVs in the UK accelerates and moves ahead of key European markets, there is the potential for it to increase its share of the EU market; a more rapid shift in production capacity in the UK to deliver EVs would mean that it could meet demand for EVs in European markets, even if the underlying demand for these vehicles in Europe is developing more slowly than in the UK. To assess the potential impacts of such a development, a sensitivity is modelled in which the UK steadily increased its share of the EU market from the currently level of 3% to 4% over 2020-40.

Table 3.3 shows the net economic impact under a 2030 ICE phaseout if the more rapid transition means that the UK can meet a greater share of Europe's EV demand than would otherwise be the case. The additional employment would predominantly come from more jobs in the production of motor vehicles, along with further gains in supply chains. Up to 55,000 additional jobs could be created by 2040 if UK producers are also able to secure this additional market share, while GDP could be increased by up to 0.7% on the same basis.

Note that in this analysis we have assumed that in the baseline the UK maintains its current (pre-Brexit) competitive position vis-à-vis European markets. We make no judgement here as to whether Brexit will affect the competitive position of the UK motor vehicle industry; however the economic benefits set out here could equally be explained as the GDP and employment 'defended' by an improvement in the UK's competitiveness position, if one believed that through this policy the UK industry could avoid a *loss* of market share, rather than securing *additional* market share, compared to its current position.

Table 3.3: EU Motor vehicle production sensitivity

		2025	2030	2035	2040
		Difference relative to a 2030 ICE phaseout			
GDP (%)	Baseline	0.0%	0.2%	0.1%	0.2%
	EU Expansion	0.1%	0.4%	0.6%	0.7%
Employment (000s)	Baseline	3	32	48	27
	EU Expansion	17	54	75	55

Increase in domestic battery production for EVs

If the UK delivers a more rapid phase out by 2030, and was at the forefront of European moves to increase the role for EVs, then it offers the opportunity for the UK to capture more of the nascent European battery market – for example, through encouraging investment in a UK equivalent to a 'Gigafactory'. To assess the potential economic impact of this, a sensitivity was developed under which the UK domestic production of batteries for EVs increases from 1/3rd of domestic demand (based on the current share of demand in the broader electrical equipment sector) to 2/3rds of domestic demand for the required batteries incrementally over the period 2020-40.

The modelling shows that improved battery production capacity would create modest economic gains in GDP and jobs. This reflects the fact that batteries only make up a relatively small share of EV production costs, and that the price of batteries are expected to continue to fall, reducing the overall value of additional production going forward; it is for this reason that the economic impacts start to tail off after 2035. At the same time, as Figure 3.2 shows, the labour intensity of battery production is lower than motor vehicle production.

Table 3.4: Economic impact from increase EV battery production sensitivity

		2025	2030	2035	2040
		Difference relative to a 2035 ICE phaseout			
GDP (%)	Baseline	0.0%	0.2%	0.2%	0.2%
	Additional EV battery production	0.1%	0.2%	0.3%	0.3%
Employment (000s)	Baseline	3	32	48	27
	Additional EV battery production	10	37	52	31

However it should be noted that there may be broader strategic reasons for the UK to attempt to secure a greater share of this market, including better terms of trade with a higher proportion of UK content, and security of supply issues as the deployment of electric vehicles, and indeed electrification of the economy more widely, continues.

4 Conclusions

In this study, two established models, ECCo and E3ME, have been used to assess the potential impacts of a 2030 phase out of the sale of internal combustion engine cars and vans, as compared to the UK Government's current default position of a 2035 phase out. The analysis has evaluated the impact on the vehicle fleet, including changes to fuel demand, emissions, infrastructure and government expenditure, and the overall macroeconomic impacts in terms of GDP, employment (including by sector) and total government revenues. In addition, the potential macroeconomic effects of leveraging such a phase out to improve the UK motor vehicle industry's competitive position have been explored.

The analysis shows that a more rapid transition can represent a win-win to the UK; it will bring down emissions from the vehicle fleet more rapidly, and bring these segments of the transport system more closely into line with the UK Government's 2050 net zero target; and, at the same time, it can create additional activity and jobs in the UK economy.

Under a 2030 phase out, well-to-wheel CO2 emissions from the fleet are expected to reach zero by 2040 (as a result of negative emissions technologies in the electricity generation sector), while the shift to zero-carbon powertrains can also be expected to reduce local emissions (such as nitrogen oxides) and therefore improve air quality.

