Accelerating the EV transition

Part 1: environmental and economic impacts

Report prepared for

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Glossary and abbreviations

Light duty vehicle (LDV)	A classification of road vehicles that includes cars, vans and sport-utility vehicles.
Electric Vehicles (EVs)	EVs (often referred to Battery Electric Vehicles – BEVs) refers to vehicles with an electric motor and battery. In this report we focus on LDV EVs – electric cars and vans.
Internal Combustion Engines (ICEs)	ICEs are conventional vehicles that produce power through the combustion of fossil fuels with air inside an engine.
Extended Range Electric Vehicles (E-REVs) and Plug-in Hybrid Vehicles (PHEVs)	E-REVs and PHEVs use an electric motor and battery but are supported by an internal combustion engine that may be used to recharge the vehicle's battery. PHEVs use their electric and ICE motor interchangeably, whereas E-REVs only use the ICE motor when the electrical charge is exhausted.
Vehicle fleet	The total stock of vehicles in circulation at a particular point in time.
ICE phase out	The UK's commitment to end the sale of all new conventional petrol and diesel cars and vans by 2040
Gross Value Added (GVA)	The value of goods and services produced in the UK. In national accounts GVA is defined as output minus intermediate consumption
Private and public charging points	Private charging points refer to those in workplaces (including depots for fleet vehicles) and homes; Public charging points include long-distance en-route charging, and parking-based charging
Original Equipment Manufacturer (OEMs)	A company that produces parts and equipment to be marketed by another manufacturer, such as batteries and electric motors.
Nationally Determined Contributions (NDCs)	The means for governments to communicate internationally their level of ambition under the Paris Agreement, commonly expressed as a reduction in emissions in 2030.
CO_2; NO_x; PM10	Pollutants from the burning of fossil fuels. CO_2: carbon dioxide; NOx: oxides of nitrogen (NO and NO_2); PM10: particulate matter of 10 micro meters or less

1 Introduction

In 2017 the UK Government's Air Quality Plan set out a commitment to end the sale of all new conventional petrol and diesel cars and vans by 2040, and "for almost every car and van on the road to be a zero emission vehicle by 2050" (Defra 2017). WWF has commissioned Vivid Economics to identify key impacts of moving from a 2040 to a 2030 phase out of conventional cars and vans.

This report covers selected impacts on the economy and the environment. It highlights a few important costs and benefits, but further work is required to move from this analysis to a detailed impact and feasibility assessment[1]. This analysis also makes clear that the significant scale of the transition from conventional vehicles on the manufacturing sector. Measures to enable the transition may be warranted, as highlighted in the Government's Sector Deal, such as a skills package and supporting access to global supply chains. Our detailed sub-sector analysis suggests a mapping of impacts by sub-sector (for example, engines, parts, assembly) is required to identify the right interventions, which will vary for each skill set.

An important feature of this report is use of scenario analysis to investigate how UK-based EV manufacture could change. Scenarios are plausible narratives about the future that are useful in the context of uncertainty and are not intended to be predictive. The scenarios all entail increased UK production of EVs, as they take place in the context of the UK becoming a leading European player in electric vehicles and ambitious Government commitments. Box 1 includes more detail on the nature of the UK automotive industry today and how it is changing.

Box 1. **Key features of the UK automotive industry**

- The UK produces 1.7 million cars, 93 thousand vans and 2.5 million engines and a variety of other parts.
- Auto manufacturers and major component suppliers represent approximately £13 billion of gross value added (GVA), £47 billion of turnover and 136,000 jobs in direct manufacturing
- The majority of the UK's automotive production (75% of vehicles) is exported. The majority of the vehicles used in the UK (85% of vehicles) are imported.
- The UK industry is focussed on assembly: 69% of automotive sector GVA and 57% of jobs are in assembly of vehicles, rather than parts.
- The UK Government has announced measures to support the transition from conventional vehicles to EVs in the 2017 Clean Growth Plan and Automotive Sector Deal. These include a £246 million investment in the Faraday Battery Challenge, which aims to make the UK a world leader in the design and manufacture of batteries. Further measures on EV infrastructure are summarised in Box 2.
- Key new facilities include the all-electric Nissan LEAF and lithium-ion batteries in Sunderland, electric taxis by Geely in Coventry and plans for Jaguar Land Rover's battery manufacture plant.

[1] Although part 2 of this work will take account of energy system costs, a full assessment would take account of the costs and benefits of a larger automotive sector, incorporating crowding out of other sectors and regional impacts. It would also assess who pays.

This report is Part 1, and focuses on key selected economic, environmental and energy impacts. Part 2 will cover the impact on the energy system, including the costs of distribution network reinforcements and potential benefits to system balancing of smart charging, battery reuse and vehicle to grid.

The impact areas studied in this report include road transport (including sales, fleet and charging infrastructure), the automotive manufacturing industry (including employment and GVA) and environmental impacts and the energy sector (carbon emissions, air pollution and oil imports). Results below and throughout the report are for a snapshot in 2030 (unless otherwise stated).

Impacts on road transport: sales, fleet and charging infrastructure

- A 2030 phase out scenario could increase the number of electric cars and vans on the road from around 0.1 million today to 20 million in 2030, compared to 13 million in a 2040 phase out scenario.
- A 2030 phase out scenario could increase the scale of charging infrastructure from around 140,000 today to 21 million chargers in 2030, compared to 13 million in a 2040 phase out.
- Private charging infrastructure (home and workplace, including depots for fleet vehicles) will be widespread, and accounts for more than 95% of charging points; public charging infrastructure (long-distance en-route charging, and parking-based charging) is also important, but much smaller scale.
- The cost of private chargers is around £500; the cost of public chargers is higher with a wider range: starting at around £7,500 for charge points for local authorities in residential areas, and up to £34,000-£112,000 for rapid chargers.

Impacts on automotive manufacturing: employment and GVA

- As a result of a 2030 or a 2040 phase out, the UK could become the dominant location of EV sales in Europe. A 2030 phase out scenario increases the UK sales of EVs from 21% of European sales today to 47% in 2030 (compared to 36% in a 2040 phase out scenario). This will provide an opportunity for both UK and European EV production. The increase in UK production will depend on its ability to develop and maintain a competitive EV industry, to attract investment, and to access global supply chains.
- Vehicles are a highly traded good, which implies that where they are sold can be far from where they are produced. However, there is evidence to suggest that location of EV sales does impact decisions about locating production facilities.
- In the UK context in the short term, Brexit is likely to heighten the uncertainty around the location of future production facilities. In the medium term, it is possible that there are other changes that could impact production, such as new import tariffs in the US, China or elsewhere. In this report we focus on the impact of UK EV sales on UK production, and assume other factors that may impact production stay broadly the same as today.

- The UK has a substantial existing EV and automotive sector, as well as strategic advantages in some areas of manufacture, particularly assembly. The UK's current production patterns and areas of competence suggest that there are plausible futures in which an increase in domestic sales does lead to increasing production in the UK.
- The UK's 2040 phase out commitments and associated EV policies (for example, charge point deployment, EV and automotive regulations passing through Parliament, funding for battery innovation) are already impacting investors and Original Equipment Manufacturers (OEMs) considering where to locate their plant.
- Against this backdrop, we develop two scenarios to represent plausible futures for UK production in the context of increasing EV sales in the UK.
  - The **2030 scenario** assumes that the UK's share of European vehicle sales stays the same as today. Because the number of sales increases, the UK production increases from around 16,000 EVs today to around 880,000 EVs per year (210,000 more than under the 2040 scenario). Gross Value Added (GVA) in the EV industry increases to around £7.7 billion, and jobs in the EV industry to around 89,000 (an additional £2.1 billion of GVA and 24,000 jobs relative to the 2040 scenario).
  - The **2030+ scenario** adds an additional medium scale UK manufacturing plant to the 2030 scenario, capable of producing 100,000 vehicles. It assumes that the UK's larger domestic market and strategic advantages in assembly helps attract additional investment. In this more ambitious scenario, the UK produces around 980,000 EVs per year (further 100,000 EVs compared to the 2030 scenario), adding a further £1 billion of GVA and 14,000 jobs to the EV industry (which comprises 103,000 jobs in 2030) and UK automotive as a whole (which comprises 176,000 jobs in 2030), compared to the 2030 scenario. *The size of the new facility in the 2030+ scenario is illustrative, and at the lower end of current facilities in the UK. If a new facility was added capable of producing 200,000 vehicles, it would double the increase GVA and jobs of a 100,000-vehicle plant.*
- Total automotive industry jobs in the 2030 scenario are likely to be similar to the 2040 scenario, while in the 2030+ scenario the total number of jobs supported is larger.
- It is likely that for the majority of jobs, for example in assembly and the majority of parts, skills are transferable and the increase in EV jobs can provide employment that offsets the decrease in conventional car and van jobs.

Impacts on the environment and energy: carbon emissions, air pollution and oil imports.

- The 2030 phase out would reduce tailpipe CO_2 emissions by 13 $MtCO_2e$ in 2030, and 62 $MtCO_2e$ over the fifth carbon budget period. This saving could reduce the policy gap to meet the fifth carbon budget by 53%. Put differently, this is equivalent to the CO_2 from 6 million homes.
- The 2030 phase out would reduce total cumulative CO_2 emissions to 2050 by around 280 $MtCO_2e$ relative to a 2040 phase out. This is equivalent to the emissions from around 5 million homes over a 30-year period.

- The 2030 phase out would reduce NOx emissions from cars and vans in 2030 from 134 kt today to around 42 kt in 2030. This is 91 kt (68%) below today's levels and 14 kt (25%) lower than under a 2040 phase out. A 2030 phase out would also reduce PM10 emissions from cars and vans from around 2 kt today to around 0.7 kt in 2030. This is 1.4 kt (68%) below today's levels and 0.2 kt (24%) lower than under a 2040 phase out. The economic value of this reduction could be around £300 million per year in 2030 (with an uncertainty range of £127-485).
- The 2030 phase out would reduce oil consumption, and therefore net oil imports, by around 4.4 $MtCO_2e$ in 2030, a 15% reduction compared to a 2040 scenario. This is a £2 billion saving per annum in 2030 to the UK in terms of avoided costs of oil imports.

This report covers these issues in the following three sections:
- Section 2 impacts on road transport: sales, fleet and charging infrastructure
- Section 3 impacts on the automotive manufacturing industry: employment and GVA
- Section 4 impacts on the environment and energy: carbon emissions, air pollution and oil imports.

2 Impact on the road transport sector: sales, fleet and charging infrastructure

Key messages

- A 2030 phase out scenario could increase the number of electric cars and vans on the road from around 0.1 million today to 20 million in 2030, compared to 13 million in a 2040 phase out scenario.
- A 2030 phase out scenario could increase the scale of charging infrastructure from around 140,000 today to 21 million chargers in 2030, compared to 13 million in a 2040 phase out.
- Private charging infrastructure (home and workplace, including depots for fleet vehicles) will be widespread, and accounts for more than 95% of charging points; public charging infrastructure (long-distance en-route charging, and parking-based charging) is also important, but much smaller scale.
- The cost of private chargers is around £500; the cost of public chargers is higher with a wider range: starting at around £7,500 for charge points for local authorities in residential areas, and up to £34,000-£112,000 for rapid chargers.

