Energy & Climate INTELLIGENCE UNIT

November 2022

GLOBAL MOMEMTUM 1
ON CLEAN TRANSITION

The energy price shock and the transition to electric vehicles

About

The Energy & Climate Intelligence Unit (ECIU) is a non-profit organisation supporting informed debate on energy and climate change issues in the UK. Britain faces important choices on energy and on responding to climate change, and we believe it is vital that debates on these issues are underpinned by evidence and set in their proper context.

Contents

Executive summary

The key points in this report are:

The global oil and gas crunch will further spur electrification of the energy system

Futures markets indicate continued **high and volatile oil, gas and power prices**, linked to Covid-19 and Russia's invasion of Ukraine, at least until 2025.

As nations place greater value on energy security and reducing cost, we expect **accelerated investment in electrification of heating and transport, as well as in renewable power**, as the cheapest source of electricity.

On electric vehicle (EV) momentum:

We seem to be at a tipping point in electrification of the transport system, indicated by the number of EV models available in Europe – at 184 models, up five-fold compared with five years ago.

Global EV sales more than doubled in 2021, and we expect similar growth in 2022. Germany and Britain led the world's biggest economies in EV share of new passenger vehicle sales in 2021, at 26% and 22% respectively.[1]

Sales growth has caught out analysts. Sales this year are likely to overshoot expectations for 2030, as forecast by Goldman Sachs just five years ago, as well as the International Energy

Agency's EV fleet projections looking likely to be passed.

EV battery prices have fallen 89% since 2010 and are projected to fall a further 66% by 2035.

On EV cost of ownership:

Total cost of ownership (TCO) – we compare the costs and savings over the average or expected 14-year ownership period of a vehicle in Britain and Germany, for three popular EV brands versus equivalent combustion cars.

All EV models generate net savings over the lifetime of the vehicle.

Average net savings of £8.3k in Britain and €7.4k in Germany, over a 14-year lifetime, imply national cash savings of £300 billion and €353 billion respectively, over the next 14 years, if replicated across national passenger car fleets.

Making a conservative assumption that 10% of the EV battery value will be available to consumers at scrappage, average net savings rise to £8.7k in Britain and €7.8k in Germany

The **EV premium above the upfront price of an equivalent combustion car is significantly higher in Germany** than in Britain for two of the three models looked at in this report, indicating carmakers are capturing Germany's EV grants, now phased out in Britain.

There are tax neutral policy choices to boost EV adoption:

In Germany, an accelerated smart meter rollout would make cheaper, off-peak tariffs available to EV drivers, as is already the case in Britain, offsetting the effect of halving German EV grants next year.

I**n Britain, EV adoption could be spurred by simplifying rapid charging network tariffs**, to eliminate hidden charges and minimise risks of price-gouging. Most charging operators benefited from public funding to roll out their charging infrastructure, making it legitimate for government to follow France's lead and apply the sort of regulation and standardisation to charging that many cities in the UK have brought to bear on public transport ticketing, for example.

If there were a shift towards taxing "bads", instead of "goods", such as by shifting the burden of environmental and other taxation and charges to gas bills, and away from electricity bills (as already in the Netherlands), this could further reduce EV charging costs in both countries.

The global energy crunch

The present oil and gas price shock, with resulting higher and more volatile energy prices, is throwing a greater focus on electrification and efficiency. This is driving prioritisation of electrification of the energy system, since electric heating and electric cars are more efficient than fossil fuel counterparts such as gas boilers and petrol or diesel combustion cars.

A focus on electrification will, in turn, see an acceleration of investment in renewables, as the cheapest power source, with the lowest political risk. This is only adding momentum to the global clean energy transition which is already well underway, as it becomes evident that the cleaner and more efficient energy alternatives are also considerably cheaper and more reliable than volatile and expensive gas.

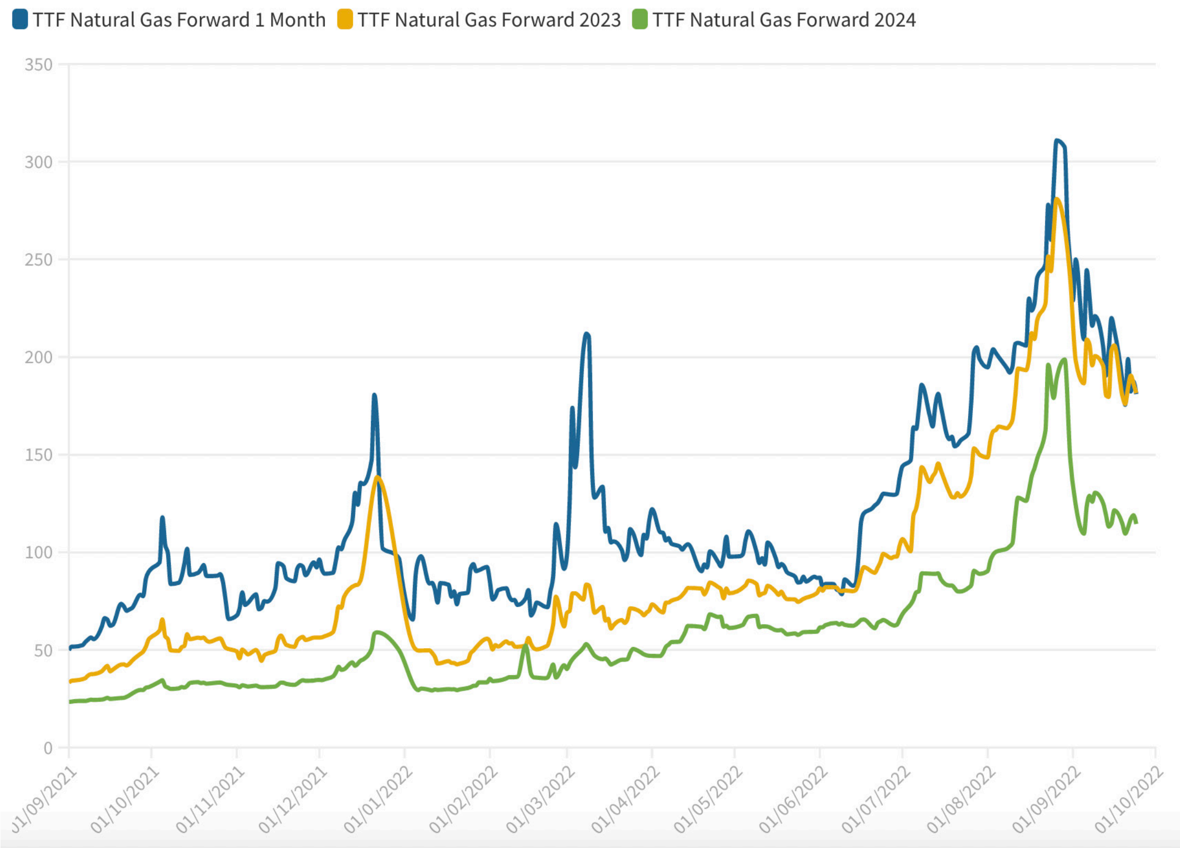
We focus here on Europe, as the region most impacted by higher and more volatile energy prices. Disruption of the energy economy is global, however, as a result of international competition in sea-borne markets in gas, coal and oil.