GDP is expected to be up to 0.2% higher as a result of a more rapid phase out, while 32,000 additional jobs could be created in 2030 (employment peaks at 48,000 additional jobs in 2035). This is primarily a result of the shift away from imported fossil fuels; the improved efficiency of electric vehicles (and lower tax rates) results in lower overall costs of mobility, and consumer spending on electricity (for fuel) and other consumer goods and services.

However, the benefits do not fall evenly across the economy. Under the accelerated phase-out, some jobs in the motor vehicle industry are lost as a result of the more rapid shift away from conventional ICE vehicles, although by 2035 these jobs disappear in the baseline as well as demand for new ICEs falls to zero. The gains, as outlined above, are concentrated in services, but also in the manufacture of both consumer goods and charging infrastructure, as well as the installation of the latter.

If the UK motor vehicle industry, with support from the UK Government where needed, can leverage a more rapid transition to improve the competitiveness of its products ('first mover advantage') then there is the potential for further substantial benefits. Increasing the proportion of UK demand for vehicles met by domestic production by 8% (from 34% of domestic demand being met by UK-based production, to 42% by 2040) as a result of the more rapid transition could increase GDP by 0.6%, and employment by an additional 63,000 jobs, in 2030. Increasing exports of vehicles to Europe, or securing a substantive share of the nascent vehicle battery industry, could also lead to greater economic gains.

5 References

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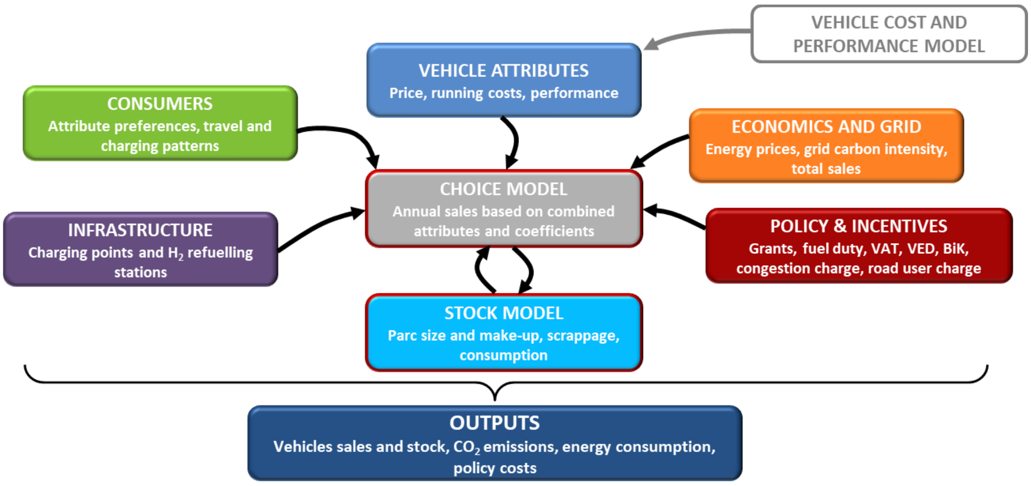
Appendices

Appendix A The ECCo model

The uptake and stock modelling in this study have been carried out using Element Energy's ECCo model. ECCo was originally commissioned by the Energy Technologies Institute (ETI) in 2010 and has been updated regularly since for the Department for Transport as well as the ETI. It is used by the DfT to aid policy design, such as supporting reviews of the Plug-in Car Grant and Plug-in Van Grant.

Figure 0.1: Flow chart of ECCo inputs, choice & stocks models, and outputs



At ECCo's core is a consumer choice model which simulates the vehicle purchasing decision. This is populated with behavioural coefficients taken from a consumer survey of more than 2,000 new car buyers designed to quantify willingness to pay for key vehicle attributes[9]. ECCo accounts for elements such as future vehicle attributes, electricity[10] and fuel[11] prices, policy & incentives[12], and other characteristics of different car and van buyer types, such as their annual mileage[13], EV awareness[9], and access to charging infrastructure[9,14,15].

Projections of future vehicle attributes (e.g. price, energy consumption, range) are fed into ECCo from Element Energy's Car and Van Cost and Performance Models. This employs a bottom up modelling approach to determine present and future attributes of a range of different vehicle sizes and powertrains.