2.1 Impact on vehicle sales and fleet

The UK's light duty vehicle fleet (cars and vans) is currently made up of around 35 million vehicles; new sales in 2016 were 3 million vehicles. In 2016 there were 31 million cars and 3.8 million vans in the UK. New car sales were around 2.6 million, while new van sales were around 380,000.

Under a 2040 phase out, there could be a fleet of 13 million EVs by 2030, up from around 137,000 today. In the 2040 scenario, electric car sales increase to 1.8 million per annum in 2030 and electric van sales increase to 275,000 per annum (around 60% of new vehicles) in 2030. The impact of this sales profile is that the electric car fleet increases to around 11 million (30% of the fleet) and the electric van fleet increase to around 2 million (40% of the fleet) in 2030.

A 2030 phase out could increase the fleet of EVs to 17 million in 2030. In the 2030 scenario, electric car sales increase to around 3 million while electric van sales increase to around 440,000. Put differently, 100% of new vehicle sales in 2030. The impact of this sales profile is that the electric car fleet increases to around 17 million (47% of the fleet) and the electric van fleet increase to 2.8 million (56% of the fleet) in 2030.

2.2 Impact on charging infrastructure

Electric vehicles need four key types of charging infrastructure. Private charging infrastructure includes home and workplace charging; public charging infrastructure includes long-distance en-route charging and parking-based charging.

Private charging infrastructure will be in most homes and many workplaces. The opportunity to charge at home rather than relying on public charging infrastructure is an attractive feature of electric vehicles, and we assume that owners who are able to charge at home will do so when convenient (for example overnight). Workplace chargers are also likely to be required; evidence suggests that around 20% of electric vehicles currently make use of workplace charging (Element Energy 2013). In the 2040 scenario, 11 million home chargers and around 2.2 million workplace chargers are needed by 2030.

Long-distance en-route charging, and parking-based charging infrastructure are also important, but much smaller scale. In developing our projections of required charging infrastructure, we have drawn on recent work by Systra for the Committee on Climate Change (Systra 2018). Systra's estimate is that around 27,000 chargers will be needed for parking-based charging in 2030 (up from 2,700 in 2016), around 1,200 chargers for en-route rapid charging (up from 460 in 2016)[2]. These estimates assume that the proportion of EV owners who have access to off-street home charging decreases from 93% in 2016 to 80% by 2030, as consumers increasingly rely on workplace and public charging.

Overall, the 2030 phase out will require investment in charging infrastructure to be brought forward, with an additional 8 million chargers installed in 2030 relative to a 2040 phase out. Figure 1 presents the volume of charging infrastructure needed in the 2040 and 2030 scenarios.

Under a 2030 phase out the private chargers will cost around £11.5 billion in 2030, while the public charging infrastructure will cost a fraction of this, at around £800 million (Figure 2). While this is higher than the government's current commitments (the 2040 scenario costs £7 billion in 2030), it represents cost brought forward in time, rather than additional expenditure. Public charging is more expensive than private per unit. Rapid chargers (used in long distance en-route and some parking-based charging) are estimated to cost between £34,000 and £112,000 (depending on type and location), while public chargers are estimated to cost between £500-£1,000. However, due to much smaller scale, the cost of public charging infrastructure is significantly lower, at under 10% of the total infrastructure cost.

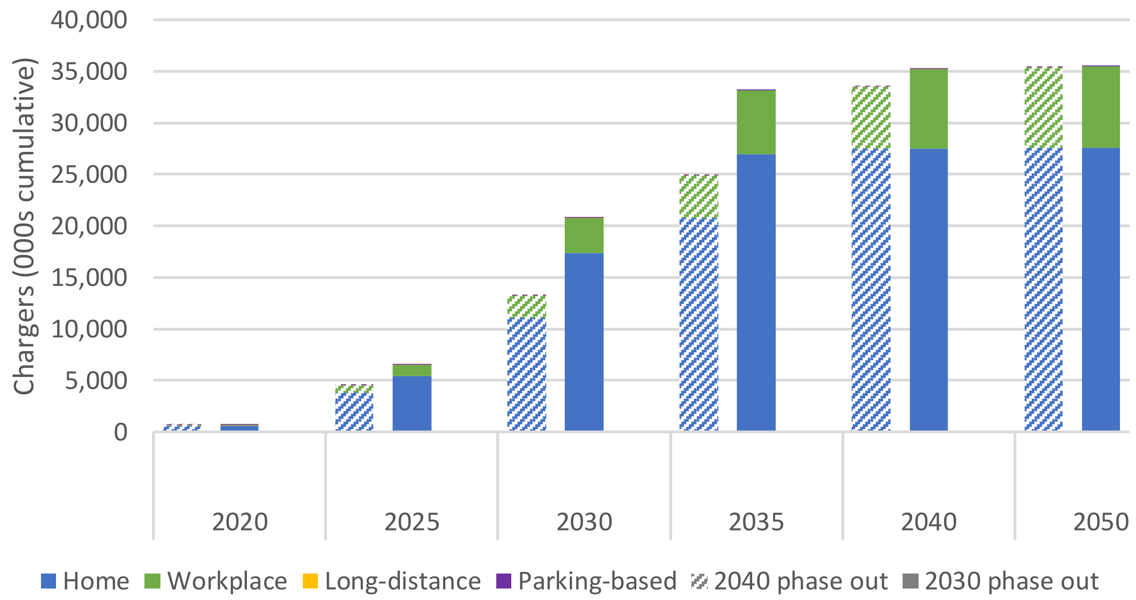
[2] The 2040 scenario in this report is aligned to the CCC Central EV Uptake Scenario.

Box 2. **UK Government measures for infrastructure to support the deployment of EVs**

The UK Government has announced measures for supporting infrastructure for EVs, including:

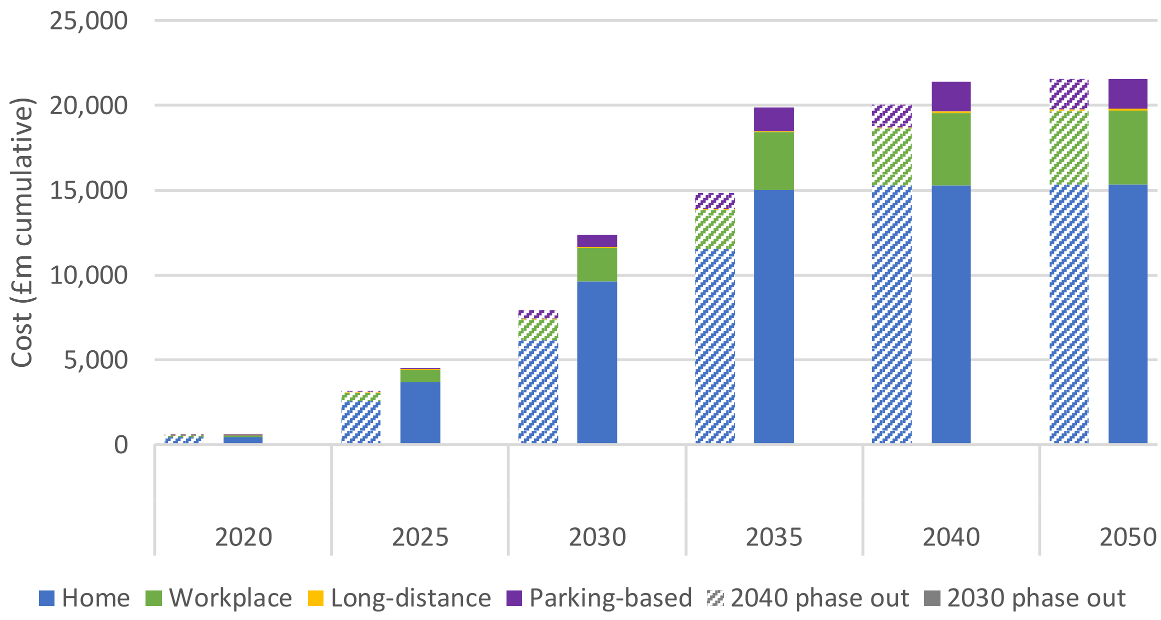
- Workplace and residential charging funding, including £400 million Charging Infrastructure Investment Fund (£200 million from the government to be matched by private investors)
- Rapid charging funding, including £80 million to support charging infrastructure deployment, alongside £15 million from Highways England to ensure rapid points every 20 miles across 95 per cent of England's Strategic Road Network
- R&D funding of £40 million funding (matched by industry) for new charging technologies including on-street and wireless projects
- New powers under the Automated and Electric Vehicles Bill, allowing the Government to set requirements for the provision of charging points

Figure 1. **Private charging infrastructure in most homes by 2030; public charging is also important, but smaller scale**



Note: *Private charging infrastructure includes home and workplace charging; public charging infrastructure includes long-distance en-route charging, and parking-based charging*

Figure 2. **Public charging infrastructure will cost significantly less than private**



Note: *Private charging infrastructure includes home and workplace charging; public charging infrastructure includes long-distance en-route charging, and parking-based charging.*

3 Impact on the automotive industry: employment and GVA

Key messages

- As a result of a 2030 or a 2040 phase out, the UK could become the dominant location of EV sales in Europe. A 2030 phase out scenario increases the UK sales of EVs from 21% of European sales today to 47% in 2030 (compared to 36% in a 2040 phase out scenario). This will provide an opportunity for both UK and European EV production. The increase in UK production will depend on its ability to develop and maintain a competitive EV industry.
- We develop two scenarios to represent plausible futures for UK production in the context of the 2030 phase out increasing EV sales in the UK.
  - The **2030 scenario** assumes that the UK's share of European vehicle sales stays the same as today. Because the number of sales increases, the UK production increases from around 16,000 today to around 880,000 EVs per year (210,000 more than under the 2040 scenario). GVA in the EV industry increases to around £7.7 billion, and jobs in the EV industry to around 89,000 (an additional £2.1 billion of GVA and 24,000 jobs relative to the 2040 scenario).
  - The **2030+ scenario** adds an additional medium scale UK manufacturing plant to the 2030 scenario, capable of producing 100,000 vehicles. It assumes that the UK's larger domestic market and strategic advantages in assembly helps attract additional investment. In this more ambitious scenario, the UK produces around 980,000 EVs per year (further 100,000 EVs compared to the 2030 scenario), adding a further £1 billion of GVA and 14,000 jobs to the EV industry (which comprises 103,000 jobs in 2030) and UK automotive as a whole (which comprises 176,000 jobs in 2030), compared to the 2030 scenario. *The size of the new facility in the 2030+ scenario is illustrative, and at the lower end of current facilities in the UK. If a new facility was added capable of producing 200,000 vehicles, it would double the increase GVA and jobs of a 100,000-vehicle plant.*
- Total automotive industry jobs in the 2030 scenario are likely to be similar to the 2040 scenario, while in the 2030+ scenario the total number of jobs supported is larger.
- It is likely that for the majority of jobs, for example in assembly and the majority of parts, skills are transferable and the increase in EV jobs can provide employment for the decrease in conventional car and van jobs.