Europe's net energy imports are 55% of total energy demand, placing it midway between other major importers such as China (21%) and India (38%) at one end of the spectrum, Turkiye (72%) and Japan (84%) at the other. The difference in Europe is its dependence on Russia, and especially on a Russian gas supply now entirely under threat. In Europe, therefore, diversification into domestic renewables and electrification of the transport and heating sectors has become a strategic imperative. Speaking of the European Union's plans to end reliance on Russian gas, EU Commissioner responsible for the European Green Deal, Frans Timmermans said, "let's dash into renewable energy at lightning speed".

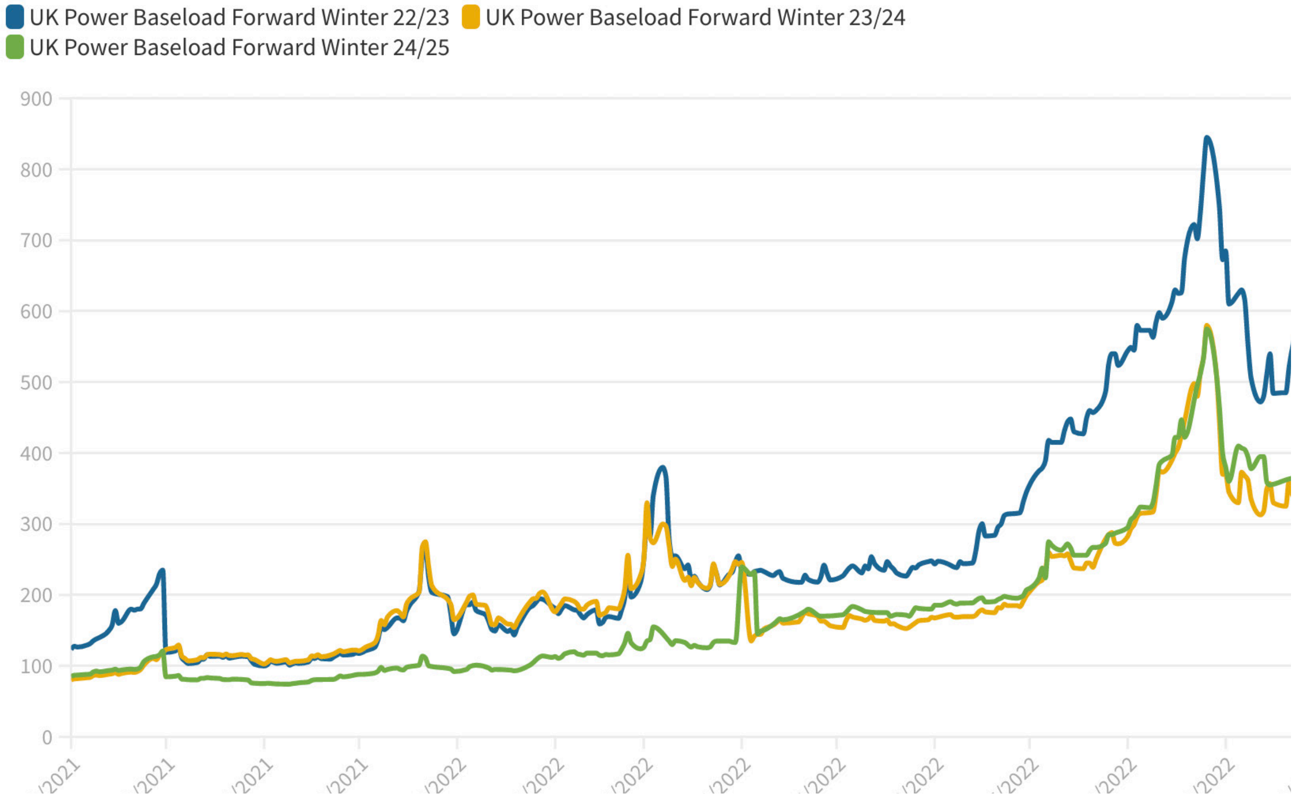
At present, the immediate energy crunch is linked to ongoing events, including the combined effect of the Covid-19 pandemic and the Russian invasion of Ukraine in February 2022. But we expect this era of energy volatility and elevated prices to last around four years, following energy markets' expectations. The first chart in Figure 1 shows that prices for European gas delivered in 2024 (grey line) are lower than for delivery in 2022 (blue), but still nearly five times their level 12 months ago. The second chart shows that prices for UK power delivered in winter 2024/25 (grey) are four times their level 12 months ago. We see a permanent, disruptive impact from these higher prices, by driving a faster net zero transition.

