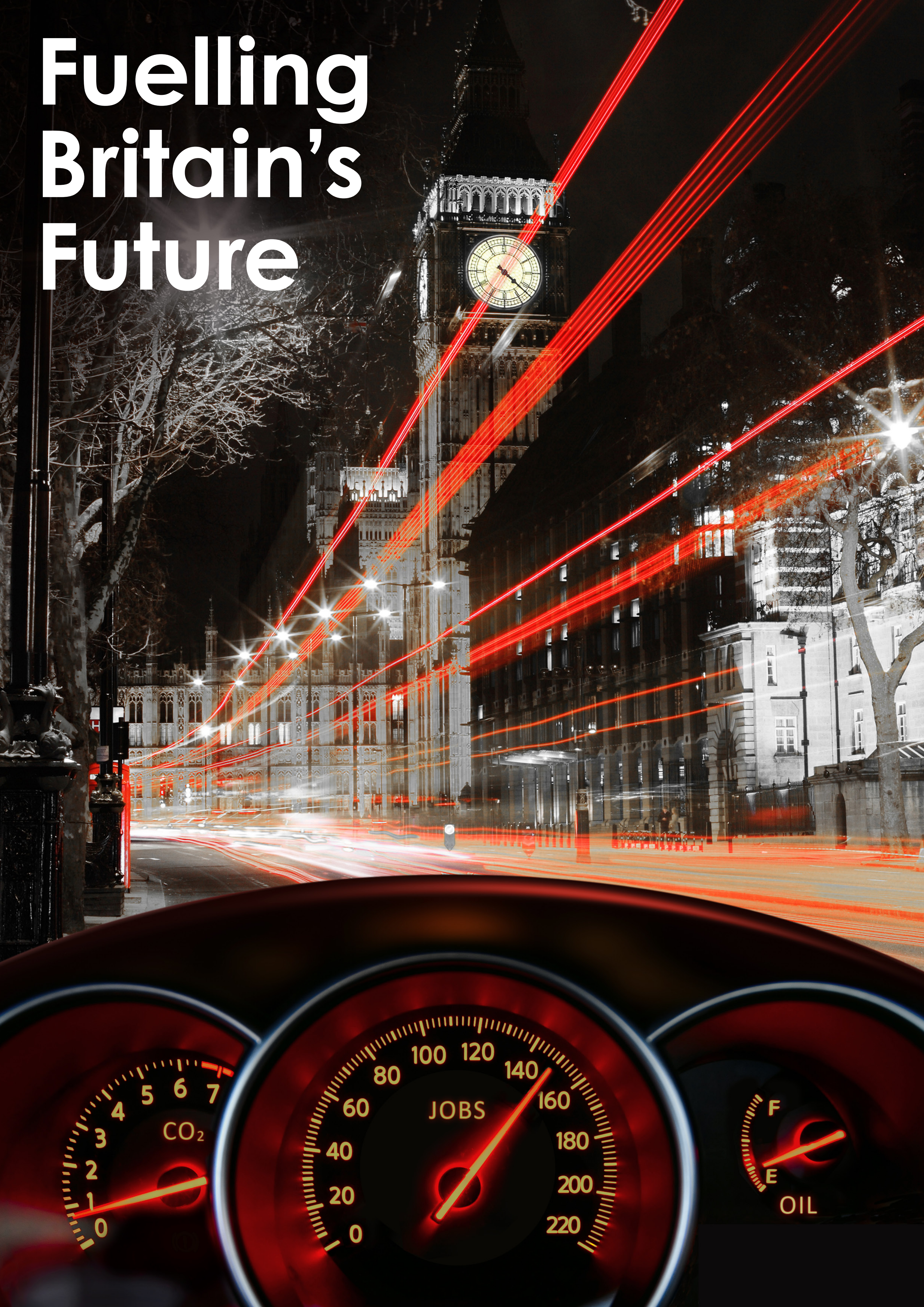
Fuelling Britain's Future



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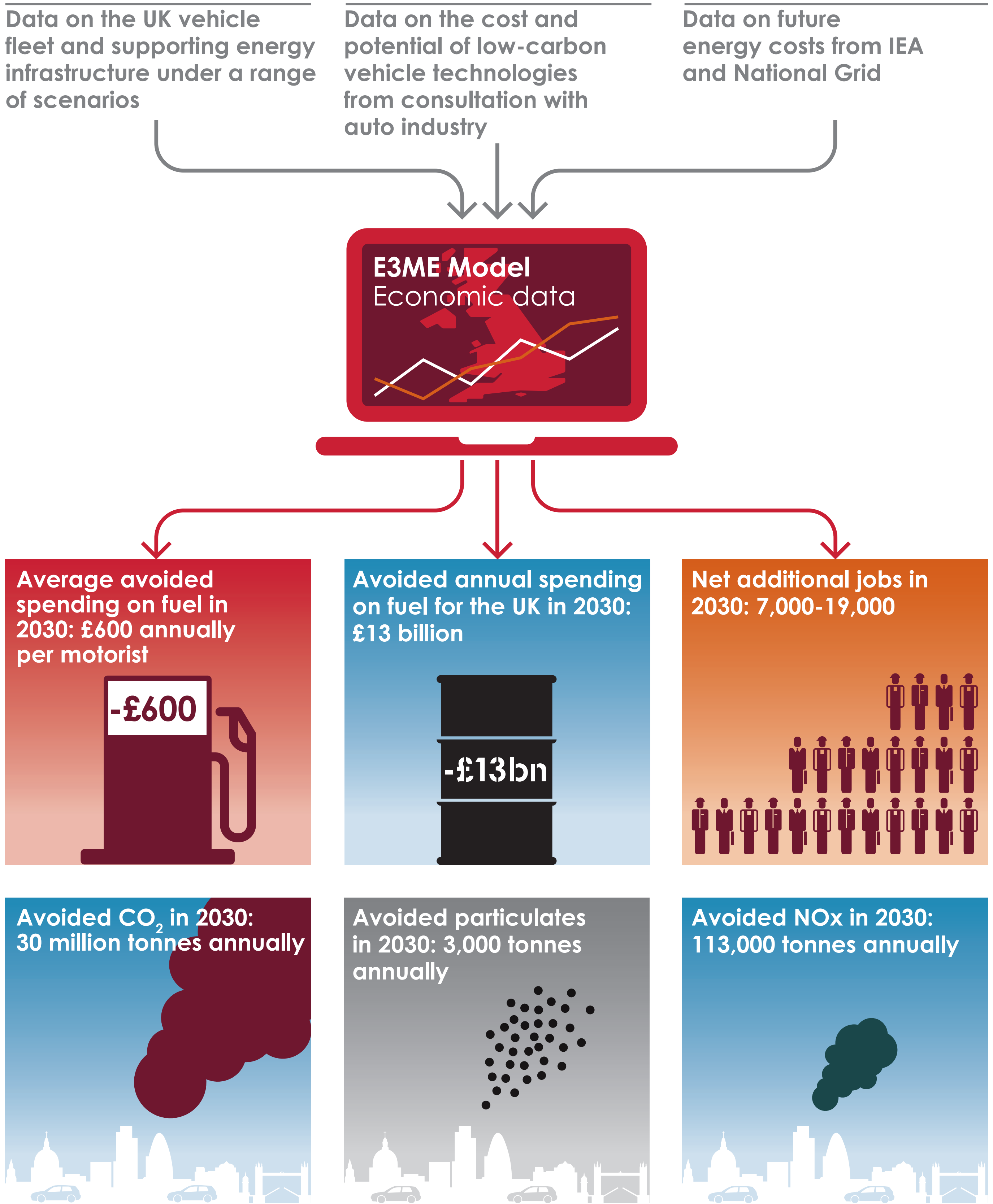
Identifying the UK co-benefits of shifting to low-carbon vehicles in 2030



Summary

By 2030, low-carbon technologies can make the following impact:

CO_2 emissions from cars and vans can be cut by 47%

Fuelling the average new car can be £600 cheaper per year than for today's new cars

The national cost of running and replacing cars can be £5 billion to £7 billion lower per year than without low-carbon technologies

The cost of motoring will fall in Britain as a result of efforts to tackle carbon emissions and clean up urban air pollution. Improvements to the efficiency of internal combustion vehicles are already saving motorists hundreds of pounds each year. Advances in engine efficiency, lighter construction materials, more efficient tyres, and the gradual introduction of electric propulsion will reduce energy costs further.

In 2014, the average motorist spent £1,190 on fuel. By 2030, fuelling the average new low-carbon car could be £600 cheaper per year than for the average car today. The average electric car could deliver even bigger savings in annual energy costs, worth around £960.

These technically-advanced vehicles will be more costly to buy at the outset, but the initial investment will be outweighed by energy-savings within a few years, leaving households significantly better off. Even if oil prices were to remain at today's unusually low level, energy-savings would rapidly outweigh the cost of low-carbon technologies.

From a national perspective, by 2030, the total cost of renewing and fuelling the UK car fleet would be £7 billion lower for low-carbon vehicles than if the fleet were to continue running on today's technology, or £5 billion cheaper in a low oil price scenario. The car and van fleet would also be increasingly powered by domestically-produced clean energy sources, reducing Britain's dependence on oil imports from overseas and helping protect households and businesses from volatile oil prices.

Meanwhile, CO_2 emissions from the car and van fleet could be cut by 47% by 2030, and as much as 80% in 2050. Reductions of air pollutants, such as nitrogen oxides and particulates, would help lower the incidence of respiratory diseases. The health benefits associated with these air-quality improvements are estimated to be worth £1 billion to £1.2 billion to the UK economy.

This transition would not be without its challenges: investments would need to be made in new infrastructure; Britain's automotive workforce would need to gain new skills to remain competitive; and there would be job losses in the refining of fossil fuels. But overall, Britain would reduce its dependence on imported oil; the economy would become more resilient; the climate would be better protected; and the air in our cities would be cleaner.