[9] Element Energy for DfT (2015) "Survey of consumer attitudes to plug-in vehicles"

[10] Based on the average domestic retail electricity price and the forecast from the latest Green Book supplementary guidance

[11] Based on oil price forecast scenarios from the BEIS 2018 Fossil Fuel Prices, combined with a correlation of past oil prices with past petrol and diesel prices

[12] Including fuel duty, VED, company car tax, VAT, the Congestion Charge and Plug-in Car and Van Grants, and fleet CO_2 emissions targets

[13] Based on analysis of the results from the DfT/EE 2015 consumer survey and a database of fleet vehicles provided by RouteMonkey

[14] DfT "Plug-In Car Grant survey"

[15] Projections of future charging infrastructure agreed with DfT, aligned with plans from Highways England and Transport Scotland, and reflecting dedicated OLEV funding

Unless stated, all ECCo input values have been kept the same as those used by DfT in their baseline modelling assumptions.

Appendix B Estimating charging infrastructure requirement

Assumptions underpinning the estimate of the number of charge points required is largely based on a recent study by the ICCT[16]. The stock of plug-in electric vehicles in each year were separated into the 11 user groups shown in Table 0.1.

Table 0.1: Share of charging energy by charging location, for the 11 different EV user groups.

Vehicle Type	Powertrain	Commuter	Overnight Location	Home	Work	Slow public (3-22kW)	Rapid Public (≥50kW)
Car	BEV	Yes	Home	70%	20%	5%	5%
Car	BEV	Yes	On-street	0%	45%	30%	25%
Car	BEV	No	Home	85%	0%	5%	10%
Car	BEV	No	On-street	0%	0%	40%	60%
Car	PHEV	Yes	Home	65%	30%	5%	0%
Car	PHEV	Yes	On-street	0%	65%	35%	0%
Car	PHEV	No	Home	90%	0%	10%	0%
Car	PHEV	No	On-street	0%	0%	100%	0%
Car	-	-	Depot	0%	100%	0%	0%
Van	-	-	Home	100%	0%	0%	0%
Van	-	-	Depot	0%	100%	0%	0%

EVs are allocated to each user group using the assumptions shown in Table 0.2. It is assumed that each share is independent.

Table 0.2: Assumptions for calculating share of EVs falling into each EV user group.

Assumption	Value
Share of EVs stored at depots	Outputted by ECCo stock model
Share of EVs with off-street parking	Share held at 85% in all years. 2020 share is 85%[16]. Element Energy off-street parking model estimates share for all cars is also 85%. Note this is higher than 72% of car owning households with off-street parking observed in the 2018 National Travel

[16] ICCT (2020) Quantifying the electric vehicle charging infrastructure gap in the United Kingdom, https://theicct.org/publications/charging-gap-UK-2020

	Survey, as those with off-street parking generally have higher number of cars per household.
Share of EVs used for commuting	Set at 70% in 2020[16], but gradually reduced towards overall car average of 53% as EV stock share grows.

The number of home charge points required is calculated as the number of EVs based overnight at home, multiplied by the average EVs per household. This assumes that a household with multiple EVs will share a single charge point across their vehicles. Average number of EVs per household is assumed to be 1 at 0% stock share of EVs, and this is gradually increased to 1.16, the average number of cars per car owning household[17], at 100% EV stock share.

The number of work charge points is derived from both the number of depot-based vehicles and the workplace charging demand from non-depot-based cars. Each depot-based vehicle is assumed to have a dedicated work charge point. For non-depot based cars, the number of work charge points is calculated as the number needed to supply the workplace charging energy demand if in use for an average of 6 hours per working day[16]. The assumptions are outlined in Table 0.3.