Figure 1. Medium-term higher gas and power price expectations

Dutch TTF gas prices

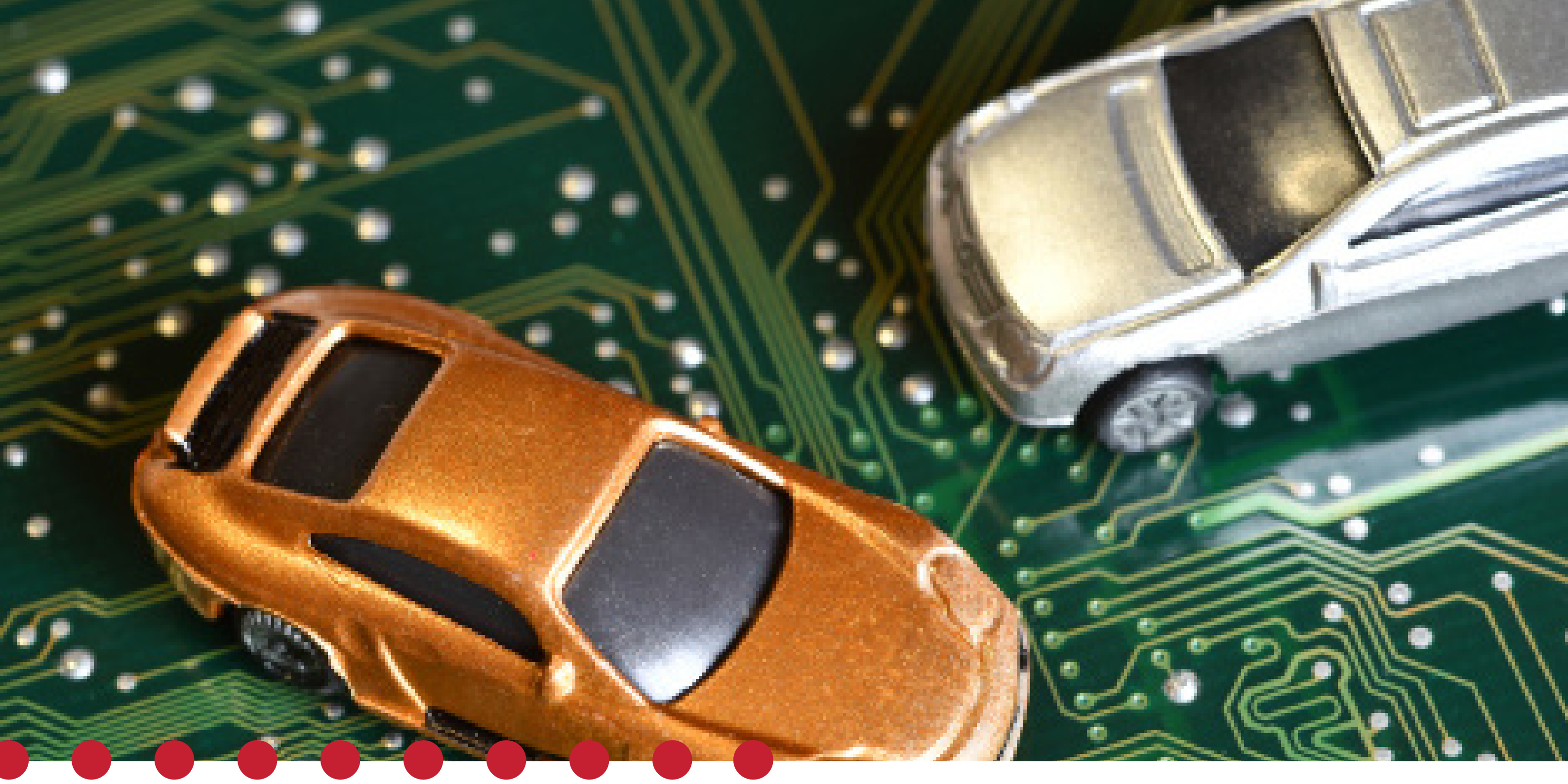


UK baseload power



In this report, we explore sales trajectories in the global EV and battery market. We then focus on the economics of EVs vs petrol/diesel cars in our two focus countries, Britain and Germany – two major economies with distinct policy approaches to energy markets and infrastructure, inside and outside the EU.

We note that many countries already have target dates to phase out the sales of new internal combustion engines, including in Britain by 2030, and Germany by 2035. Such phaseouts may help drive EV adoption. However, the economics of ownership are still critical, for consumers to switch from combustion vehicles, while EV charging infrastructure also needs to be in place.



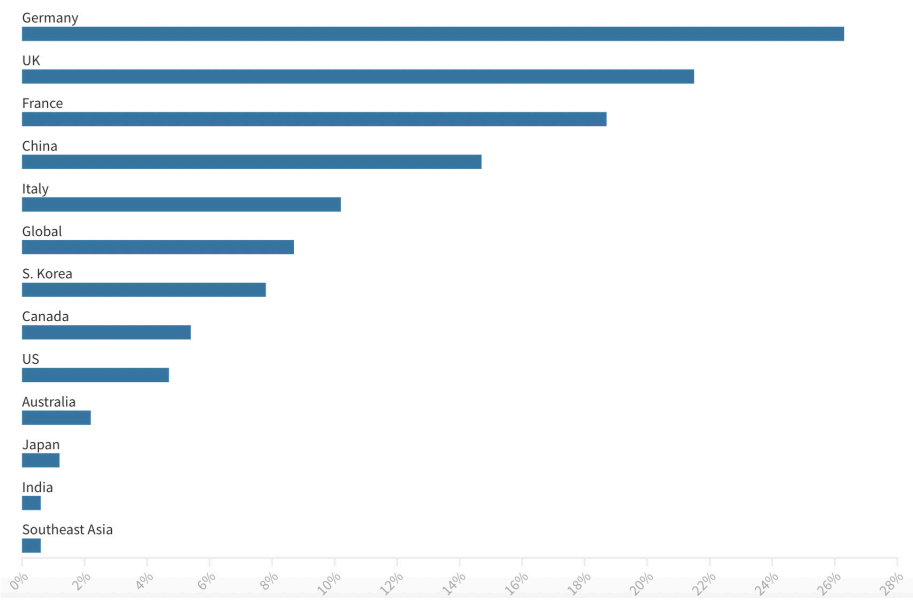
EV momentum

Vehicle sales

EV share of passenger vehicle market

Our two focus markets, Britain and Germany, were the two world leaders last year, among major economies, in terms of the EV share of new vehicle sales.

Figure 2. Passenger EV sales, leading economies, 2021

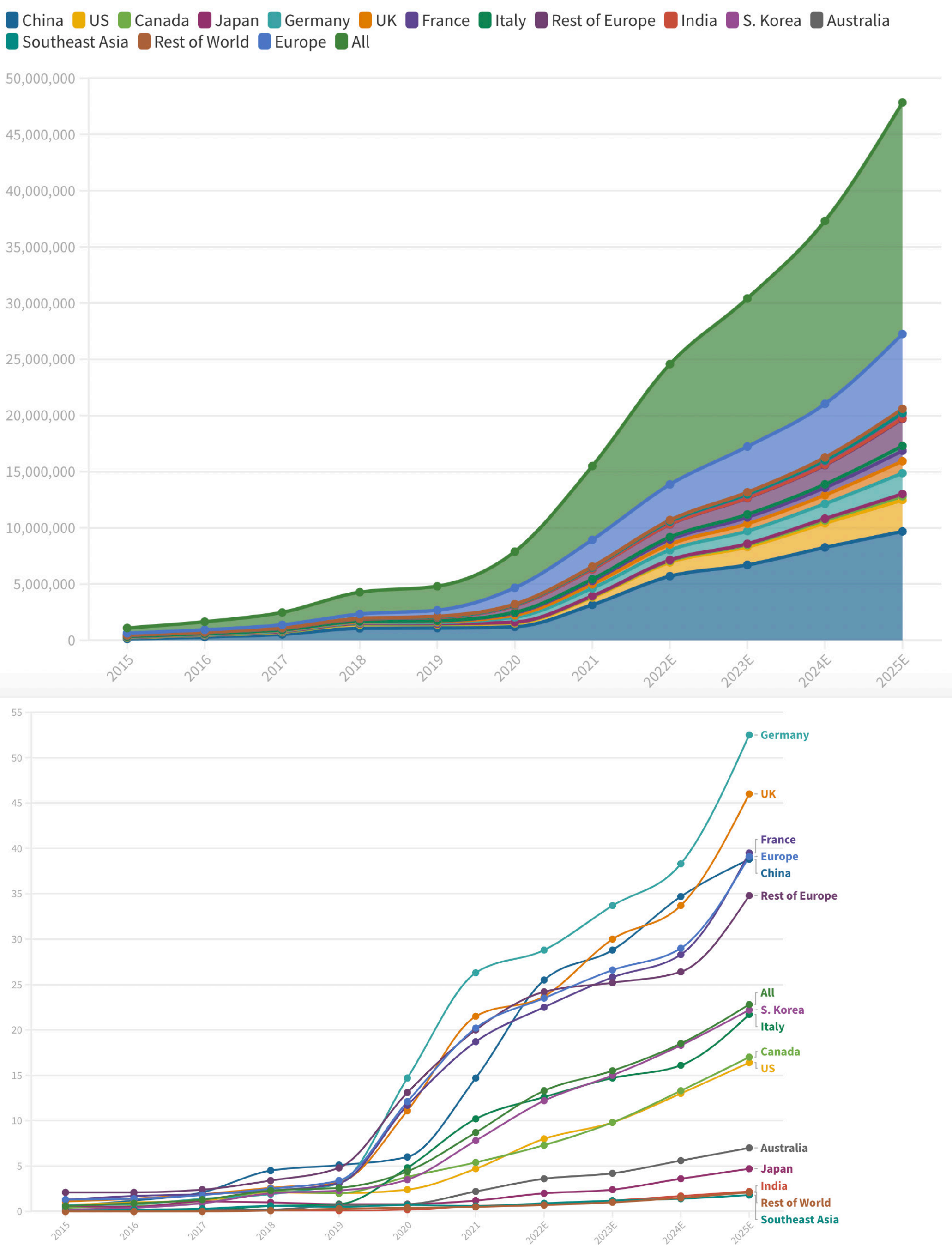


Source: Bloomberg NEF

Growth in the EV market

In 2021, sales of passenger EVs (including plug-in hybrids) reached 6.6 million cars globally – more than double the previous year. The market is on track for a near-doubling again in 2022 (Figure 3, first chart). Europe now has the highest EV market penetration globally, last year accounting for 17% of vehicles sold (Figure 3, second chart). Among smaller, leading countries, the biggest market share was Norway (86%), followed by Iceland (72%) and Sweden (43%).