3.1 The current UK automotive industry

The UK has a large automotive sector. The UK produces 1.7 million cars, 93 thousand vans and 2.5 million engines per year, as well as a variety of other parts (SMMT 2017). In total auto manufacturers and their Tier

1 suppliers (specialist suppliers of vehicle parts such as engines, brakes, chassis etc.) currently represent approximately £13 billion of gross value added (GVA), £47 billion of turnover and 136,000 jobs in direct manufacturing (ONS 2017).[3] The vehicle manufacturing sector is dominated by a handful of large scale players including Nissan and Jaguar-Land Rover with eight plants producing 93% of the vehicles produced. Similarly, a handful of manufacturers dominate engine manufacturing for light duty vehicles, with the six key[4] ones listed in Figure 5.

Around 85% of the UK's automotive production is exported. Of its completed vehicle exports, the UK exports around 53% to Europe, and a further 16% to the US and 8% to China, with the remainder dispersed over a large number of countries. Trade is mostly in complete vehicles, although vehicle parts are also highly traded, with the UK exporting 42% (by value) of parts produced (UN 2018). Notably, 57% of the internal combustion engines (ICEs) produced in the UK are exported; a number of plants produce engines purely for export, such as the Ford engines produced in the UK.

The UK industry is focussed on assembly rather than parts. 69% of GVA in the automotive sector is associated with the assembly of vehicles. This high percentage is because the UK produces relatively fewer parts compared to other major European countries, with an estimated 40% of UK parts in UK-assembled vehicles compared to 60% in Germany and France (Automotive Council UK 2017). Engines and engine components dominate UK exports of parts, representing 49% of value (UN 2018).

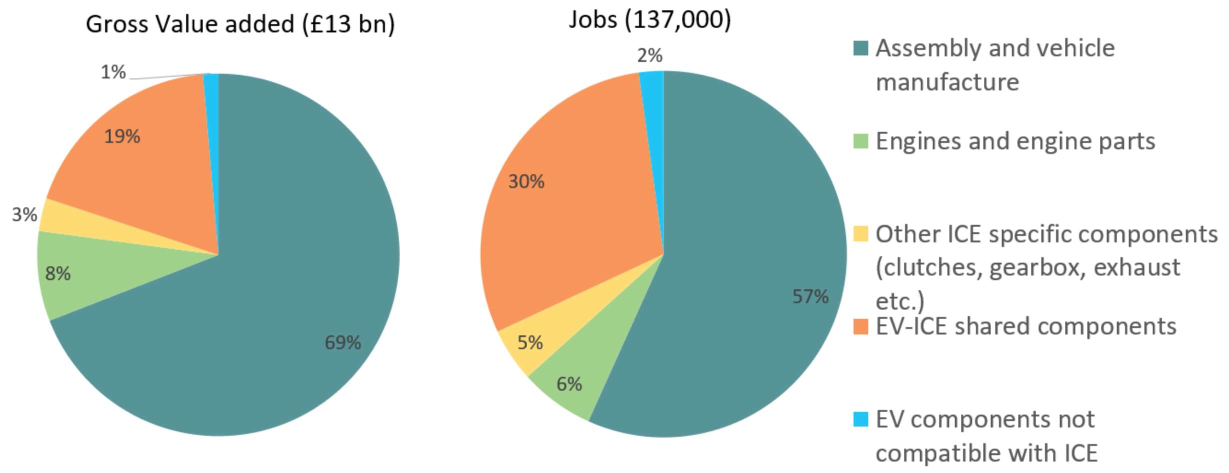
Recently, the UK has become a leading European player in electric vehicles. It is the European production base for one of the most popular EVs, the Nissan LEAF, with approximately 16,000 produced annually in the UK. 29% of the LEAFs produced in Sunderland have been sold in the UK, with nearly all of the remainder exported to Europe. Along with LEAF production, the UK is beginning to develop an EV parts industry, with companies such as YASA and Johnson Matthey producing components for EV powertrains such as motors and batteries and established ICE parts suppliers such as GKN diversifying into specialised EV axles.

The UK Government is committed to strongly supporting this transition. The UK Government intends to capitalise on the UK's strengths and to move towards mass producing electric batteries and vehicles here in the UK. To this end, the Government is investing £246 million into the Faraday Battery Challenge, which aims to make the UK a world leader in the design, development and manufacture of batteries for the electrification of vehicles.

[3] Note, these reported figures are lower than those reported by the SMMT, due to the focus of this report on manufacturing and Tier 1 suppliers. Tier 1 suppliers are suppliers of recognisable vehicle parts such as engines, brakes, chassis etc. They are differentiated from Tier 2 and Tier 3 suppliers which supply parts to Tier 1 suppliers, and typically produce products not exclusively used in vehicles (such as leather for seats).

[4] A further large UK player in ICE manufacture is Cummins based in Darlington. However, Cummins primarily produces engines for heavy vehicles, which are not considered for this report as they are less likely to be electrified in the short term.

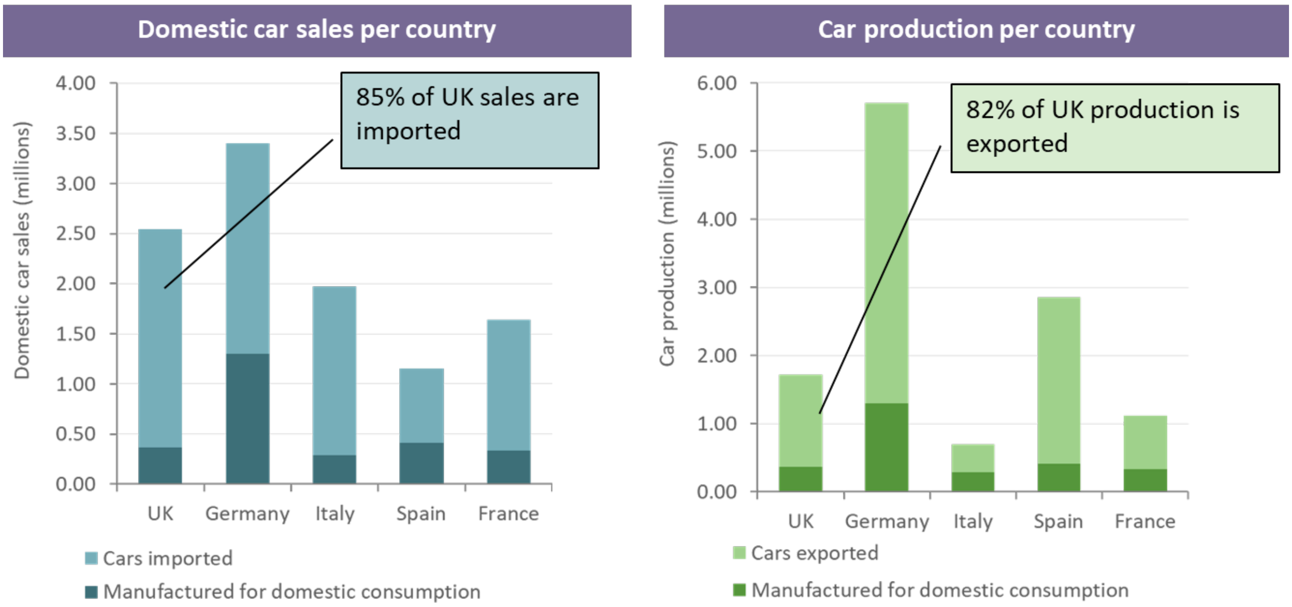
Figure 3. **The current UK automotive industry is dominated by assembly**



Note: *GVA and jobs represented for auto manufactures (original equipment manufacturers, or OEMS) and Tier 1 suppliers. This captures approximately 80% of the 'direct automotive manufacturing' jobs as reported by SMMT. Analysis is based on 2016 ONS data.*

Source: Vivid Economics based on ONS and SMMT

Figure 4. **The UK exports most of the cars it produces and imports most of the cars it uses**

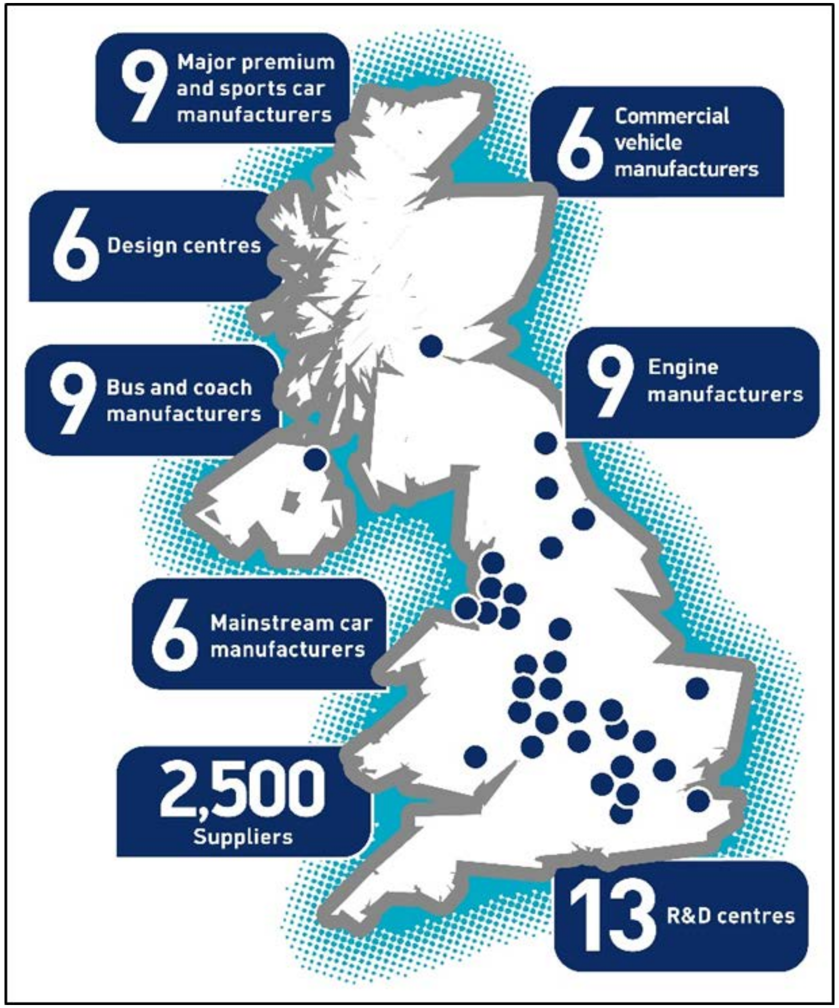


Note: *Sales and production data for 2017. This is for cars only, and excludes vans, for which trade data is not as widely available.*

Source: *Vivid Economics based on SMMT (UK), CCFA (France), ANFIA (Italy), ANFAC (Spain)*

Figure 5. **UK automotive assembly and engine manufacture is dominated by a small number of large manufacturers**

Manufacturer	Plant(s)	Assembly or engine plant	Annual production	Approximate number of jobs
Jaguar Land Rover	Castle Bromwich/ Halewood/ Solihull	Vehicle	544,000	13,200
Nissan	Sunderland	Vehicle	507,000	6,700 (across assembly and engine)
MINI (BMW)	Oxford	Vehicle	210,000	4,000
Toyota	Burnaston-Derby	Vehicle	180,000	~2,500
Honda	Swindon	Vehicle	134,000	~2,900
Vauxhall	Ellesmere Port	Vehicle	118,000	1,800*
Jaguar Land Rover	Wolverhampton	Engine	Exact numbers unknown	1,400
Nissan	Sunderland (same as assembly plant)	Engine	Exact numbers unknown	6,700 (across assembly and engine)
Ford	Dagenham and Bridgend	Engine	Exact numbers unknown	1,800 and 2,100
Toyota	Deeside	Engine	337,000	500
MINI (BMW)	Ham Hall	Engine	257,000	1,200
Honda	Swindon (same as assembly plant)	Engine	365,000	500



Source: *Vivid Economics based on SMMT, Jaguar Land Rover, MINI/BMW, Toyota, Honda, Vauxhall and Nissan*

3.2 The impact of the 2030 ICE phase out on the future UK automotive industry

A 2030 phase out of conventional petrol and diesel cars and vans is likely to increase investment and jobs in the in electric vehicle industry. Because of the phase out, the UK could become the dominant EV market in Europe. This will provide an opportunity for both UK and European EV production. The increase in UK production will depend on its ability to develop and maintain a competitive EV sector. We set out two plausible outcomes for UK production: the 2030 scenario, in which the UK's competitiveness in EVs is comparable to its competitive position in conventional vehicles today; and the 2030+ scenario, in which the UK's competitiveness increases because of the 2030 phase out.