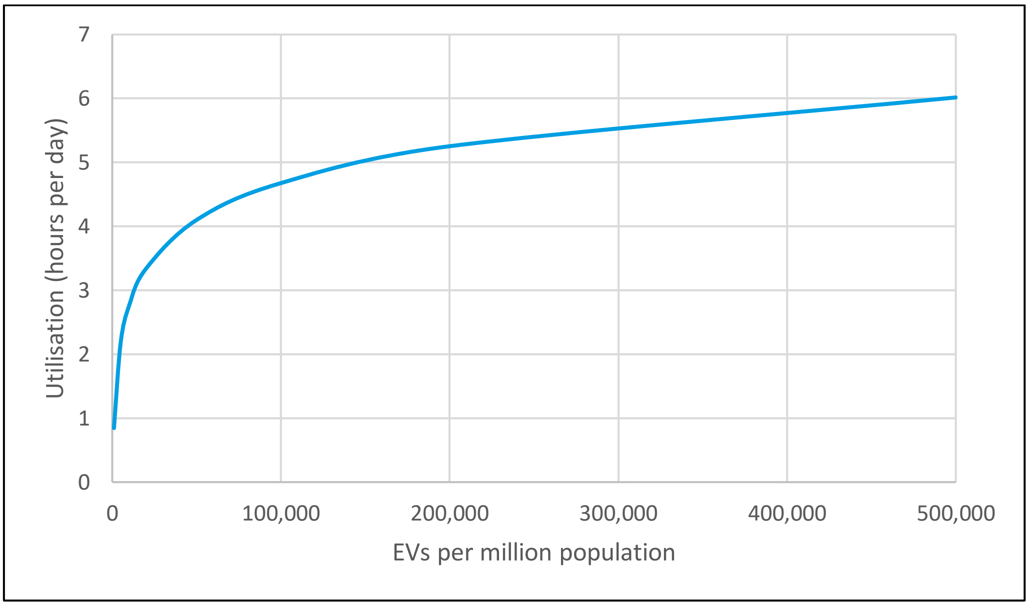
Table 0.3: Assumptions for calculating the number of workplace charge points required for non-depot based cars.

Assumption	Value
Charging rate	BEVs: 8kW, PHEVs: 3.4kW[16]
Working days per year	252
Average utilisation per working day	6 hours[16]
Electricity demand	Outputted by ECCo, and multiplied by workplace charging energy share in Table 0.1.

The number of slow public (3-22kW) charge points is estimated from the number required to provide the slow public charging energy demand for a given average utilisation per day. Utilisation per day is calculated from the following correlation:

[17] Office for National Statistics, Census 2011, CT0876 - Accommodation type (excluding caravans or other mobile or temporary structures) by car or van availability

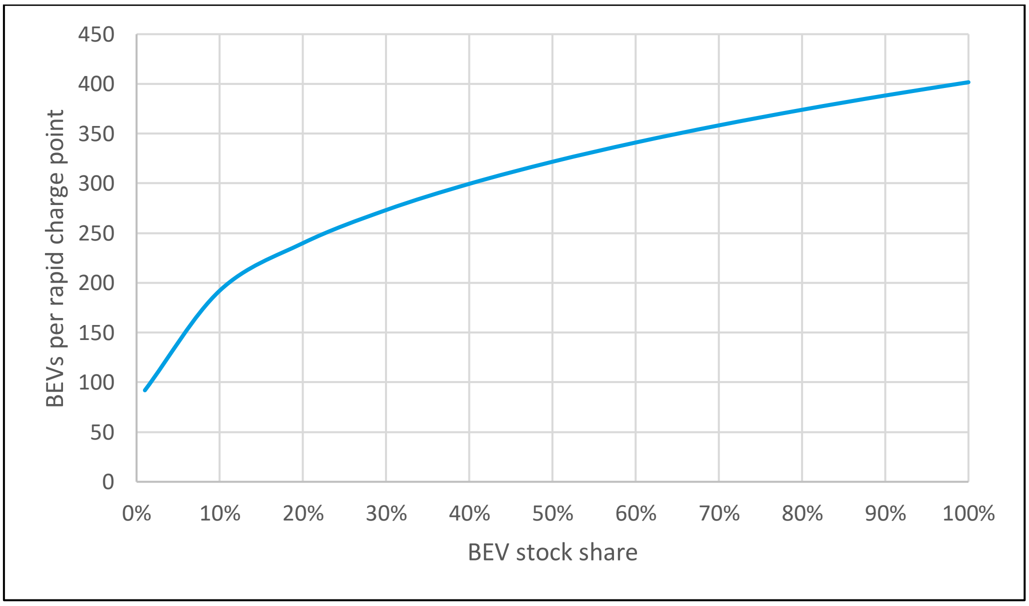
Figure 0.2: Average utilisation per day for slow public charge points (3-22kW) as a function of EVs per million population [16]



Under this relationship, average utilisation increases from approximately 2 hours per day in 2020 to 6 hours as EV approach 100% stock share.