Figure 3. Annual passenger EV sales and % market share, leading economies



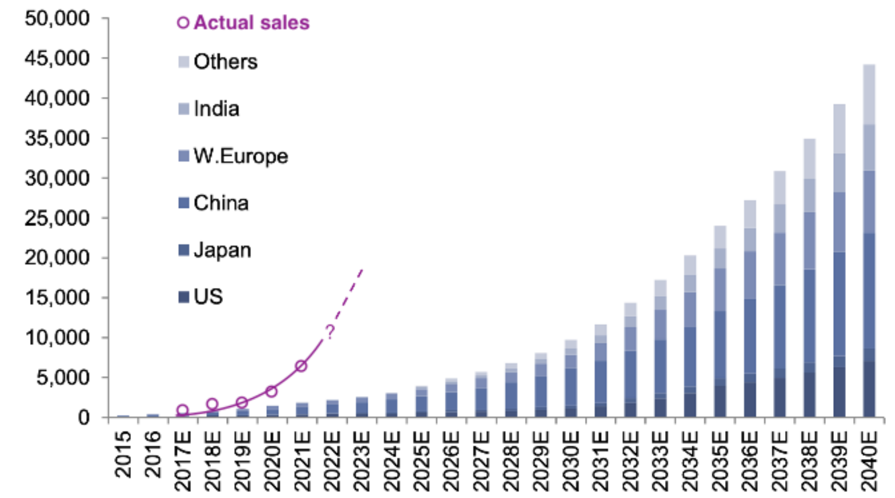
Source: Bloomberg NEF

Speed of change

There are presently substantial waiting lists for EVs, and rising demand is incentivising greater investment in battery and semiconductor value chains. The signing of the Inflation Reduction Act into law in the United States, by President Biden, has seen a swathe of investments announced into EV and battery manufacture.

The scale of the recent increase in EV sales has caught forecasters by surprise. For example, Goldman Sachs in 2017 predicted 10 million EV sales in 2030, a level likely to be exceeded in 2022 – eight years early.

Figure 4. Goldman Sachs '000 EV sales, 2017 forecast, vs actual sales data through 2021

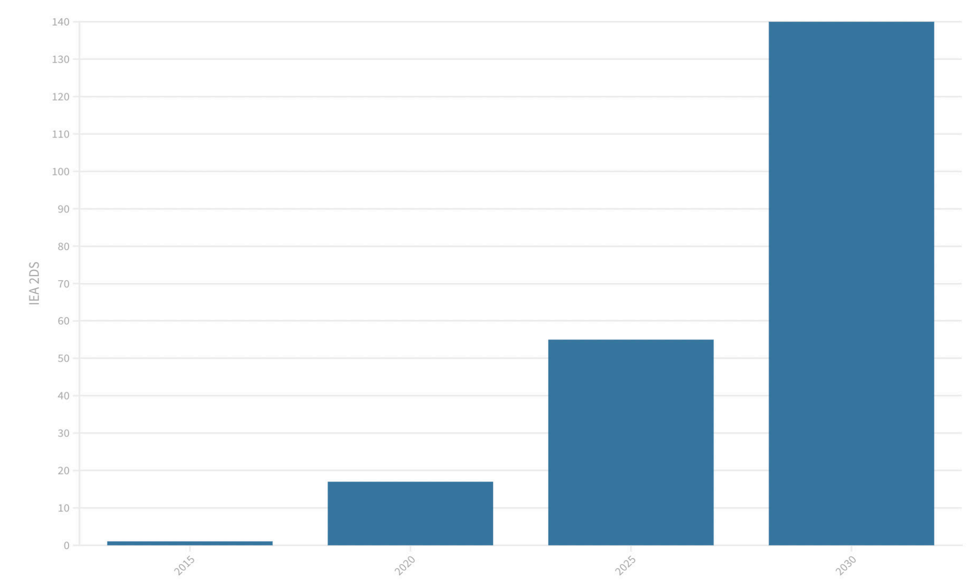


Source: Goldman Sachs

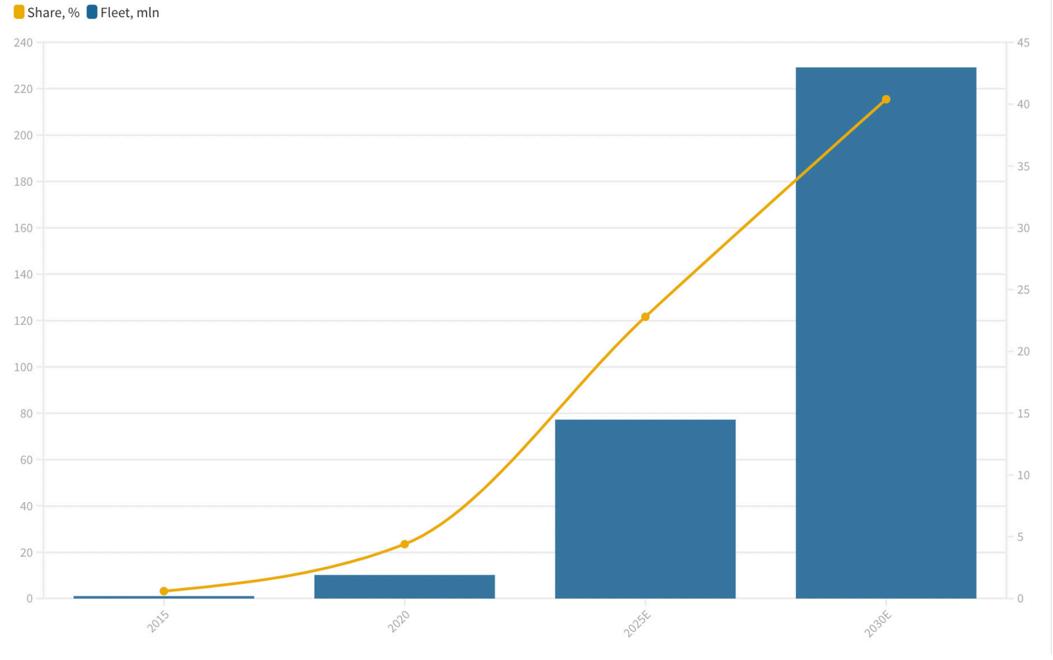
Regarding EV fleet size, in 2016, the International Energy Agency's most ambitious scenario – its 2 degrees scenario (IEA 2DS) – projected 140 million EVs by 2030, versus Bloomberg NEF's latest projection for 230 million (see Figure 5).