The reduction in oil demand, if matched across the other major oil-consuming countries could itself cause a reduction in the oil price. In doing so, the economies of oil-importing countries could be boosted further. For the UK, the case is mixed, as it is both an oil producer and importer. As the UK now imports more oil than it produces, however, it is reasonable to expect that by contributing to lower oil prices the shift to low-carbon technologies could lead to further economic benefits above and beyond those identified here.

Low-carbon investments: the story so far

The production line for the Nissan LEAF in Sunderland. Source: Nissan Motor Manufacturing UK

After years of decline, investment in the UK automotive industry has started to increase. This was helped by Britain's focus on tackling climate change, which spurred a wave of investment in low-carbon vehicle technologies. Against a backdrop of rising overall investment in UK automotive, annual investments in this area rose from less than £1 billion in 2007 to over £5 billion in 2013[1]. R&D spending more than doubled over the same period to nearly £1.7 billion in 2013. At the same time, motorists' consumption of petrol and diesel fell, partly as a result of low-carbon policies.

The picture that emerges, of rising investment and falling emissions, is in stark contrast to the decade that came before. At that time, the automotive sector was in decline, and many in government and industry expected this to continue. British car brands were closing factories, innovation was modest, supply chains became depleted, and environmental regulation was mostly seen as a threat. But in the last decade, the sector's fortunes have started to turn around.

In a study in 2014[1], the Low Carbon Vehicle Partnership, a public-private partnership, sought to explore the link between low-carbon policies and the improvement in the UK automotive sector's fortunes. Firstly, investments in manufacturing low-carbon technologies were catalogued, showing that more than 85 companies had made over 290 investments with a confirmed value of £17.6 billion during the period 2003-2013.

For example:

- Nissan has invested £1.4 billion in its facilities in Sunderland to make the next generation of products such as the Nissan LEAF
- Ford has invested £2.3 billion in producing EcoBoost engines at its Bridgend plant
- JLR has invested £9 billion at its Wolverhampton facilities to reduce weight and emissions across the range.

The real figures are doubtless much larger, because many investments do not receive publicity and there are wider multiplier effects in the supply chain. The LowCVP study also interviewed over 100 experts to determine the impact of policy on investment decisions. The message that emerged was that the revitalisation of the UK automotive sector had been underpinned by initiatives such as the Auto Council Technology Roadmap and a new era of cooperation between industry and government. Meanwhile, the Stern Review[2] (2006) and the Climate Change Act[3] (2008) created confidence that the UK was committed for the long-term to tackling climate change, thereby improving investment security for manufacturers of low-carbon technologies. Finally, the EU brought harmonisation to the decarbonisation of vehicles with the EU-wide CO_2 standards, reducing investment risks and widening the market for technology suppliers.

Looking into the future

The Nissan BladeGlider, which made its European debut at the 2014 Geneva Motor Show. Source: Nissan Motor Corporation

By embracing the imperative to reduce transport emissions, Britain appears to have created new value and new employment in the automotive value chain. But is it fair to assume that this trend will continue? While predicting future technologies can be uncertain, the imperative to keep global temperature increases below 2°C and to improve urban air quality gives a clear indication that policies to promote investments in low-carbon vehicle technologies will continue.

In this project, we have explored the future impact of low-carbon vehicles on the UK by modeling a series of scenarios. Many experts believe future vehicles will be propelled by a range of low-carbon technologies: efficient internal combustion; battery electric- and fuel cell electric propulsion; and varying degrees of hybridisation. Three vehicle deployment scenarios were used in this project to span a wide range of possibilities for technology deployment, meanwhile ensuring that fleet emissions would be in line with the UK carbon budgets and the EU's goal of cutting overall climate-warming emissions by at least 80% in 2050.

Battery electric vehicles are expected to play an important role in reducing CO_2 emissions and air pollutants from Britain's roads. While projecting the future deployment of plug-in electric vehicles is difficult, sales already comprised 15,631 new cars in 2014, a year-on-year increase of 300%[4]. The central deployment scenario used in this project envisages battery electric vehicle sales within the mid-range of previous analyst estimates, at around 2% in 2020, rising to 10% in 2030 and 35% in 2050.

Electric vehicles are just one low-carbon option. Great strides have been made to improve the efficiency of the internal combustion engine and the automotive sector is working hard to achieve more. Start-stop technology, using advanced lead-based batteries, is one of the most cost-effective ways to cut CO_2 emissions in the range of 5-10%. Other highly cost-effective options include direct injection for petrol engines or downsizing and boosting the engine. Combining internal combustion engines with electric propulsion offers even greater benefits. Our scenarios model UK hybrid sales reaching 20% in 2020, rising to 40% by 2030.

All vehicles, regardless of how they are powered, can be made more efficient by reducing weight, aerodynamic drag and rolling resistance. In a car today, about one tank of fuel in five is consumed overcoming rolling resistance, but tyres also affect the aerodynamic performance of a vehicle. Tyre manufacturers are investigating new height and width ratios, coupled with new internal architecture, to develop lighter products to help reduce drag.