Because of the phase out, the UK could become the dominant EV market in Europe. In the 2030 scenario, UK electric car sales increase from around 56,000 today to around 3 million in 2030 (compared to 1.8 million in a 2040 scenario). Electric van sales increase from approximately 1,000 today to around 440,000 in 2030 (compared to 273,000 in a 2040 scenario). In the 2040 scenario, the UK share of that light duty vehicle (cars and vans combined) EV market will be 36% of the European total; in the 2030 scenario, this share increases to 47%[5].

The impact of a larger domestic market on UK EV production is difficult to predict and will depend on its ability to develop and maintain a competitive industry compared to other major European manufacturing locations. Given the highly traded nature of cars and vans across Europe, a larger domestic market will provide an opportunity for both UK and European EV production. That is, UK demand will be met through a combination of UK and Europe based production. It is possible that the UK's share of future EV production evolves in line with its share of conventional vehicles today (2030 scenario). However, it is also possible that the UK's larger domestic market helps attract investment in additional EV manufacturing plant in the UK (2030+ scenario).

Decisions about the location of future automotive manufacturing plant are finely balanced. The UK competes within a European market for manufacturing facilities, and the factors that determine location decisions are currently finely balanced. Key factors that determine location decisions include cost of inputs, including labour, energy and capital. However, recent research suggests that the UK and its competitors are relatively finely balanced (Autoanalysis 2014). In this context, other factors, such as closeness to market and supportiveness of the policy environment, could sway important investment decisions (Klier and Rubenstein 2016). Given the key impact of a 2030 phase out is to increase the market size in the UK, the above analysis suggests that an earlier phase out could be important in decisions about factory location.

To capture the possible impact of a 2030 phase out on manufacturing and jobs, the analysis presents two scenarios and compares these against a baseline of a 2040 phase out of petrol and diesel vehicles. The UK EV market created by a 2030 phase out could lead to increases in UK production in two principal ways:

1. UK production currently supplies 15% of the UK ICE market and if this continues for EVs (as we assume it does in our scenarios), a large UK EV market would increase UK EV production;

[5] BNEF EV sales projections suggest that by 2030, 29%, of the European market will be EVs, and 67% by 2040 (Bloomberg New Energy Finance 2017).

2. The dominant position of the UK EV sales market increases the attractiveness of the UK as a location for producers, possibly attracting additional production to the UK.

We now describe the three scenarios that form the basis of the analysis.

The '2040' scenario, which phases out conventional vehicle sales by 2040 in line with current Government policy, assumes the UK's share of production in EVs is similar to conventional vehicles. That is, the 2040 scenario assumes that the UK will produce 15% of cars and vans sold in the UK, 4% in Europe and 1% in the rest of the world, as it does today. This assumption is supported by the observation that the processes and skills involved with producing EVs and ICEs and the majority of their parts are broadly similar (see Section 3.2.2 for more detail). This suggests that current ICE competitiveness is likely to translate into EV competitiveness.

The '2030' scenario makes the same assumptions as the 2040 scenario but increases EV sales to deliver a faster phase out of conventional vehicle sales. A 2030 phase out implies higher UK EV assembly numbers because the UK continues to produce 15% of its own market.

The '2030+' scenario delivers a phase out of conventional vehicle sales by 2030 and includes a more ambitious assumption about production capacity – adding a new medium scale production plant capable of producing 100,000 vehicles. This more ambitious scenario is plausible because location of market does plays into decisions about locating production, and the 2030 phase out would create a substantially larger market in the UK. An additional assembly factory also increases parts production.

The 2030+ scenario reflects a case where the UK's EV industry becomes more competitive than its current ICE industry. This is a plausible scenario based on an analysis of the factors that underlie decisions about production location (Figure 6):

1. *Factors relating to productivity, such as cost of capital and labour, are relatively even between the UK and its competitors.* In an assessment of the productivity of UK production, the UK scores the same as the Netherlands, slightly lower than Germany and France, and slightly above Italy.
2. *A 2030 phase out means more demand for EVs in the UK, and proximity to demand matters in manufacturing facility location decision.* Klier and Rubenstein (2016) show that manufacturers tend to locate close to areas of high vehicle demand in order to reduce transport costs. This is particularly emphasised in the European context where there is little difference in other factors that affect competitiveness (see 'productivity' in Figure 6). Given the UK will represent 47% of demand by 2030 under a 2030 phase out, closeness to vehicle demand could become a key driver for producers to locate in the UK.
3. *A 2030 phase out plays to the UK's strengths in assembly rather than parts manufacture.* EVs have fewer parts than ICEs – they are mechanically less complex, although electronically more complex (UBS 2017). An area of weakness for the UK with conventional vehicles is parts manufacture, where the UK makes less of the parts it uses than its competitors. In a world of high EVs, this area of weakness is eroded, as the parts supply chain becomes smaller. A 2030 phase out therefore accelerates this process.

Figure 6. **Reasons for possible future attractiveness of the UK for EV manufacturing**

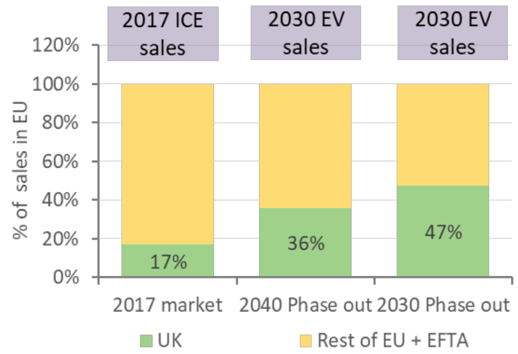
1 **Little difference in productivity across EU**

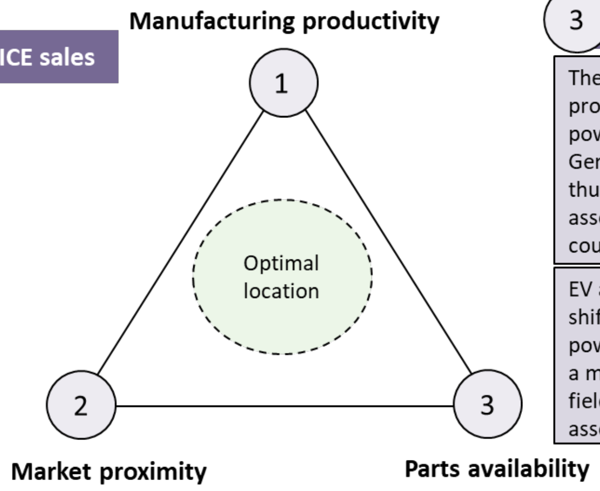
	FR	GER	IT	NL	UK
Average rank (lower is better) across 9 categories affecting automotive productivity	2.8	3.3	3.7	3.6	3.6

Summary of projected changes to UK competitiveness

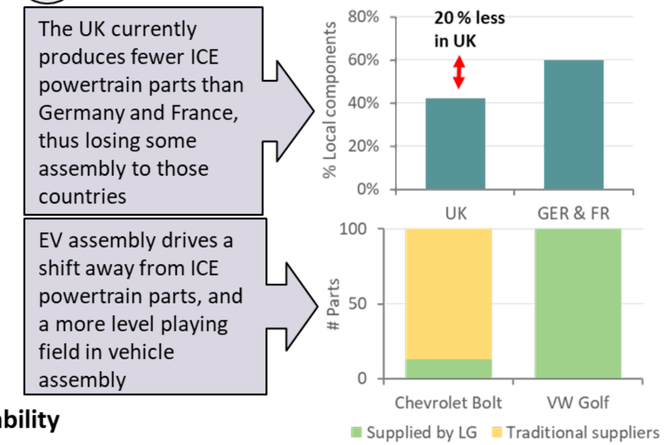
Category	2030 EV compared to current ICE
Manufacturing productivity	→
Proximity to demand	↑
Parts availability	↑

2 **UK EV sales more dominant than current ICE sales**





3 **Current UK disadvantage in parts less important for EVs**



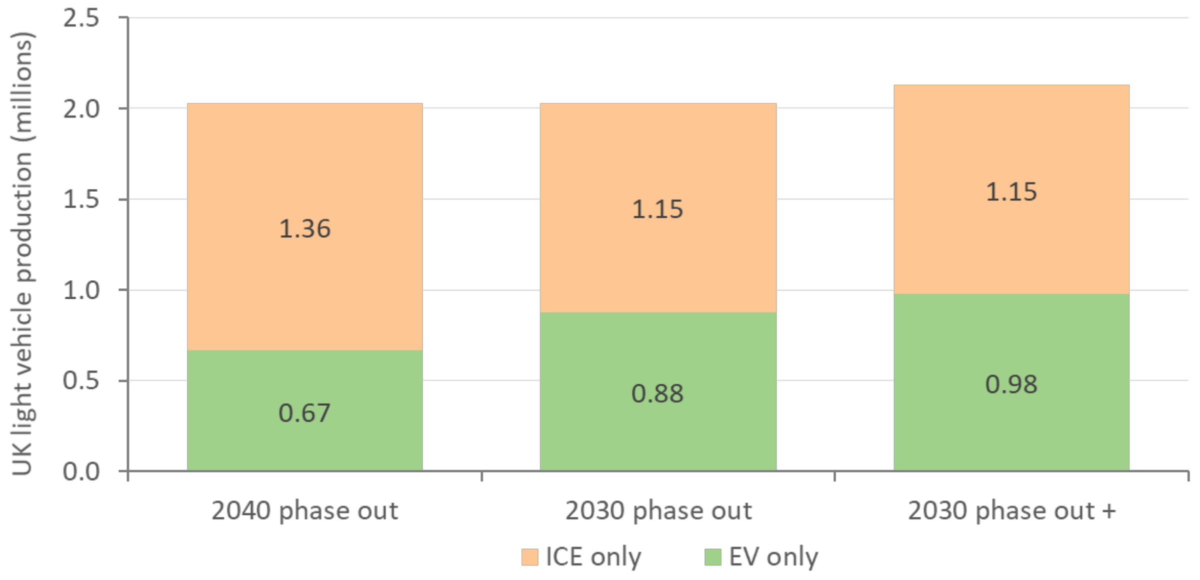
Source: *Vivid Economics based on* (Klier and Rubenstein 2016; Automotive Council UK 2017; Autoanalysis 2014; UBS 2017; SMMT 2017)

3.2.1 Impact of a 2030 phase out on UK EV industry and investment

An additional 210,000 EVs are produced in the UK in a 2030 phase out scenario (Figure 7). If the UK continues to provide 15% of its own vehicles as it does today, annual demand for EVs would be 3.4 million in 2030 (47% of European sales). However, ICE production will decline, leaving total automotive production levels broadly unchanged. It is likely that ICE and EV manufacture involves similar jobs, as the assembly of vehicles is the same, and assembly is the major job type in the UK. Also, many UK parts suppliers (for example, wheels, vehicle bodies and airbags) could provide goods equally to ICE and EV assemblers.