Figure 5. EV fleet projections, millions, 2016 versus now

IEA 2016 EV fleet projection



Bloomberg NEF EV projections in 2022

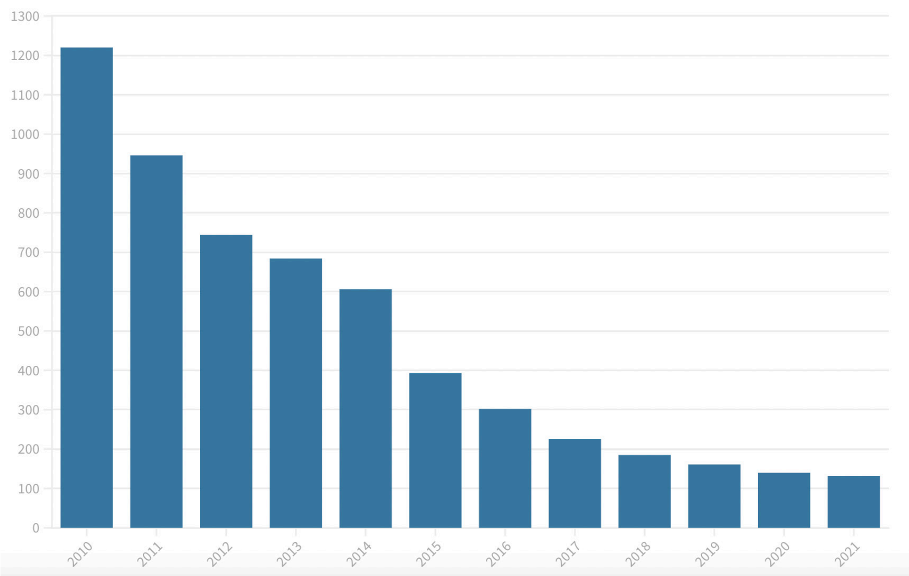


Falling battery prices

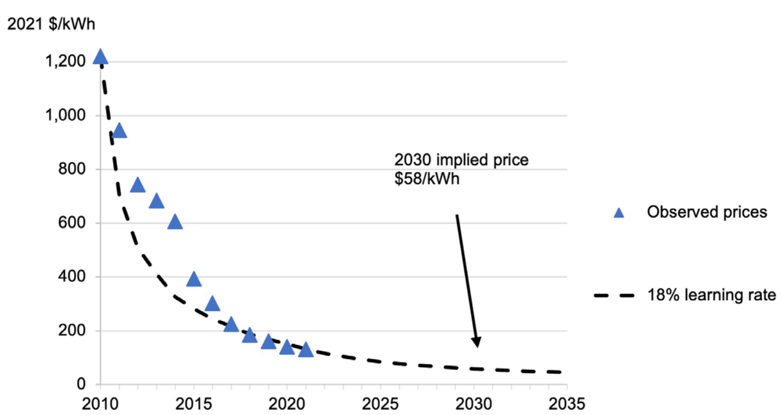
EV battery prices have fallen by 89% since 2010 and, if they follow the same 'learning rate', are projected to fall by a further two thirds by 2035 (see Figure 6).

Figure 6. EV battery prices continue to fall (real 2021 prices)

Prices down 89% since 2010



Outlook for further 66% drop by 2035

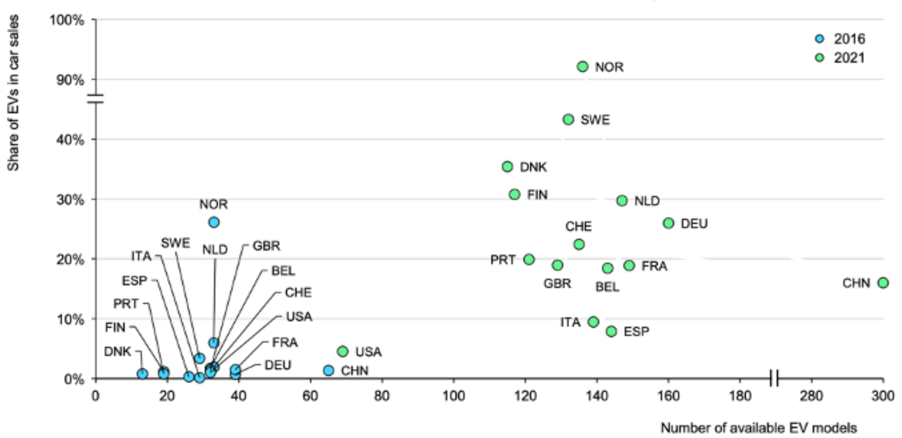


Carmaker response: a tipping point

Proliferating EV models

Global sales of fuel cell passenger vehicles in 2021, at 16,257, were dwarfed by battery electric and plug-in hybrid sales of more than 6.5 million, according to Bloomberg NEF. Automakers seem to have accepted that the future is electric, with a growing proliferation of new models. In 2021, Europeans could choose from 184 EVs models, up more than five-fold over the last five years. In Britain, choice has grown to around 130 models, from 30 in 2016, and in Germany to nearly 160 models, from around 40 (see Figure 5).

Figure 7. Proliferation of EV models, by country, 2021 vs 2016



Source: [IEA]

Range anxiety

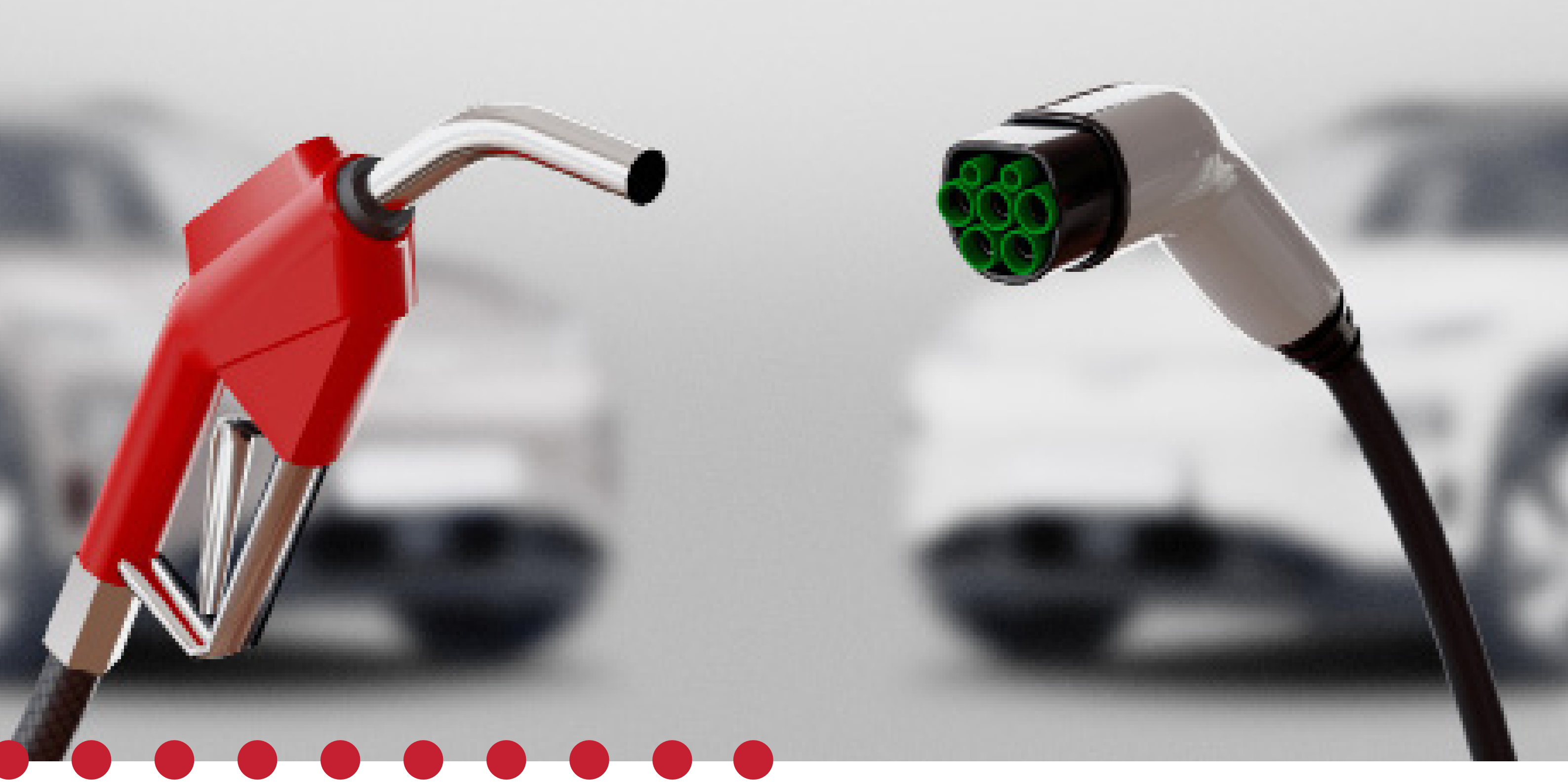
The notion of ‘range anxiety’ – that a car may not reach its destination – is now retreating, as EV ranges grow with newer, bigger batteries. In our cost analysis below, we looked at the:

- Renault Zoe Techno R135 EV
- Volkswagen ID.3 Life EV
- Kia Niro EV “2” EV.

Their WLTP-rate ranges were:

- Renault: up to 370km/230 miles;
- Volkswagen: up to 427km/265 miles; and
- Kia: up to 459km/285 miles.

These are much higher ranges than typical daily journeys, of below 160km (100 miles), and are approaching the average range of petrol and diesel cars, of around 500km.



EV Cost of Ownership

A household's decision about whether to buy a car, and if so, whether that is an EV or equivalent combustion car, will depend on issues including cost, EV range, personal taste and the ability to charge at home. Here, we focus on cost.

The difference in full ownership cost between an EV and nearest equivalent combustion car depends on the balance between upfront price and running cost. At the moment, EVs typically have a higher upfront price and lower running cost. The lower running cost reflects their higher efficiency, where compact combustion cars consume around three times more energy per kilometre (at 1.9 MJ of fuel per km) than equivalent EVs (at 0.7 MJ of electricity per km).

In this section, we compare the costs for three new EVs, in Britain and Germany, versus their nearest combustion car equivalent. We chose these cars as popular examples of a super-mini, a compact and an SUV. They are all at the more budget end of the EV market, which will be most important to crack, to achieve adoption of EVs at scale.

Renault Zoe Techno R135 EV	VS	Seat Ibiza Xcellence Lux DSG
Volkswagen ID.3 Life EV		VW Golf 8 Life 1.0 eTSI Automatic
Kia Niro EV "2" EV		Kia Sportage "2" 1.6 petrol manual

When comparing vehicles, we are limited by what the market provides, and no EV has an identical combustion engine equivalent; in fact, quite the opposite. For example, the nearest same-brand equivalent, in terms of size and accessories, to the Renault Zoe Techno is the Renault Clio "RS Line". However, the latter lacks multiple features required as standard in the

Zoe Techno.[2] In our cost analysis, we instead compared the Zoe with the highest specification Seat Ibiza (Xcellence Lux DSG), which is comparable in size and closer in extras to the Zoe, but still lacking many Zoe features.[3] This limited investigation of 'equivalent cars' shows that even 'budget' or compact EVs, such as the Zoe, are in fact tailored as hi-spec cars.

We measure vehicle cost using a total cost of ownership (TCO) methodology. We compare the cost and savings over the average ownership period of a vehicle in Britain and Germany. We assume the average lifespan of a combustion vehicle is 14 years.[4] Most EV carmakers provide an eight-year warranty for batteries, implying a significantly longer maximum lifespan. Since industry professionals quote a 10 to 20-year battery lifespan, we assume a 14-year average lifetime also for EVs.

Total cost of ownership (TCO)

The TCO concept calculates total costs and savings, over the expected lifespan of a vehicle, when buying an EV compared to its nearest equivalent combustion vehicle. We summarise the results below, in Tables 1 and 2, based on assumptions provided in the appendix:

1. All three of our EV models made money over our assumed lifespan of 14 years, compared with the purchase of a petrol car, in both Britain and Germany.

2. For the Zoe and Niro EVs, there is a far higher vehicle premium (excluding battery) in Germany compared with Britain. Renault and Kia may be successfully capturing some of the very large EV grants available in Germany. The exception is the VW, a German car, which has a lower premium in Germany than Britain, perhaps reflecting the different priorities marketing into a domestic market.

3. Domestic EV charging costs are far lower in Britain than in Germany. For our TCO calculations, we assume that vehicles are charged at home – half of the time at peak rates and half at off-peak rates. Only Britain has off-peak EV tariffs (thanks to its roll-out of smart meters), available at around one fifth of peak rates, because of its near universal rollout of digital meters.[5] Germany has barely started this rollout.

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2 As of Sept 2022, the specifications required as standard in the Zoe Techno and unavailable in the Clio RS Line included: automatic gearbox; heated steering wheel; heated front seats; keyless entry; electrically adjustable door mirrors; autodimming rearview mirror; automatic lights; automatic windscreen wipers; overspeed prevention; tyre pressure monitors; hands-free parking; Apple "carplay"; and satnav screen. See here: https://www.renault.co.uk/

3. As of Sept 2022, the specifications required as standard in the Zoe Techno and apparently unavailable in the Seat Ibiza DSG included: heated steering wheel; heated front seats; autodimming rearview mirror; overspeed prevention; tyre pressure monitors; and hands-free parking.

4. The latest UK data for average vehicle lifespan is 13.9 years, from the SMNT, in 2015. The average age of passenger vehicles has continued to rise, according to the RAC, making 14 years a conservative assumption.

5. In Britain, the electricity utility Octopus has an off-peak charging tarrif of 7.5p/kWh, compared with a 35p/kWh peak rate, which we apply in this analysis. These figures are correct as of September 2022.

4. Overall EV net savings over vehicle lifetimes are actually greater in Britain, despite having no EV grant in place at all. We compare the relative effects of an EV grant versus smart charging in more detail in the following section.

Table 1. Total EV costs and savings vs combustion car, over 14 years: UK findings (cash prices)

EV costs and savings		Zoe vs Ibiza	ID.3 vs VW Golf	Niro EV vs Sportage	AVERAGE
Costs					
	Battery pack	£5,974.43	£6,663.78	£7,445.05	
	Vehicle price premium excl battery	£2,205.57	£2,271.22	£2,134.95	
	Home charger	£600	£600	£600	
	Charging cost over the period	£6,765.34	£5,962.53	£6,299.33	
	TOTAL	**£15,545.34**	**£15,497.53**	**£16,478.33**	
Savings	,497.53				
	EV grant	£0	£0	£0	
	Insurance savings over the period	-£1,072.85	-£417.59	£125.41	
	Avoided gasoline costs over the period	£19,281.28	£17,115.24	£22,022.69	
	Servicing savings over the period	£820.14	£881.65	£881.65	
	Road tax savings over the period	£4,193.37	£4,153.37	£4,548.37	
	TOTAL	**£23,221.94**	**£21,732.68**	**£27,578.13**	
NET SAVINGS	TOTAL	**£7,676.61**	**£635.15**	**£11,098.81**	£8,336.85