The number of rapid public (≥50kW) charge points is estimated using a correlation between BEVs per charge point and the BEV stock share:

Figure 0.3: Number of BEVs per rapid charge point as a function of BEV stock share [16]



A portion of these rapid charge points are assumed to be ultra-rapid (≥150kW) highway charge points, used by BEVs to complete long-distance journeys. It is assumed that there are 1,355 BEVs per ultra-rapid highway charge point. This is based on the assumptions there are 1,500 BEVs and 1,000 BEVs per ultra-rapid highway charge point across metropolitan and non-metropolitan areas, respectively, and 29% of the EV stock is in non-metropolitan areas[16].

The cost of providing this infrastructure is calculated using assumptions shown in Table 0.4. Note that this excludes the cost of distribution network upgrades required for work and home charging. For work charging these costs are highly location specific and thus uncertain, and it is assumed that most commercial properties will deploy some level of load balancing to avoid connection upgrades. The cost of distribution upgrades due to home charging will be socialised, and again it is assumed that smart charging will be widespread to avoid charging during peak times. To calculate total costs, it is assumed that charge points are replaced every 10 years, but only the hardware and installation cost is paid upon replacement.

Table 0.4: Cost assumptions for each charge point type

Charge Point Type	Hardware (£)[18]		Installation (£)[19]		Connection (£)[19]	
	2020	2030	2020	2030	2020	2030
Home	529	309	353	353	0	0
Work	705	397	353	353	0	0
Slow Public (3-22kW)	2204	1234	2,998	2,998	1,543	446
Rapid Public (50kW)	26,451	19,397	23,806	23,806	3,368	1,371
Rapid Public (150kW)	52,902	36,150	43,203	43,203	6,860	2,238

[18] Cambridge Econometrics and Element Energy for ECF (2018) Fueling Europe's Future 2 https://www.camecon.com/what/our-work/fuelling-europes-future/

[19] Provided through consultation with charge point operator

Appendix C The E3ME Model

E3ME is a computer-based model of the world's economic and energy systems and the environment. It was originally developed through the European Commission's research framework programmes and is now widely used in Europe and beyond for policy assessment, for forecasting and for research purposes. A technical model manual of E3ME is available online at www.e3me.com.

E3ME is often used to assess the impacts of climate mitigation policy on the economy and the labour market. The basic model structure links the economy to the energy system to ensure consistency across each area.

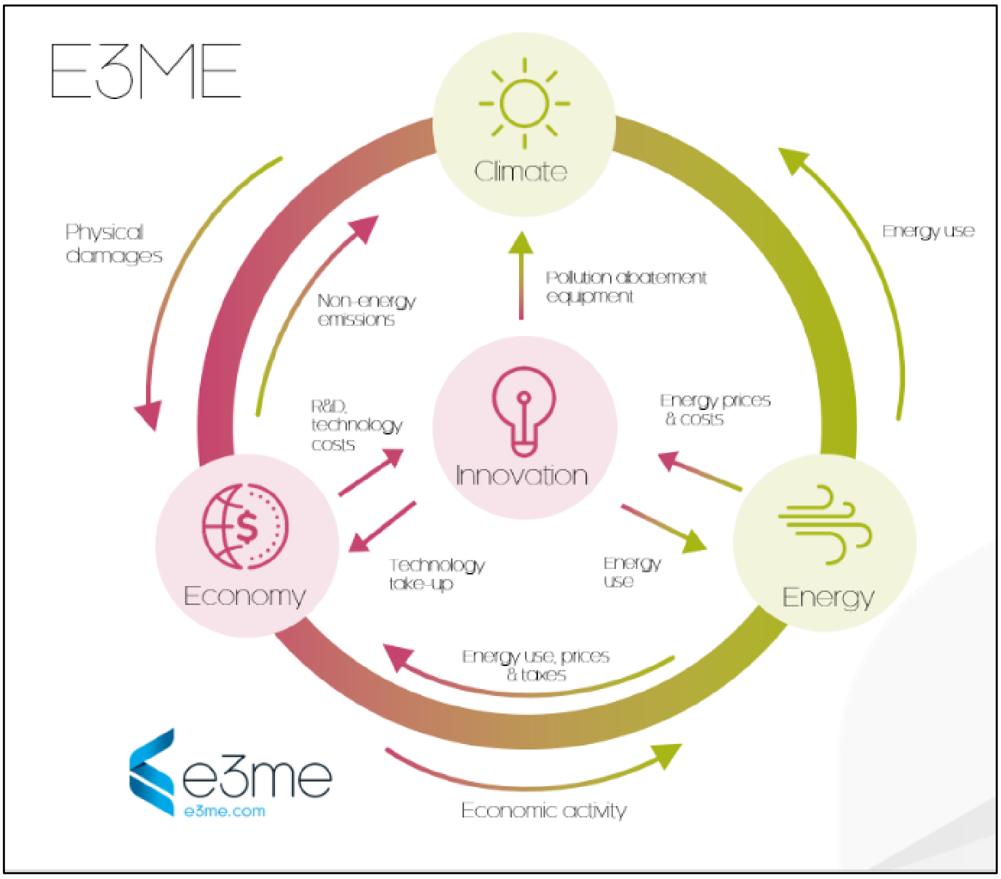
As a global E3 model, E3ME can provide comprehensive analysis of policies;