If, in addition, the UK were able to attract an additional factory (the 2030+ scenario) overall automotive production would increase by a further 100,000 EVs. As we set out above, there are two reasons to believe that additional manufacturing capacity might locate in the UK in a 2030 phase out scenario: (1) a 2030 phase out means more demand for EVs in the UK, and proximity to demand matters in location decisions (2) a 2030 phase out plays to the UK's strengths in assembly. It is possible that multiple new factories locate in the UK, however for the purposes of this study we assume a stylised example of the impact of one new factory locating in the UK. The size of factories varies (see Figure 5), with a reasonable medium scale estimate of around 100,000.

Figure 7. **A 2030 phase out shifts the relative importance of EV and conventional vehicle production in the UK**



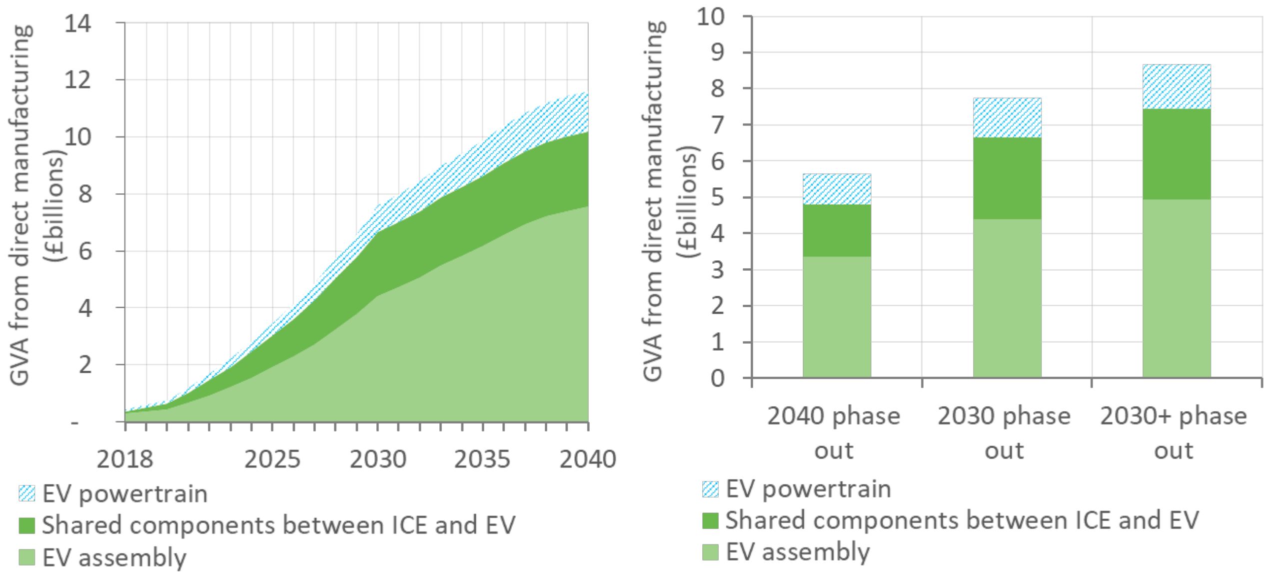
Source: *Vivid Economics*

Relative to a 2040 scenario, the 2030 scenario increases gross value added (GVA) from the EV industry by £2.1 billion per annum in 2030 (37%,Figure 8), and a 2030+ scenario adds £3.0 billion per annum (54% increase). Mirroring the current UK ICE industry, the UK EV industry is likely to generate most value through assembly. Other sources of value include some that are EV specific (electric motors and batteries, also known as the EV powertrain), and others that are shared between ICEs and EVs. The development of the EV-specific industries is less certain than for those that are shared between ICEs and EVs, because these latter sectors are part of a mature ICE industry. These less certain aspects of production are represented by a hashed area in Figure 8.

Box 3. **Relating the modelled scenarios to real world impacts**

The modelled estimates for GVA presented in this section, and jobs in subsequent sections, are presented as gradual increases or decreases. The nature of the automotive industry, with its large parts and vehicle factories, means that, changes are likely to be more abrupt. That is, investment in a factory will increase GVA and jobs significantly within a short timeframe (2-3 years). Plant closures are likely to occur within a similar timeframe.

Figure 8. **A 2030 Phase out would increase GVA, per year, in the UK EV industry**

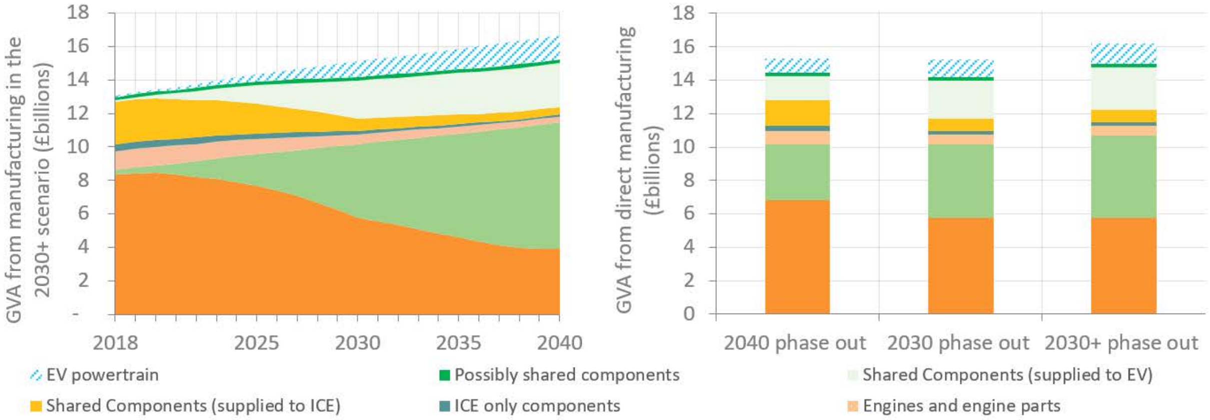


Note: *Left hand chart reflect EV industry GVA evolution over time for the 2030 scenario. Right hand chart presents a snapshot across the scenarios for the year 2030.*

Source: *Vivid Economics*

The UK automotive industry as whole, would see broadly constant GVA in the 2030 scenario, and net growth in the 2030+ scenario. Attracting an additional factory represents £0.9 billion in additional GVA in EV assembly, parts, and EV powertrain manufacture. Approximately £0.5 billion is attributable to the additional factory, with the remainder split between shared ICE and EV parts, and EV specific powertrain parts, as UK parts suppliers increase production to meet the additional demand resulting from the EV factory.

Figure 9. **GVA composition over time in the 2030 scenario, and GVA snapshot in the 2040, 2030 and 2030+ scenarios in the year 2030**



Note: *The 'Shared components between ICE and EV' category includes components such as vehicle bodies. The GVA represented in this graph corresponds to the share of this industry attributed to EVs. A 2030 phase out is unlikely to negatively impact the total GVA. Left hand chart is 2030 scenario.*

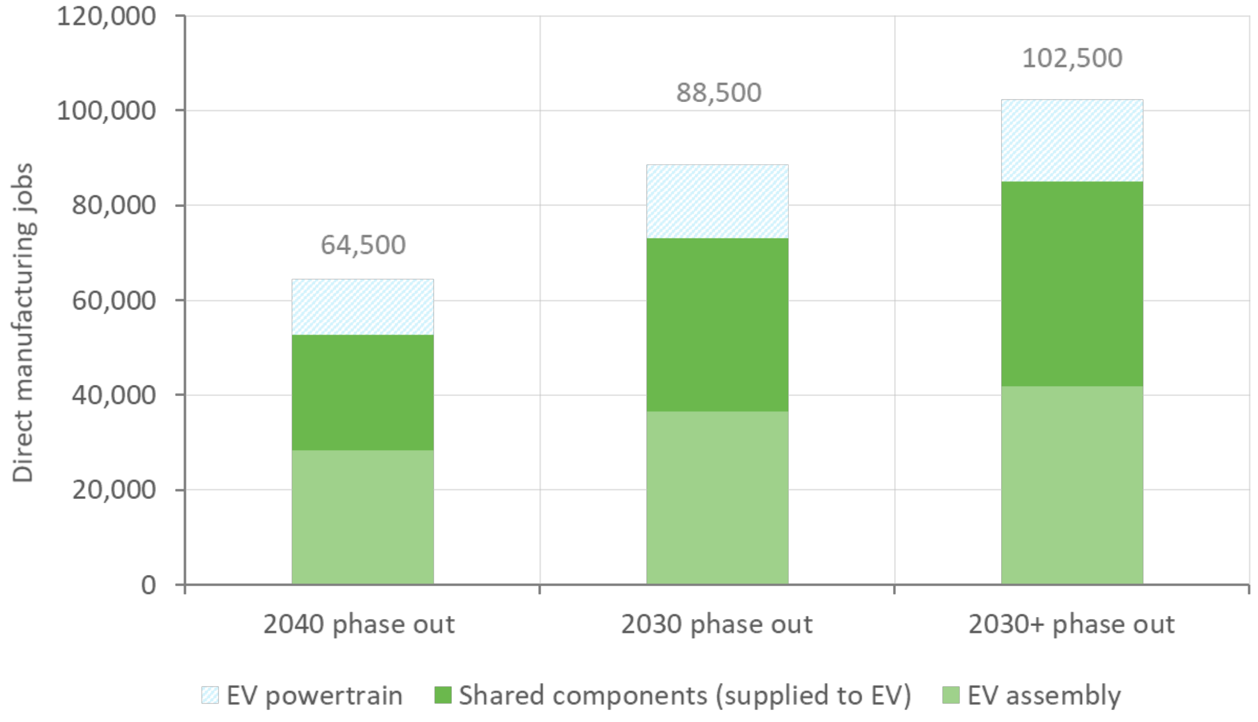
3.2.2 Impact of a 2030 phase out on UK automotive jobs

This study considers direct jobs associated with automotive manufacturing. This includes vehicle assembly and the manufacture of vehicle parts. Only tier 1 parts are considered; these are the recognisable major vehicle parts such as engines, axles, brakes, vehicle bodies, and steering columns. This study does not include tier 2 and 3 parts (for example, metal sheets for bodywork). Furthermore, it does not consider jobs in, for example, dealerships or repair shops. Estimates of the total jobs in the automotive industry differ to some degree depending on what exactly is included. Our estimates capture 80% of the 'direct manufacturing' jobs reported by SMMT.