Interior of the Nissan BladeGlider.
Source: Nissan Motor Corporation

In the short-term, weight reductions are likely to come from seating, glazing and interior components, and through increased use of aluminium and high strength steels in body structures. A weight reduction of 100kg can reduce CO_2 by 10g/km, according to Plastics Europe.[5]

In our Low-Carbon Technology scenario, weight reduction of new vehicles accounts for energy savings of around 15% in 2030 and 25% in 2050, considerably reducing the total cost of ownership. Lightweight materials alone could help reduce spending on fuel across the vehicle lifetime by £1,200 in 2030, while only increasing the cost of manufacturing the average vehicle by £212. Reducing vehicle weight could actually reduce the total upfront costs of reaching EU CO_2 standards by 16% during 2020-2030, according to Ricardo-AEA.[6] For electrically-powered vehicles, the benefits of reduced weight are particularly notable. Because electric powertrains are highly efficient, weight accounts for a much larger proportion of the total efficiency losses, and weight reduction are crucial to extend battery range.

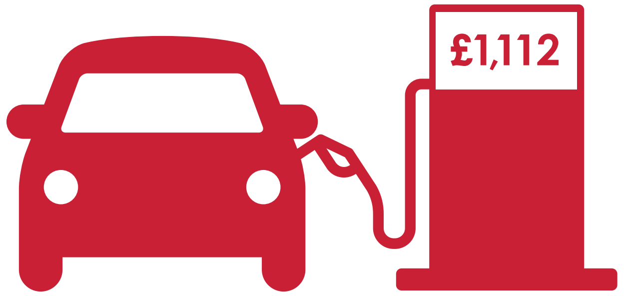
Currently, weight reductions are mainly achieved through increased use of aluminum, high strength steel or hybrid materials, which combine metals and high-tech plastic composites. Components made of hybrid materials are roughly 20% lighter than full steel solutions. Applications include seating, glazing, interior components and body structures, such as the Audi A8's front-end.

In the mid- and longer term, more significant weight reductions of 30-40% are possible with new light-weight applications and a bigger share of fibre-reinforced high-tech plastic composites. The carbon- and glass-fibre fuel tank of Audi's gas-powered A4 vehicle, for example, is 60% lighter than the original steel tank. Albeit slightly heavier than carbon-fibre, glass fibre-reinforced plastics benefit from significantly lower material and processing costs, making them more suitable for mass production. All composite solutions have the big advantage of bringing down system costs with injection molding technologies, allowing for more efficient production and mounting of the actual vehicle parts. It has been estimated that the overall market for lightweight solutions for automotive applications will increase from €70 billion to €300 billion, reflecting an annual growth rate of 8 percent.[7]

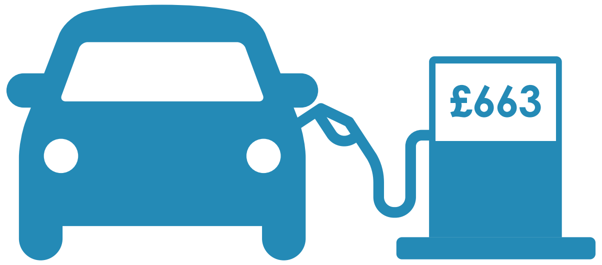
Impact on UK motorists

Figure 2

Fuel bills per motorist in 2030 under the two scenarios (as an average across the various vehicle technologies used in UK cars). Source: Cambridge Econometrics



2030 fuel bill per motorist in No Change scenario



2030 fuel bill per motorist in Low Carbon Technology scenario

While fuel costs are inherently difficult to predict, this project has used a range of projections and found that the cost of running a car will be much reduced for British motorists in all low-carbon scenarios compared to today. The incorporation of new technologies to reduce fuel consumption will increase the cost of new cars, but this will be outweighed within a few years by the reduced spending on fuel, with significant savings across the remainder of the car's life.

Car buyers have been shown in some studies to undervalue future fuel savings, but a recent survey of prospective car buyers found that over one third were willing to pay €1,000-2,000 extra for a hybrid car, and over a quarter were willing to pay a premium of more than €2,000.[8]

In our central scenario, the cost of manufacturing conventional petrol- or diesel-fuelled cars would typically increase by £1,540 for a new car in 2030 compared to today, but fuel bills would be reduced, on average, by £495 per year, saving up to £6,435 across the lifetime of that car. Based on these figures, one might assume that this would mean that the increase in the sale price would be repaid in 3.1 years, but in reality this would happen much more quickly. Data compiled during MoT test inspections shows that far more mileage is clocked up in the first few years of a car's life than in later years.[9] As a result, the average investment in fuel-saving technologies will be paid back in 2.5 years.

Hybrid vehicles are also likely to play an important role. While hybrids sell at around a £3,000 premium today, compared to the internal combustion equivalent, this is likely to be reduced as a result of scaling effects due to mass production and learning effects as production efficiencies are optimised. As a result, by 2030 the average hybrid car will only be around £2,270 more expensive than today's average new car, or £730 more than the average internal combustion car in 2030. Average lifetime fuel savings for the same vehicle will amount to almost £6,600.

Electric and fuel cell vehicles offer an entirely different proposition, with higher purchase costs balanced against significantly lower running costs. For example, while today's average car costs around £1,190 per year to fuel, the energy costs could be just £225 for the average new fuel cell vehicle and just £254 for the average new battery electric vehicle by 2030. The total cost of owning an electric car is found to reach parity with the average internal combustion car in 2025.