Table 2. Total EV net savings vs combustion car, over 14 years: Germany findings (cash prices)

EV costs and savings		Zoe vs Ibiza	ID.3 vs VW Golf	Niro EV vs Sportage	AVERAGE
Costs					
	Battery pack	€6,874.30	€7,667.48	€8,566.43	
	Vehicle price premium excl battery	€7,820.70	-€752.48	€10,533.57	
	Home charger	€765	€765	€765	
	Charging cost over the period	€12,238.93	€10,786.61	€11,395.89	
	TOTAL	**€27,698.93**		**€31,260.89**	
Savings	,497.53				
	EV grant	€9,000	€9,000	€6,750	
	Insurance savings over the period	€956.83	€222.12	€375.90	
	Avoided gasoline costs over the period	€19,565.42	€15,875.83	€31,260.89	
	Servicing savings over the period	€491.23	€1243.88	€3,953.23	
	Road tax savings over the period	€2,477.02	€1,601.31	€3,953.54	
	TOTAL	**€32,490.51**	**€27,941.15**	**€39,071.54**	
NET SAVINGS	TOTAL	£4,791.58	£9,474.54	£7,810.65	£8,336.85

Taking the average values from Tables 1 and 2, and applying these to the national passenger car fleets in Britain and Germany today (36 million and 48 million), we can make estimate of total national savings over the next 14 years at £300 billion and €353 billion respectively.

Sensitivity Analysis

Correspondence by the authors with automakers indicates an expectation that 10-20% of the value of the EV battery will be available to the consumer at scrappage, for new models retailing today. Conservatively assuming 10% of the value will be available to consumers, and based on a battery cost of £63 (€72)/ kWh in 2036 (in real 2021 prices, in line with our 18% learning rate, taken from Bloomberg NEF), the average savings in Tables 1 and 2 move upwards.

Average savings rise to £8,704 in the UK, and €7,779 in Germany, implying national savings of £313 billion and €373 billion respectively.

Finally, we investigate the impact on net savings of making available in Germany the benefit of the same off-peak charging rates as already available in Britain. In Britain, more than half of all gas and electricity meters are now 'smart' or 'advanced' meters, according to the government's statistics service. In Germany, this rollout has barely begun. Smart electricity meters allow utilities to track electricity use according to the time of day, and so to make available tariffs that charge less at off-peak periods, or which track wholesale power prices.

Smart meter rollout in Britain has encouraged some major utilities such as Octopus to tailor tariffs for EV owners, offering steeply discounted off-peak charging at around one fifth of the average power price. If such tariffs were available in Germany, and the average household used off-peak charging half the time, average net savings for our three EV models in Germany would rise more than 50%, to €11,748, from €7,359 (Table 2), which would offset the impact of reducing EV grants next year.

TCO Changes to 2033

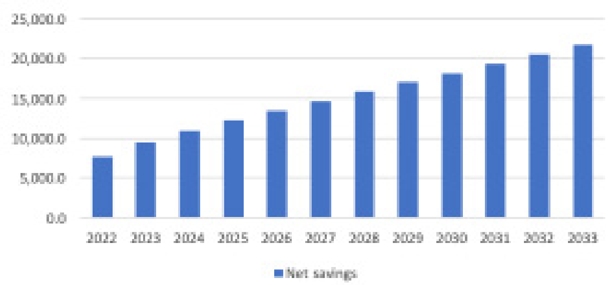
Here we explore how the TCOs reviewed above change over time, for two popular EVs compared with their petrol equivalents, in Britain and Germany. In Britain, we take the Kia Niro EV and the Renault Zoe EV. In Germany, we take the Kia Niro EV and the VW ID.3 EV.
The EV net savings rise over time, with the exception of Germany in 2023, which reflects a planned halving or more of Germany's EV grants next year. The main drivers for rising savings over time are:

- steeply falling EV battery costs;
- a falling EV price premium, excluding the battery;
- rising net fuel savings; and
- a rising vehicle excise duty (or equivalent) tax on petrol cars in line with historical tax inflation.

The findings are summarised in Figures 8 and 9 below.

Figure 8. UK EV net savings, over a 14-year vehicle lifetime, 2022-2033 (cash prices)

Renault Zoe EV vs Seat Ibiza.



Kia Niro EV vs Kia Sportage

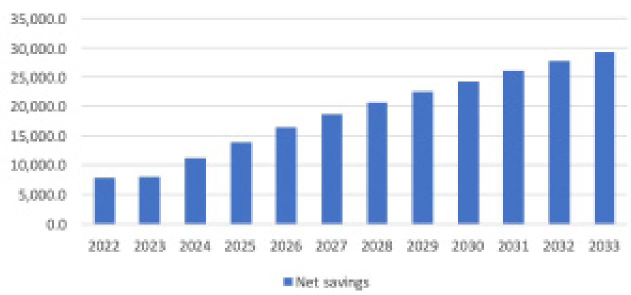
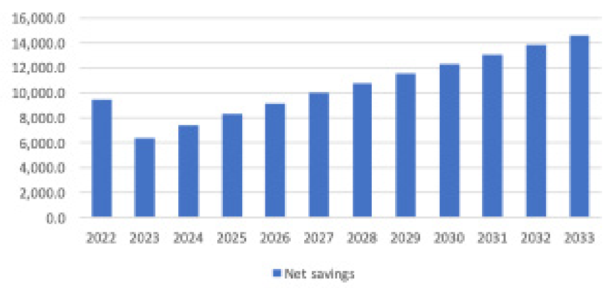
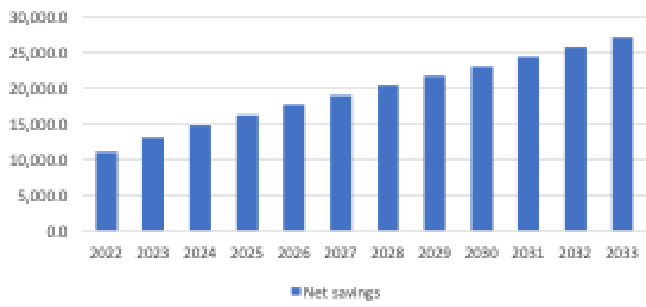


Figure 9. Germany EV net savings, over a 14-year vehicle lifetime, 2022-2033 (cash prices)

VW ID.3 EV vs VW Golf Life



Kia Niro EV vs Kia Sportage



Cutting EV charging costs

UK focus: Exploring the 'EV-switch power price'
In this section, we show that there is no prospect for EVs to become more expensive to run, per kilometre, than combustion cars, at present domestic power prices. However, whilst that is true for home charging, it is a different story for the public EV charging network, where we see price-gouging by private operators of publicly subsidised networks, undermining the purpose and value of such public funding.

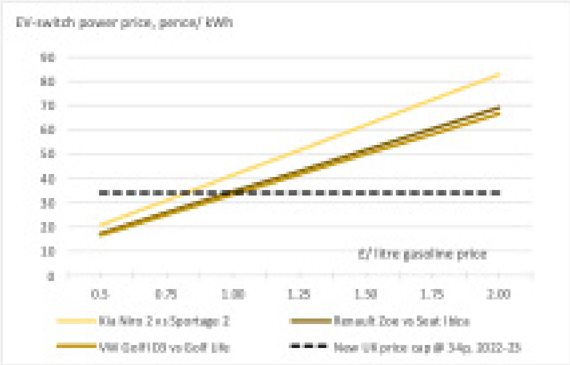
We define the level of electricity price where combustion cars become cheaper to run, for any given petrol or diesel price, as the 'EV switch power price'. Since the running cost of any car is a function of the fuel price and vehicle efficiency, it is important to compare like with like, for example a small EV with a small combustion car, or a mid-range EV SUV with a combustion SUV.