Vehicle assembly typically generates higher GVA per job than parts manufacture. This study does not consider potential changes in the ratio of GVA to jobs, that is, changes in the labour intensity of manufacturing are not considered. While the EV revolution more broadly may impact labour intensity in automotive manufacturing, this is unlikely to change across different scenarios considered in this report.

Relative to a 2040 phase out, the 2030 scenario increases jobs in the EV industry by 24,000 in 2030 (37%,Figure 8), and a 2030+ scenario adds 38,000 (59% increase). These increases broadly mirror the increases in GVA described above. The 2030+ scenario adds 14,000 jobs compared to the 2030 scenario, these jobs are the direct consequence of the additional factory (approximately 7,000 jobs) and an equivalent number of jobs in parts supply.

Figure 10. **A 2030 phase out increases EV manufacturing jobs**

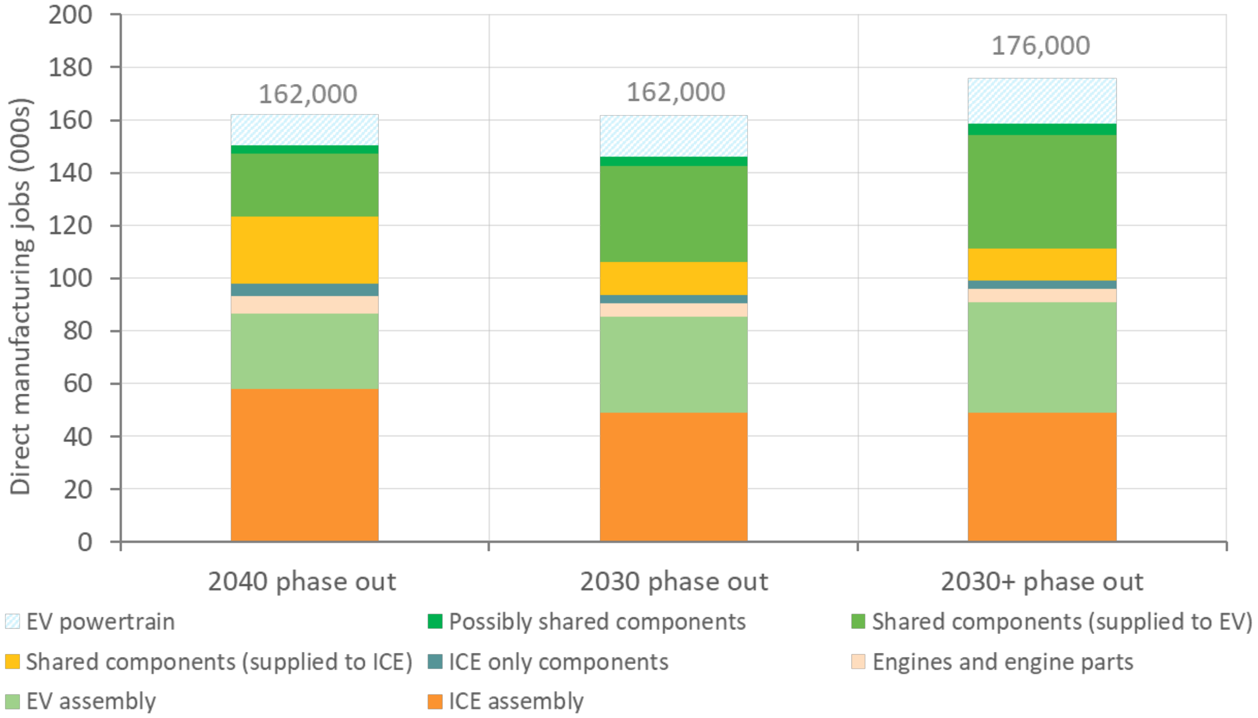


Source: Vivid Economics

Despite an increase in EV jobs, total automotive jobs in 2030 are similar between the 2030 phase out and 2040 phase out scenarios. This is because, although the 2030 phase out scenario adds 24,000 EV jobs in 2030, the production of conventional vehicles declines. Approximately 40% of the new EV jobs will be in assembly, 40% in parts that are similar across EVs and ICE vehicles (but supplied to EVs) and 20% in EV powertrain manufacture.

The 2030+ scenario supports 14,000 additional automotive jobs, compared to both the 2030 and 2040 scenarios (Figure 10). This total increase is comprised of 38,000 additional EV jobs, which are offset by declining production of ICE vehicles and parts. The additional factory would however support a jobs increase, as the 2030 scenario alone is predicted to be jobs neutral.

Figure 11. **Manufacturing jobs in the auto industry stay broadly flat in a 2030 phase out scenario and rise in a 2030+ phase out scenario**



Source: *Vivid Economics*

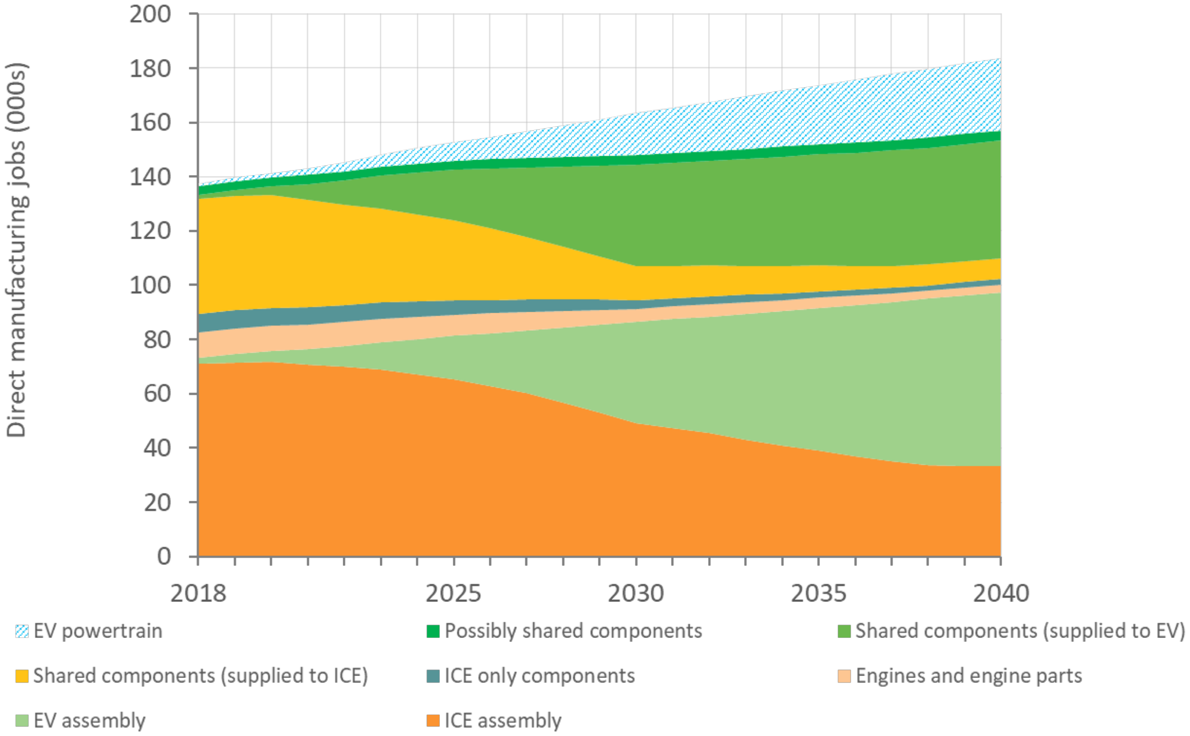
The key shifts in employment are assembly, shared ICE and EV components and engine, and engine parts:

— The largest GVA shift occurs in **assembly** (which is currently 57% of automotive jobs) but given low labour intensity it is the second largest shift in jobs. 8,000 jobs shift from ICE vehicle assembly to EV assembly in the 2030 scenario. As EV and ICE assembly are broadly similar, the change is unlikely to be very disruptive and follows a process similar to commonly made assembly line changes when a new model is introduced.

— The largest shift in jobs occurs in **parts that are shared between EVs and ICEs** (which form 30% of current automotive jobs). Vehicle bodies do not differ substantively between EVs and ICEs, and so retraining and retooling will likely be similar to that offered when a new part is produced for a different ICE vehicle model. Approximately 13,000 jobs shift from supplying parts to ICE manufacture to EV manufacture.

— Jobs in **engine and engine parts** (7% of current automotive jobs) decrease by approximately 2,000. Other **ICE specific component jobs** (5% of current automotive jobs)**,** such as gearboxes and exhausts, may also be difficult to replace directly. See Box 4 for a discussion of enabling changes in employment patterns.

Figure 12. **The largest shifts in jobs is between the assembly of conventional vehicles and EVs, which involve broadly similar skill sets**



Note: *The jobs composition over time is shown for the 2030 scenario*

Source: *Vivid Economics*

Box 4. **Enabling the transition from manufacture of conventional vehicles to EVs**

As indicated above, automotive employment benefits from a high level of skills overlap between conventional and electric vehicles. However, all jobs are likely to require some degree of re-skilling, and there are jobs for which there is no obvious counterpart in the EV supply chain, such as engines, engine parts, gearboxes and exhausts.

The UK Government's automotive sector deal sets out ambitions for new measures to enable the transition, although these are described at a high level:

- Establish a technical education system
- Invest an additional £406 million in maths, digital and technical education
- Create a new National Retraining Scheme that supports people to re-skill

Our analysis suggests a more detailed mapping of optimal transition pathways and associated impacts is required to identify the right interventions. For example, engine manufacturing jobs are the most significant area at risk from the transition to EVs. If the EV fleet includes plug-in hybrids, which have a conventional engine as well as an electric motor, then the transition is likely to be smoother. This could have a significant impact: the number of redundant engine jobs is halved by using a scenario that has a higher share of E-REVs or PHEVs in the fleet (using IEA rather than BNEF projections).

Support may be needed to bring young people into new industries and to reskill existing employees. A targeted scheme might ensure that fewer young people become ICE engineers, and so that ICE engineers not be replaced as they retire. Using the retirement profile to phase out ICE engineers could play a major role in managing the risk. Some unions, such as Unite, have called for a Just Transition Plan[6] to protect jobs and enhance skills in the auto industry as the UK transitions from ICE to EV manufacture.

Support may also be required to assist industry re-tool and access to supply chains of new goods and services (for example, electric motors) and from new importing locations (for example, from Asia rather than Europe). Targeted measures may be required including capital allowances, facilitating access to credit and reducing barriers in the supply chain.