The figures presented above represent the savings if oil prices continue to rise along the trajectory forecast by the International Energy Agency (IEA). In reality, of course, oil prices might be lower, in which case the potential for shaving money from fuel bills would be reduced. However, this project explored what would happen if oil prices turned out to be 30% below the IEA's projections, and found that the cost of low-carbon vehicles would still be paid back via fuel savings within the fifth year of the average new vehicle's life.

Furthermore, drivers of low-carbon vehicles are protected against unexpected hikes to the price of oil, as might happen as a result of hostilities in the Middle East, as just one example. A 50% spike in oil prices in 2030 would hit the average driver in the Low-Carbon Technology scenario by £145 per year, compared to £257 per year if they were to continue driving today's average car.

Impact on auto-sector competitiveness

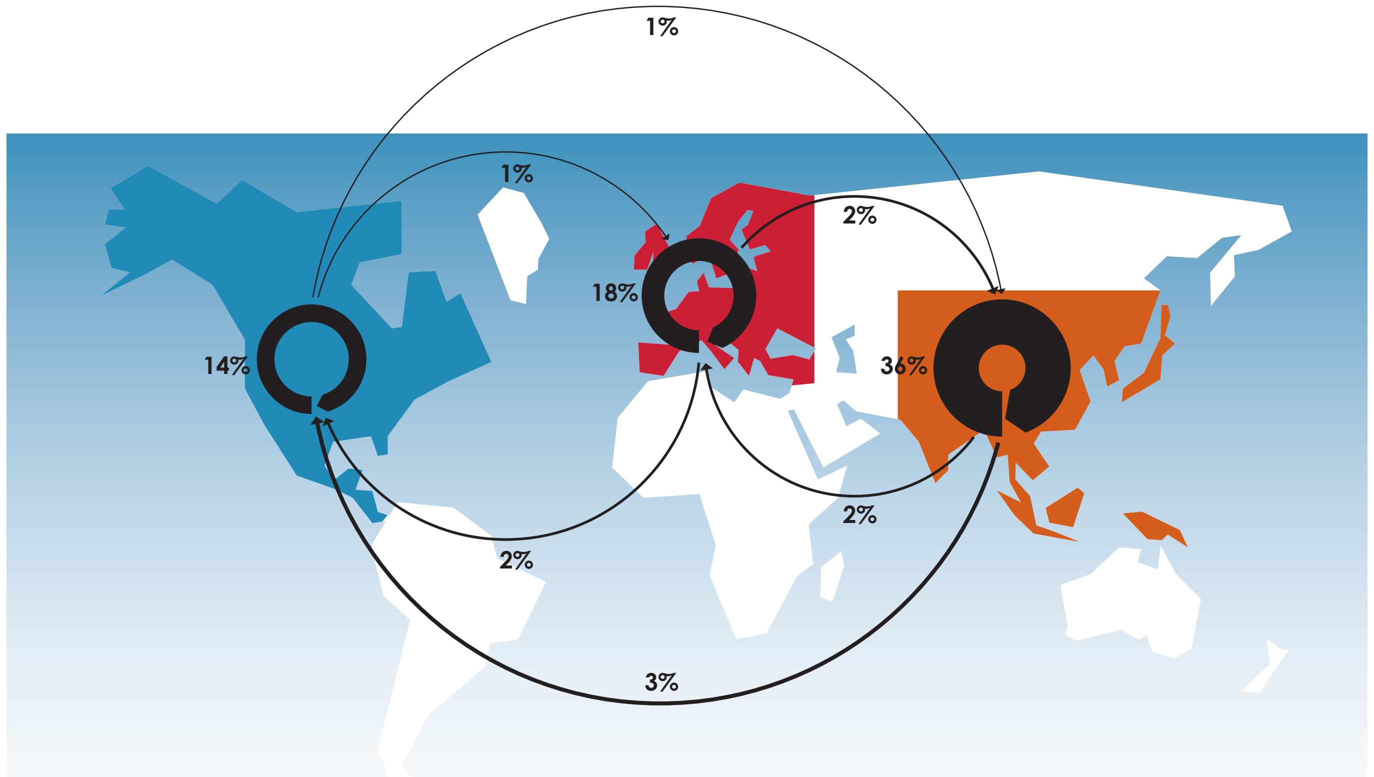


Figure 3

Cars are for the most part manufactured in the region in which they are sold. Flows of passenger cars as a percentage of global production, 2011. Source: OECD, based on UN Comtrade, LMC Automotive.

The auto manufacturing industry is truly global. Given the large bulk and weight of cars, shipping them from region to region can be costly, and manufacturers will usually locate vehicle production close to the market. The amount of cars being physically manufactured in Asia and then imported into Europe represents just 2% of global automotive trade, while imports to Europe from North America represent just 1%.[10]

Likewise, manufacturers of automotive components will generally be located close to the car factories they supply. There are over 3,000 auto parts companies in Europe, accounting for about 75% of the vehicle industry's final product value.[11] In addition, second-tier suppliers, such as chemical and high-tech plastics producers have become an important enabling industry, playing a pivotal role in providing innovative materials and technological solutions for moving towards low-carbon mobility.