Starting with domestic power prices, since Russia's invasion of Ukraine, UK electricity prices have risen relatively slightly faster than petrol and diesel (see Figure 9 righthand chart below), raising a question mark over whether EVs lower running costs may be under threat. The lefthand chart in Figure 9 below shows the car switch power price for our three previous EV-combustion car comparisons, for any given petrol/diesel price.

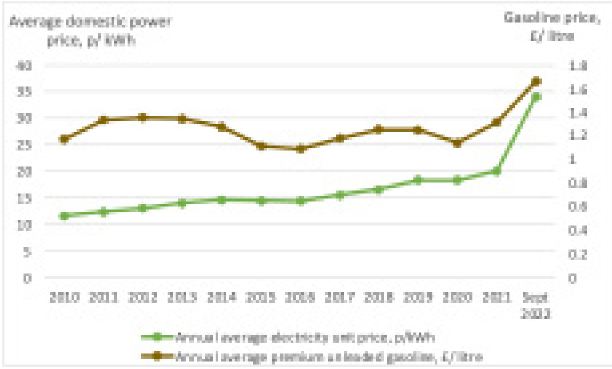
The figure shows that, even at the new, higher, UK electricity price cap of 34p/kWh, from October 2022, petrol prices would have to fall below £1 per litre for combustion cars to become cheaper to run than their EV equivalents. The righthand chart shows that petrol prices have been well above £1/ litre over the last decade. We therefore see no precedent for combustion cars to become cheaper to run than EVs, at domestic power prices. This is made even more true if EU and UK governments succeed, as is their stated aim, in decoupling gas and power prices in their energy markets.

Figure 10. UK focus - Historical petrol and power prices, and “EV-switch power price”

‘EV switch power price’, selected models



Historical fuel prices



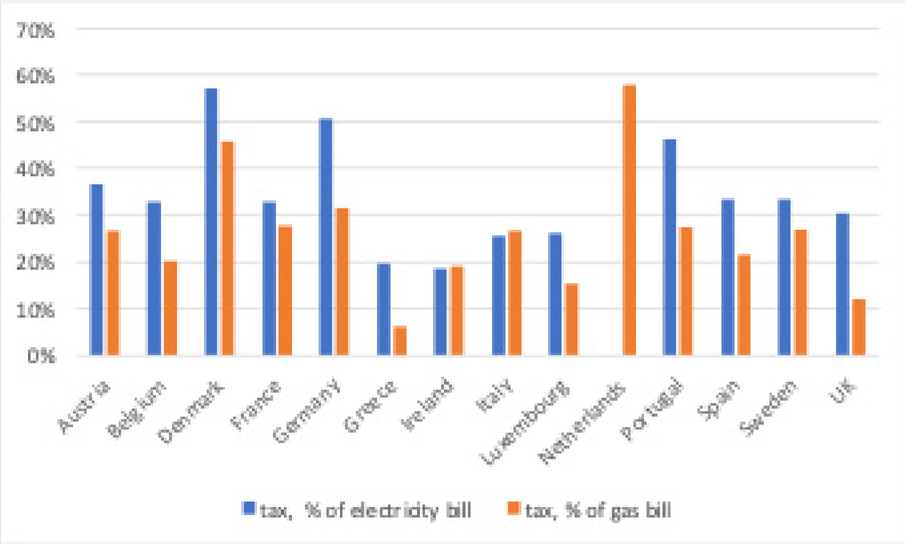
Germany focus: Smart meter rollout

Britain has achieved much faster roll-out of smart meters than Germany. These meters enable time-of-use tariffs, including tariffs for cheap, off-peak overnight charging for EV owners. Our analysis, described above, shows that making such smart tariffs available for domestic EV charging has the equivalent effect on EV economics of large EV grants funded by the taxpayer.

Britain and Germany: Taxing ‘bads’, not ‘goods’

Britain and Germany, in common with most western EU members, place a far higher burden of taxation on domestic electricity than gas bills, even though gas is a fossil fuel and electricity is a carrier for less carbon-emitting renewable power (see Figure 14). The standout exception is the Netherlands, where tax accounts for 0% of electricity bills, and 58% of gas bills. We note that these are 2021 data, and political intervention in energy billing is a fast-moving area.

Figure 11. Tax component of domestic gas and electricity prices, EU-14 plus UK, July-Dec 2021



Source: [UK Dept for Business, Energy and Industrial Strategy]

Britain: evolving public charger infrastructure

France has regulated its public charging infrastructure to unify systems and make it more transparent and accessible for drivers charging vehicles away from home. It is analogous to regulation in cities like London to unify public transport payment behind a single mechanism in the form of the Oyster card.

As it currently stands in the UK public charging network, there is considerable variation in power price charged and in means of accessing chargers, as well as hidden costs for rapid charging on major highways at service stations. As some of this infrastructure has benefitted from public investment to enable it, it may be that government will seek to better regulate public rapid charging infrastructure as it expands. This would not only help bring longer journeys within reach of drivers considering switching from petrol/diesel to EVs, but also contribute to further reducing the cost of owning an EV.

Appendix: assumptions

We follow these assumptions, in our TCO analysis:

- Our TCO cost modelling refers to cash prices. We assume RPI of 3%
- UK electricity prices: we assume a fall to 24p/kWh in 2033 in real terms (34p in cash prices), from 34p today, as wholesale power prices fall and the price cap is lifted.
- UK petrol prices: we assume a fall to £1.57/litre in real terms (£2.18 in cash prices), from around £1.70 today, in line with the UK government's 'high prices' scenario projection for the gasoline unit price in 2033, as published in 2020.
- German electricity and gasoline prices: we assume these follow the same inflation as in Britain.
- Electricity tariff choices: we account for various charging options, combining peak and off-peak domestic tariffs, and the more expensive public network of rapid chargers (>22kW). In Britain, we use a base case of home charging, where 50% is off-peak charging (7.5p/kWh) and 50% peak charging (34.9p). In Germany, with low rollout of smart meters, our base case is 100% peak charging at domestic power prices.
- Battery cost: batteries account for about one third of the cost of an EV. We assume that EV batteries prices rise in 2022 for the first time on record, and then follow an 18% learning rate, following Bloomberg NEF, indexed to inflation.
- EV price excluding battery: we assume that manufacturing economies of scale lead to 20% annual deflation in the EV price premium, excluding the battery, until the premium falls to zero.
- Other EV costs: insurance and home charger. We use insurance premiums published at the time of writing, and add the published cost of a 7kW home charger.
- Other EV savings: vehicle excise duty (or equivalent) and maintenance costs. We use manufacturers' own servicing plans, generally cheaper for EVs, and published records for road tax, which is generally zero for EVs.
- Mileage: we assume an annual mileage of nearly 12,000 km, the pre-covid UK average.
- Prices and efficiencies: We take vehicle prices from automaker websites and use WLTP efficiencies.
- Financing: we assume buyers pay cash to own the vehicle outright, noting that some manufacturers still offer two-year interest-free credit.
- Assumed exchange rates: £/$ = 0.870; £/€ = 0.877; €/$ = 1.002