[6] http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/business-energy-and-industrial-strategy-committee/electric-vehicles-developing-the-market-and-infrastructure/written/72629.pdf

4 Impact on the environment and energy: carbon emissions, air pollution and oil imports

Key messages

- The 2030 phase out would reduce tailpipe CO_2 emissions by 13 $MtCO_2e$ in 2030, and 62 $MtCO_2e$ over the fifth carbon budget period. This saving could reduce the policy gap to meet the fifth carbon budget by 53%. Put differently, this is equivalent to the CO_2 from 6 million homes.
- The 2030 phase out would reduce total cumulative CO_2 emissions to 2050 by around 280 $MtCO_2e$ relative to a 2040 phase out. This is equivalent to the emissions from around 5 million homes over a 30-year period.
- The 2030 phase out would reduce NOx emissions from cars and vans in 2030 from 134 kt today to around 42 kt in 2030. This is 91 kt (68%) below today's levels and 14 kt (25%) lower than under a 2040 phase out. A 2030 phase out would also reduce PM10 emissions from cars and vans from around 2 kt today to around 0.7 kt in 2030. This is 1.4 kt (68%) below today's levels and 0.2 kt (24%) lower than under a 2040 phase out. The economic value of this reduction could be around £300 million per year in 2030 (with an uncertainty range of £127-485).
- The 2030 phase out would reduce oil consumption, and therefore net oil imports, by around 4.4 $MtCO_2e$ in 2030, a 15% reduction compared to a 2040 scenario. This is a £2 billion saving

4.1 Impact on CO_2 emissions and climate targets

As part of the Paris Agreement[7] countries committed to reduce or limit emissions according to commitments are included in their 'Nationally Determined Contributions' (NDCs). However, current NDCs do not add up to a credible pathway to achieve "well below 2°C" and avoid dangerous climate change. To adjust for this over time, the Paris Agreement included a five-yearly 'ratchet' mechanism to review NDC pledges. This process begins in 2018 with the Talanoa Dialogue, which will take stock of the current pledges and seek to secure commitment by governments to strengthen their NDCs by 2020. The way in which the UK engages with this process will be impacted by Brexit, as the UK currently falls under the EU's NDC.

Light duty vehicle transport is a major contributor to the UK's greenhouse gas emissions. According to BEIS emissions statistics, UK cars and vans were responsible for around 89 $MtCO_2e$ in 2016[8]. This equates to around 78% of total road transport emissions, and 19% of total greenhouse gas (GHG) emissions (excluding emissions from international aviation and shipping).

[7] The agreement commits to "holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels".

[8] At the time of publishing 2017 figures were not available, however provisional 2017 figures are due out 29 March 2018.

Electric vehicles are a key solution to reduce CO_2 emissions and meet climate targets. Unlike conventional internal combustion engine vehicles, electric vehicles have no direct tailpipe CO_2 emissions. Instead, the CO_2 emissions arising from electric vehicles are indirect, arising from the electricity generated to charge the vehicles. If the electricity generated is low-carbon, electric vehicles offer a significant saving in CO_2 emissions.

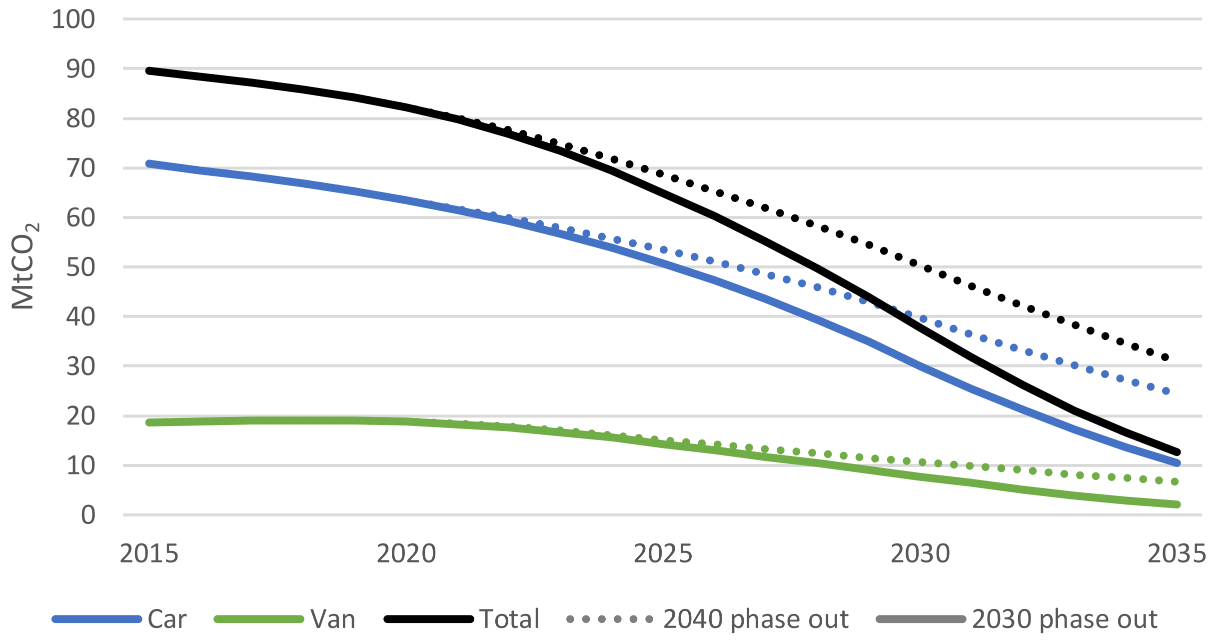
The 2030 phase out would reduce tailpipe CO_2 emissions by 13 $MtCO_2e$ in 2030, and 62 $MtCO_2e$ over the fifth carbon budget period. In the 2040 scenario, around 29 million conventional cars and vans would remain on the roads in 2030, emitting around 50 $MtCO_2e$. In the 2030 scenario, the number of conventional cars and vans would decrease to 22 million. This would result in a reduction in tailpipe CO_2 emissions of 13 $MtCO_2e$ in 2030 (Figure 13) and 62 $MtCO_2e$ over the fifth carbon budget period (2028-32).

The corresponding increase in emissions from electricity generation would be much smaller, at around 1.4 $MtCO_2e$ in 2030. Electric vehicles offer the greatest CO_2 reductions when they are charged with low-carbon electricity[9]. The Committee on Climate Change recommend that the CO_2 intensity of electricity generation should decrease to below 100g/kWh in 2030. In the 2040 phase out scenario emissions from electricity generation from EVs is 2.7 $MtCO_2e$ in 2030. In the 2030 phase out scenario, these emissions increase by 1.4 $MtCO_2e$. Smart charging and vehicle to grid, which will be assessed in Part 2 of this study, could potentially further reduce emissions.

This saving could reduce the policy gap to meet the fifth carbon budget by 53%. BEIS estimates that GHG emissions over the fifth carbon budget period (2028-32) will exceed the level of the fifth carbon budget by 116 $MtCO_2e$ (BEIS 2017b). The 62 $MtCO_2e$ reduction in CO_2 emissions resulting from the 2030 phase out would therefore reduce this policy gap by 53%.

[9] Following part 2 of this report, we may get a slightly adjusted CO_2 outcome. EVs may charge primarily at grid intensity below the annual average, and therefore it is possible savings could increase.

Figure 13. **Light duty vehicle CO_2 emissions under the 2040 and 2030 phase out**



4.2 Impact on air quality and human health

Poor air quality is a serious risk in the UK. According to the UK Government, poor air quality is the largest environmental risk to public health in the UK (Defra 2017). The Royal College of Physicians estimate that around 40,000 deaths per year can be attributed to outdoor air pollution in the UK. Specific health challenges linked to air pollution include cancer, asthma, stroke, heart disease, diabetes, obesity, and dementia with the cost to individuals, business and the health services valued at over £20 billion per year (Royal College of Physicians 2016).

As road traffic is a leading source of poor air quality, electric vehicles are a key solution. In 2016 total emissions of nitrogen oxides (NOx) were around 920 kilotonnes (kt), of which road transport made up 430 kt (47%), and we estimate cars and vans contributed around 180 kt (20% of total). NOx includes nitrogen dioxide (NO2) and produces additional NO2 through subsequent chemical reactions. Total emissions of large particulate matter (PM10) were around 145 kt, of which road transport made up 20 kt (14%), and we estimate that tailpipe emissions from cars and vans contributed around 3 kt (around 2%[10]). A recent Policy Exchange study on air quality-related mortality in London estimated that under current projections for air quality, NO2 pollution might reduce the life expectancy of a person born in 2025 by 12 months, but that the replacement of 200,000 diesel vehicles with electric vehicles (around 8% of the London fleet) could increase total life expectancy in the capital by 1.1 million life years (Policy Exchange 2015).

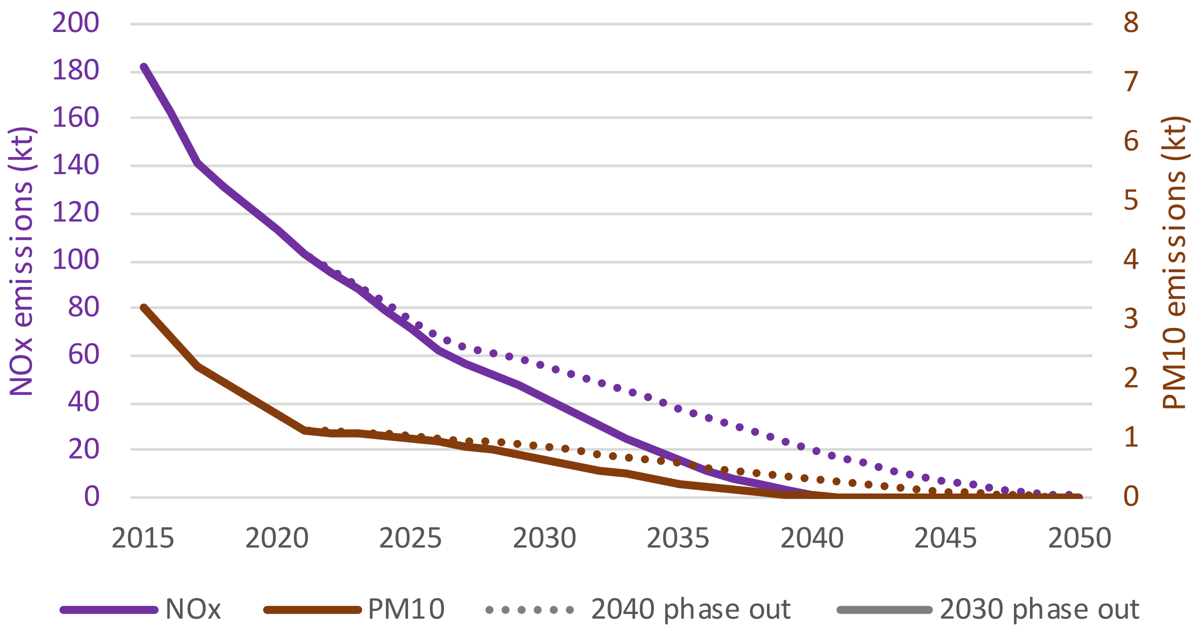
[10] Half of PM10 emissions are from the tailpipe; half are from abrasion of tyres on the road surface.