In Europe, imports from non-EU countries make up a relatively small share of supply. Trade data suggests that total imports of motor vehicles were around €64 billion in 2011, compared to an overall motor vehicle market worth around €470 billion.[12] By comparison, European exports of motor vehicles in the same year were around €150 billion. Of the imported vehicles to the EU market, around 75% come from just four countries: Turkey, Japan, the United States and South Korea. The implication is that while individual manufacturers might see changes in market share, the overall changes to auto sector manufacturing in Europe are likely to be small.

It is also worth noting that most of the value-added generated by car manufacturers accrues to the employees through the supply-chain and not to the owners of the business. As a result, it is more important to the macroeconomic results to consider where the production of the vehicles and their components takes place, rather than where the owners of a particular company are located.

The UK auto market and manufacturing sector are starkly different from those of Europe overall. According to the ONS, the UK motor vehicle market was worth £73 billion in 2012, but economic trade data shows that imports of motor vehicles to the UK were around £39 billion in the same year while exports from the UK were around £31 billion. Imports to the UK are sourced predominantly from Europe, with Germany alone accounting for over 40%, while over half of UK exports are destined for non-European markets.

Put plainly, UK manufacturers are not only operating in the UK market but also in European and global markets, and their performance in those markets will have an impact on the economic results. A recent study by the LowCVP[1] shows that the UK facilitates an attractive business environment for developing new vehicle technologies to meet the low-carbon agenda. This would imply that the economic results for the UK could be more positive if component and vehicle manufacturers build on recent successes to further grow market share. While initial signals look good, this remains an open question.

Impact on jobs and growth

Britain is a major oil importer. Some 59.1 million tonnes of crude oil were imported into the UK in 2013 at a value of £30.1 billion.[13] Compared to most other sectors of the UK economy, the value chain associated with petrol and diesel has two main features: it has a low intensity of labour, meaning that for every million pounds spent on fuel in Britain, relatively few direct jobs are created; and 60% of the value chain is outside Britain, meaning that much of the money spent on diesel or petrol leaves the economy. Unlike most other European countries, Britain has its own oil production, so clearly some of the money spent on petrol and diesel accrues back to British companies. However, in 2013 the UK became a net importer of petroleum products.

As the UK switches to low-carbon vehicles, the nationwide running costs will be reduced. This holds true across a range of possible oil price projections. Figure 4 shows how Britain's fuel bill for cars and vans would evolve to 2030 if no further investments were made in technology to cut emissions. Activity increases by 4% in line with long-term trends of increasing mobility, while fuel prices increase by 6%. By 2030, the UK fuel bill for cars would reach £33 billion.

In the Low-Carbon Technology scenario, all new internal combustion vehicles would be lighter and optimised by 2030. Lightweight hybrids would be making efficient use of the energy captured during braking. And lightweight electrically-powered vehicles would be making good use of the inherent efficiency of electric motors. As a result, the efficiency improvement is large, and by 2030 the UK fuel bill for cars would be £20 billion, 40% lower than without the investment in these technologies.

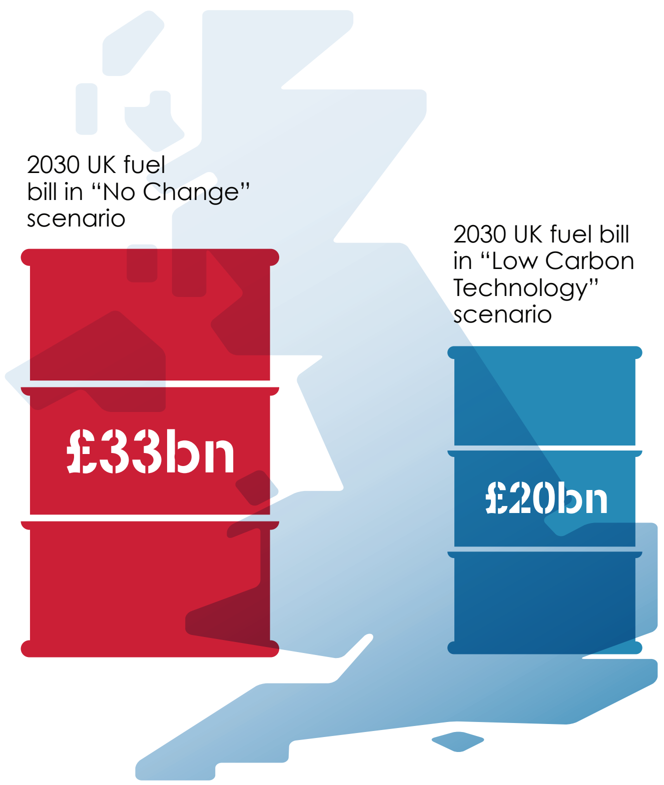
Making Britain's vehicle fleet cheaper to run would increase spending in other areas of the UK economy, and shifting to domestically-produced electricity and hydrogen would increase the share of spending on energy for vehicles that accrues to British companies.