- direct impacts, for example reduction in energy demand and emissions, fuel switching and renewable energy
- secondary effects, for example on fuel suppliers, energy price and competitiveness impacts
- rebound effects of energy and materials consumption from lower price, spending on energy or higher economic activities
- overall macroeconomic impacts; on jobs and economy including income distribution at macro and sectoral level.

Theoretical underpinnings

Economic activity undertaken by persons, households, firms and other groups in society has effects on other groups after a time lag, and the effects persist into future generations, although many of the effects soon become so small as to be negligible. But there are many actors and the effects, both beneficial and damaging, accumulate in economic and physical stocks. The effects are transmitted through the environment (with externalities such as greenhouse gas emissions contributing to global warming), through the economy and the price and money system (via the markets for labour and commodities), and through the global transport and information networks. The markets transmit effects in three main ways: through the level of activity creating demand for inputs of materials, fuels and labour; through wages and prices affecting incomes; and through incomes leading in turn to further demands for goods and services. These interdependencies suggest that an E3 model should be comprehensive and include many linkages between different parts of the economic and energy systems.

Figure 0.4: E3ME Interactions diagram [16]



E3ME is often compared to Computable General Equilibrium (CGE) models. In many ways the modelling approaches are similar; they are used to answer similar questions and use similar inputs and outputs. However, underlying this there are important theoretical differences between the modelling approaches.

In a typical CGE framework, optimal behaviour is assumed, output is determined by supply-side constraints and prices adjust fully so that all the available capacity is used. In E3ME the determination of output comes from a post-Keynesian framework and it is possible to have spare capacity. The model is more demand-driven and it is not assumed that prices always adjust to market clearing levels.

The differences have important practical implications, as they mean that in E3ME regulation and other policy may lead to increases in output if they are able to draw upon spare economic capacity. This is described in more detail in the model manual.

The econometric specification of E3ME gives the model a strong empirical grounding. E3ME uses a system of error correction, allowing short-term dynamic (or transition) outcomes, moving towards a long-term trend. The dynamic specification is important when considering short and medium-term analysis (e.g. up to 2020) and rebound effects, which are included as standard in the model's results.

Basic Structure and data used

The structure of E3ME is based on the system of national accounts, with further linkages to energy demand and environmental emissions. The labour market is also covered in detail, including both voluntary and involuntary unemployment. In total there are 33 sets of econometrically estimated equations, also including the components of GDP (consumption, investment, international trade), prices, energy demand and materials demand. Each equation set is disaggregated by country and by sector.

E3ME's historical database covers the period 1970-2018 and the model projects forward annually to 2050. The main data sources for European countries are Eurostat and the IEA, supplemented by the OECD's STAN database and other sources where appropriate. For regions outside Europe, additional sources for data include the UN, OECD, World Bank, IMF, ILO and national statistics. Gaps in the data are estimated using customised software algorithms.

The main dimensions of E3ME are:

- 61 countries – all major world economies, the EU28 and candidate countries plus other countries' economies grouped
- 44 (or 70 in Europe) industry sectors, based on standard international classifications
- 28 (or 43 in Europe) categories of household expenditure
- 22 different users of 12 different fuel types
- 14 types of air-borne emission (where data are available) including the 6 GHG's monitored under the Kyoto Protocol