The 2030 phase out would reduce NOx emissions by around 14 kt, and PM10 emissions by 0.2 kt in 2030, relative to a 2040 phase out. The 2030 phase out would reduce NOx emissions from cars and vans in 2030 to around 42 kt (68% below today's levels and 25% lower than under a 2040 phase out). A 2030 phase out would also reduce PM10 emissions from cars and vans in 2030 to around 0.7 kt (68% below today's levels and 24% lower than under a 2040 phase out). In the 2040 scenario, total NO_x emissions from conventional vehicles are around 56 kt, and total PM10 emissions are around 860 kt in 2030. In the 2030 scenario, NO_x emissions would decrease to 42 kt, and PM10 emissions to 650 kt (Figure 14).

This reduction would have a positive, but limited impact on compliance with the UK and EU air quality legislation. Under existing legislation, the annual average concentration of NO2 in the air must be no higher than 40µg/m^3 across a calendar year in every assessed location in each of the 43 air quality reporting zones of the UK. In 2017, 37 of 43 air quality reporting zones were non-compliant. Defra's projections indicate that if no further action is taken in addition to the 2040 phase out of petrol and diesel cars and vans, the number of non-compliant zones will decrease to nine in 2023, and full compliance will be achieved by 2028. In order to achieve full compliance in advance of 2028, the Government's Air Quality Plan[11] sets out a range of measures, including Clean Air Zones (zones with restricted access to more polluting vehicles). Defra's projections indicate that under Air Quality Plan, the number of non-compliant zones will decrease to four in 2021, and full compliance will be achieved by 2025. The 2030 phase out would have a small impact relative to the Air Quality Plan (Figure 15). For example, if the Air Quality Plan was not successful in achieving compliance, the 2030 phase out alone would drive compliance in the South-West of England by 2021, one year ahead of the baseline projection.

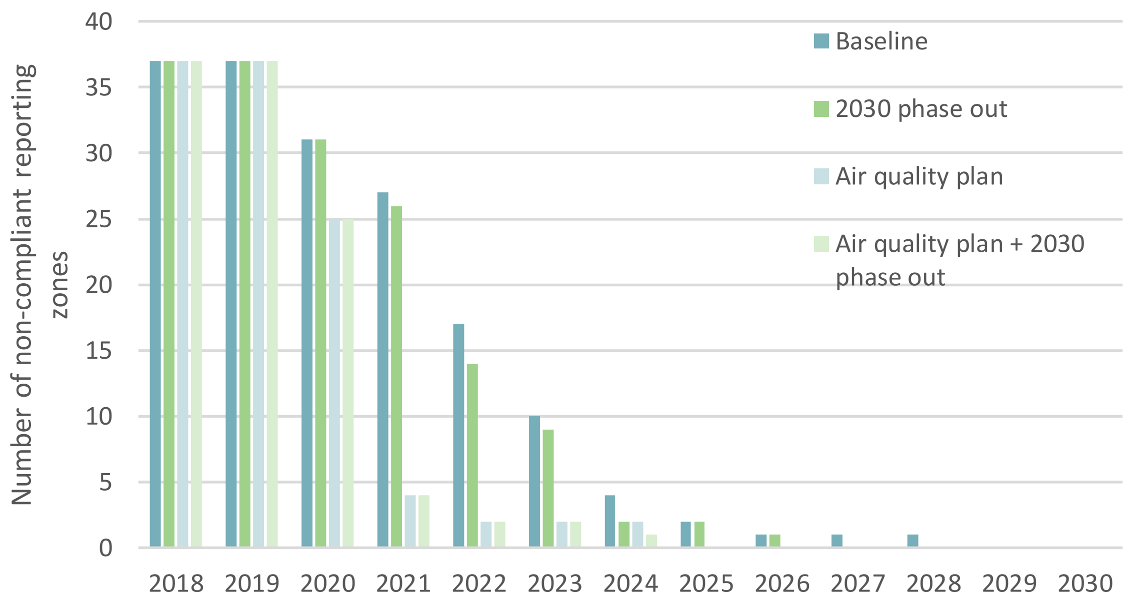
[11] The Air Quality Plan is still subject to change, given a recent High Court ruling against the Government.

Figure 14. **NOx and PM10 emissions from cars and vans in the 2040 and 2030 phase out scenarios**



Note: The 2030+ phase out scenario has the same emissions profile as the 2030 phase out scenario

Figure 15. **A 2030 phase out would have a small additional impact on compliance with air quality legislation**

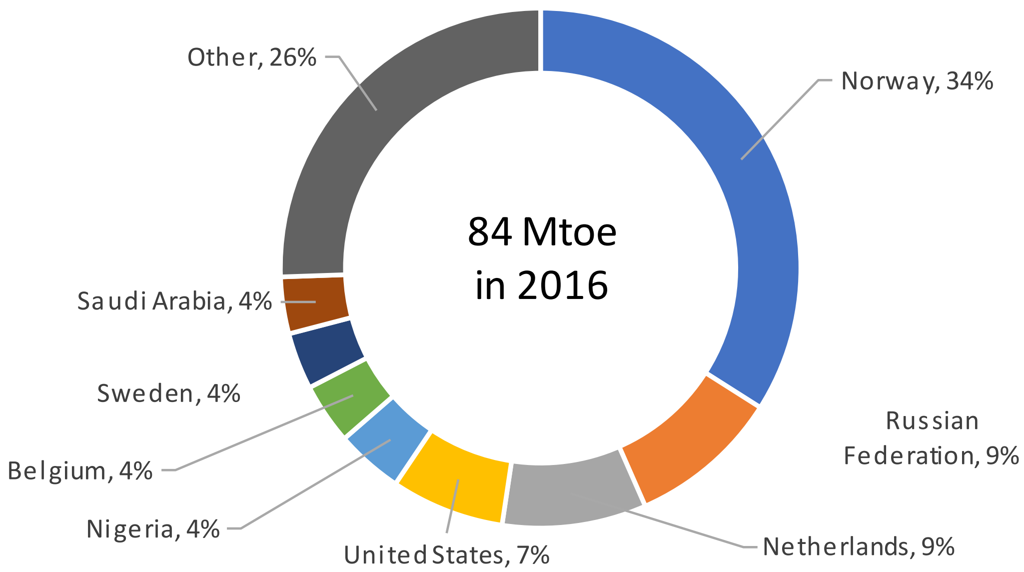


The economic value of this reduction could be around £300 million per year in 2030 (with an uncertainty range of £127-485). The costs to society of the likely impacts of changes in emissions can be expressed in terms of damage costs. Defra estimate the damage costs of both nitrogen oxides (NO_x) and large particulate matter (PM10), reflecting their impacts on human health, in terms of both loss of life years and respiratory or cardiovascular illness. Based on the range of Defra values for these pollutants, the economic value of the reduction in NO_x and PM10 emissions will is between £127-485 million per year in 2030s

4.3 Impact on oil imports

The UK will continue to be a net importer of oil and oil products. UK oil production was around 51 million tonnes of oil equivalent ($MtCO_2e$) in 2017, while primary oil consumption (including all oil products, such as petrol and diesel) was around 76 $MtCO_2e$. Oil and oil products are highly traded; while net imports of oil and oil products to the UK were around 25 $MtCO_2e$, total imports were 84 $MtCO_2e$, and total exports around 59 $MtCO_2e$. The most important supplier to the UK is Norway (34% of imports) followed by the Russian Federation and the Netherlands (9% each) (BEIS 2017a).

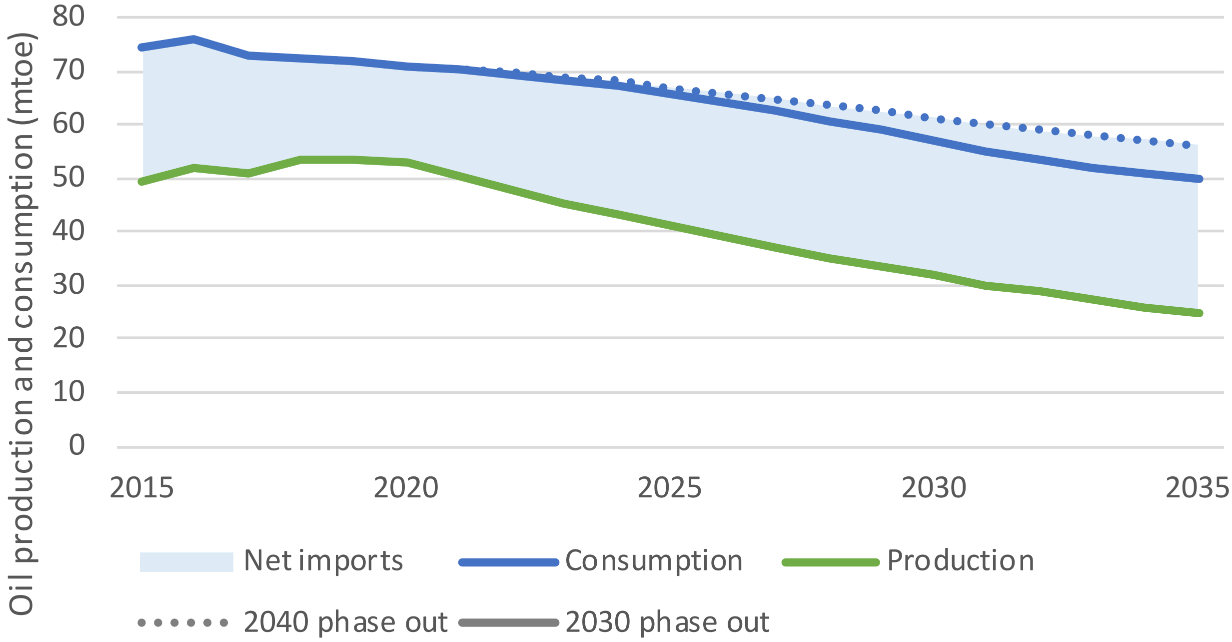
Figure 16. **Provenance of UK imports in 2016**



Source: *National Statistics. 2017. 'Digest of UK Energy Statistics (DUKES) 2017'*

The 2030 phase out would reduce oil consumption, and therefore net oil imports, by around 4.4 mtoe in 2030, a 15% reduction compared to a 2040 scenario. This equates to a £2 billion saving per annum in 2030 in spending on oil imports. The UK Oil and Gas Authority projects that UK production declines to 32 mtoe in 2030 (oil consumption in the 2040 scenario is 61 mtoe and imports are 29 mtoe in 2030). The 2030 phase out would reduce oil consumption by around 4.4 mtoe in 2030 (Figure 17), equivalent to 15% of oil imports. This could save around £2 billion per year (with a range of £1.4-3.1 billion), depending on oil prices.

Figure 17. **The 2030 phase out scenario would reduce oil imports by 15% in 2030**



Source: UK Oil and Gas Authority; BEIS; Vivid Economics

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