At the same time, additional investments will be needed for charging infrastructure in the Low-Carbon Technology scenario, and the aggregate capital cost of Britain's cars increases by £7 billion by 2030 (excluding taxes), compared to a future in which the fleet continues running on today's technology. While this additional money represents a cost to consumers, it also represents a source of revenues for the automotive value chain.

Thus, the transition to low-carbon vehicles represents a shift in spending away from the petroleum supply-chain, which creates relatively low value, and towards the vehicles and electricity supply-chains, which create relatively higher value for Britain. By using the macroeconomic model E3ME, we have made estimates of the net impact arising from the change in economic flows.

Figure 4

UK spending on fuel for cars in 2030 under the two scenarios of vehicle technology deployment. Source: Cambridge Econometrics

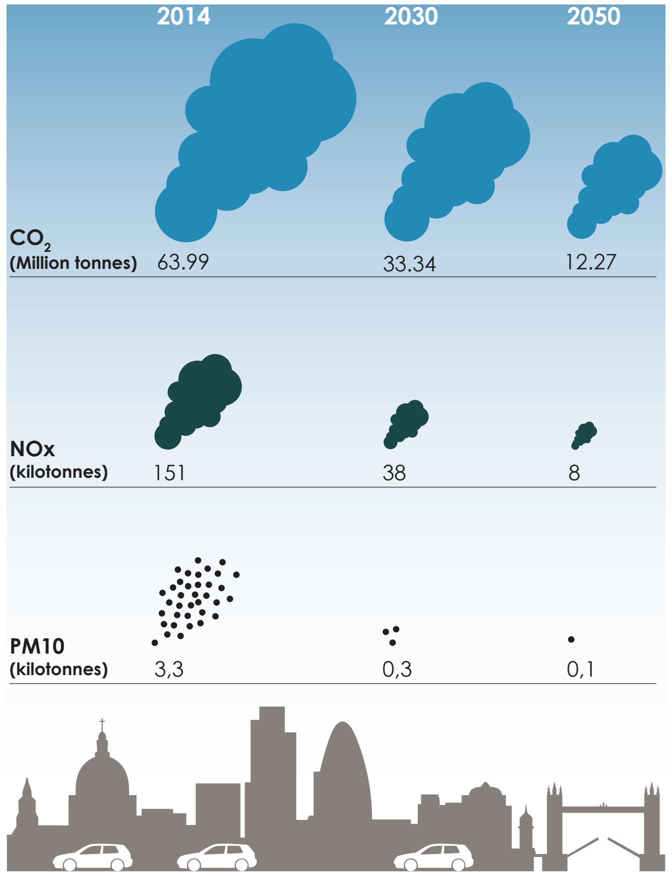


The net effect of reduced expenditure on petrol and diesel; increased spending on domestically-produced electricity or hydrogen fuel; and increased expenditure on vehicles translates to between £2.4 billion and £5 billion of additional GDP in Britain in 2030. These results include the effect of an increase in tax rates in other sectors of the economy to compensate for fuel duty revenue losses. Spending more on vehicles, less on fuel imports, and more in other areas of the economy also leads to 7,000-19,000 net additional jobs by 2030. The upper end of these ranges represents the likely outcome if Britain builds on recent successes to increase its share of the automotive value chain to reach the European average and if impacts on the refining sector are managed in an optimal manner.

Impact on climate and UK air quality

Figure 5

Emissions of CO_2, NOx and particulates are significantly reduced between now and 2050 in the "Low Carbon Technology" scenario. Source: Cambridge Econometrics



To prevent more than 2°C of warming and avoid dangerous climate change, it is widely accepted that overall EU emissions must be reduced to at least 80% below 1990 levels by 2050. Due to the challenge of reaching such reductions in many other transport sectors, it will be necessary to compensate by ensuring that cars and vans are almost entirely decarbonised by 2050.

Given that vehicles in Britain typically have a 12-15-year lifetime, this suggests that by around 2035 all new vehicles sold must be close to zero-carbon if we are to stay on track to meet our climate goals. Thus the car fleet must be radically transformed. Shifting to low-carbon technologies described in this study would substantially reduce CO_2 emissions from cars by 47% in 2030 and by 80% in 2050.

Cars also produce NOx and particulates, local air pollutants with harmful consequences for human health. Current estimates are that around 150,000 tonnes of NOx and around 3,000 tonnes of particulates are emitted by Britain's car fleet each year. NOx reacts with ammonia to form nitric acid, which can damage lungs and worsen respiratory diseases, and its reaction with volatile organic compounds forms ozone, which can also affect the tissue and functioning of the lungs. Since NOx is produced in the combustion of fossil fuels, it is also reduced by technologies to cut CO_2. Shifting to low-carbon vehicles as described in this study would substantially reduce NOx emissions from cars by 75% in 2030 and by 95% in 2050. In short, decarbonisation would have the additional benefit of effectively eradicating direct NOx emissions from the vehicle tailpipe.

In the reference case, where no further low carbon technologies are deployed, NOx emissions fall by as much as 54% by 2050 as a result of implementing the existing Euro 5 and Euro 6 air pollutant standards. However, these reductions are much less certain than the reductions in the Low Carbon Technology scenario, which includes high levels of vehicles using hydrogen and electricity with zero tailpipe emissions.

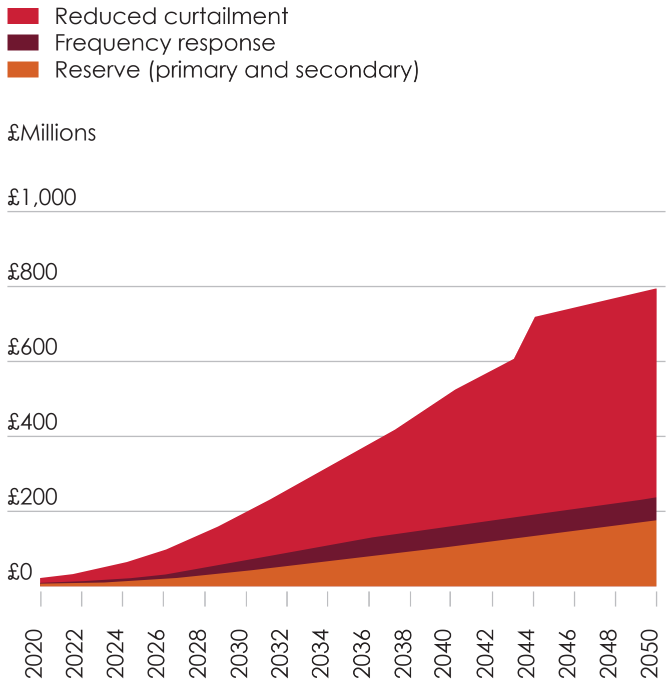
Particulate matter also affects human health and is estimated to have been responsible for 370,000 premature deaths in Europe in 2005.[14] The European Environment Agency also estimates that 90-95% of European urban dwellers have been exposed to levels of PM2.5 above the guideline levels suggested by the World Health Organisation (WHO), while around 80% have been exposed to levels of PM10 beyond the WHO's recommended levels. Shifting to low-carbon technologies described in this study would substantially reduce particulate emissions from cars by 91% in 2030 and by 98% in 2050, but these emissions would also be significantly reduced by the Euro 5 and Euro 6 air pollutant standards.

The uptake of ultra-low emission cars and vans in London would yield significant benefits to local air quality. Air quality monitoring of NOx and particulates in London shows that limits are typically exceeded at kerbside and roadside monitoring locations. This suggests that although emissions from sources other than road vehicles generate more than half of NOx emissions, it is road transport emissions that lead to the concentration of pollutants breaching the regulated limits across London boroughs. By reducing tail-pipe emissions, air quality in London could therefore be brought to within guideline concentrations.

Synergies between transport and power systems

Figure 6

An estimation of potential annual revenues from electric vehicles providing services to the UK power grid. Source: Element Energy



Shifting to electrically-powered vehicles creates both challenges and opportunities for Britain's power system. If poorly-managed, the shift to electric vehicles would necessitate a costly increase in the capacity needed for generation, transmission and distribution. But if handled smartly, electric vehicles could avoid high peaks in demand at certain times and provide services to the grid, for example by helping utilities manage network overloads, voltage levels, frequency of electricity and imbalances between supply and demand. Electric vehicles could also help soak up surplus renewable energy at times of peak supply. Smart charging is the solution to avoid excessive spikes in demand and absorb the peaks observed due to more variable renewable generation.

A model of vehicle departures and arrivals was used in the project to determine the times at which most electric vehicles would be on the road and the times at which most would be plugged into the grid and available to accept a charge. In an unmanaged system, charging would naturally occur most after the morning rush hour, as cars are plugged in at the workplace, or just after the evening rush hour, as cars are plugged in at home. By contrast, smart charging would occur in a controlled fashion, by fitting electric vehicles with smart technology that allows network operators to optimise charging times in accordance with the needs of the power system.

The daily cycle needs to be managed to ensure that high peaks in demand, especially in the evening, do not occur. Smart-charging would allow the morning charging load to be spread across the working day, absorbing any surpluses of solar energy, while the evening charging load could be shifted into the night, soaking up surpluses of night-time wind energy. This is known as avoided curtailment. Such a system would lessen the need for additional grid and generation capacity to accommodate electric vehicles and would reduce greenhouse gas emissions and energy waste.

Using data from National Grid, calculations were made to quantify the value that could be generated through services to the grid, classified here as response and reserve services, and through avoided curtailment. The EV fleet could generate nearly £1billion worth of system benefits for Britain by 2050. Most of this is from reduced curtailment, with around 40% coming from response and reserve services, and does not include transaction costs.

The potential maximum revenue per vehicle reaches a peak around 2030 but reduces thereafter due to the stabilisation of balancing costs and the dilution of value amongst more electric vehicles.

If they could be efficiently monetised, the provision of these services would reduce EV ownership costs and provide beneficial services to the grid without significant additional infrastructure. However, it should be noted that the commercial model supporting the provision of services from distributed electric vehicles is dependent on how electricity market design and regulation of TSOs and DNOs evolves.

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