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Electric Insights Quarterly

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Contents

Electric Insights was established by Drax to help inform and enlighten the debate on Britain’s electricity. It is delivered independently by a team of academics from Imperial College London. Data courtesy of Elexon, National Grid and Sheffield Solar.

1. Headlines

This quarter's Electric Insights features two special reports on Britain's power system moving towards zero fossil fuels, and how this makes electric vehicles cleaner than ever.

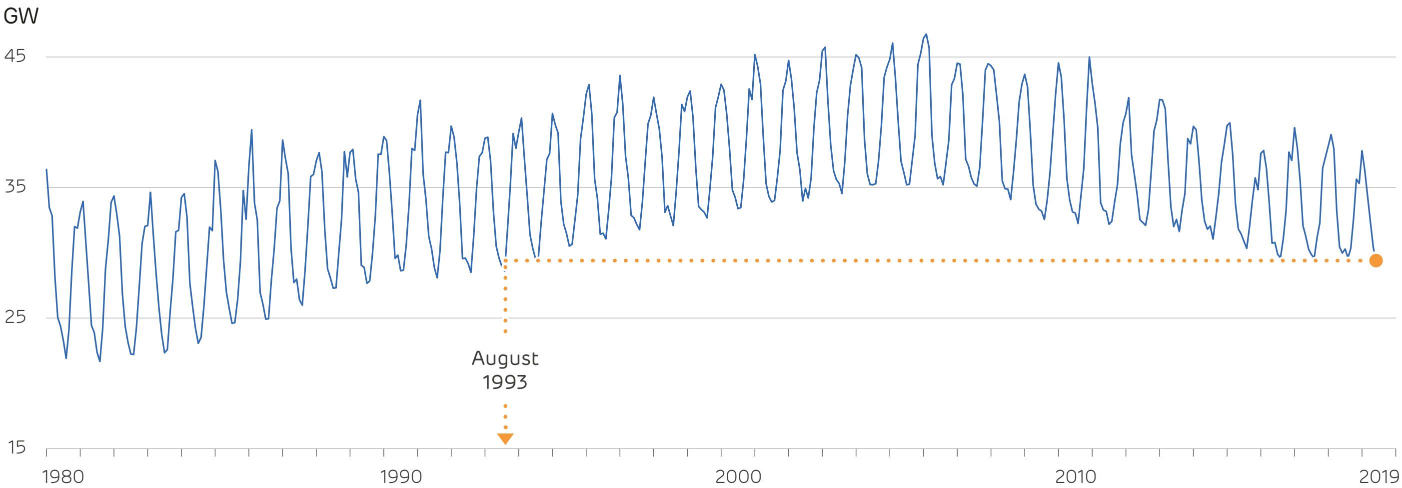
Last quarter saw major press coverage about 'zero coal' as Britain went for a fortnight without any coal power stations operating. The bigger challenge is getting all the way to zero carbon electricity and moving away from all unabated fossil fuels. Article 2 looks at the progress Britain's power system is making, and how the last quarter saw the first full day with a carbon intensity below the Committee on Climate Change's critical target of 100 g/kWh, and the first ever excursion below a 10% share of fossil fuels.

Back in 2017 we looked at electric cars getting greener due to changes in the power system. A lot has changed in the last two years, more models are available and electric vans and taxis have taken off. Article 3 looks at how these new models perform in environmental terms, and whether Britain's electricity is clean enough to repay the carbon emissions released in making their huge batteries.

This quarter, the Electric Insights website was upgraded to show the split between onshore and offshore wind. The UK has over 2,000 turbines installed out at sea, making it the world's leader in offshore wind. Article 4 shows how the country's wind industry has developed over the last 20 years, revealing that onshore wind is still the largest source of wind power.

Article 5 looks at the power system's statistics over the last quarter. Wholesale prices have fallen dramatically since the start of the year. Nuclear power fell to its lowest output in over a decade. And for the first time, coal has fallen to last place in the generation mix, producing less electricity than hydropower. Article 6 looks at the record highs and lows in the power system, 24 of which were broken over the last three months. In June, electricity demand fell to its lowest levels in 25 years.

Monthly average electricity demand



2. Britain's power system is closer than ever to being fossil-free

Electricity generation is decarbonising faster in Britain than anywhere else in the world.[1] Changes to the way we produce power over the last six years have reduced carbon emissions by 100 million tonnes per year.[2] The carbon savings made in Britain's power sector are equivalent to having taken every single car and van off our roads.[3]

This puts Britain at the forefront of the wider trend towards clean electricity. Coal generation is collapsing in Germany, having fallen 20% in the last year due to rising carbon prices. Renewables have beaten fossil fuels as the largest source of generation in Europe. A third of America's coal power stations have retired over the last decade as they switch to cleaner natural gas.

Britain's coal power stations made international headlines in May for sitting completely idle for two full weeks. But coal is only part of the story. The second quarter of 2019 saw three major milestones that signal Britain's progress towards a clean power system:

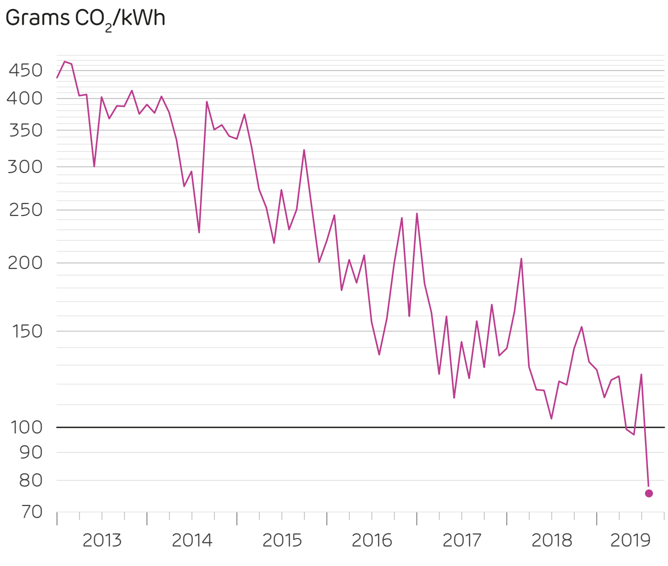
1. The carbon content of electricity hit to an all-time low, falling below 100 g/kWh across a whole day for the first time;
2. Renewables hit an all-time high, supplying more than half of Britain's electricity over a full day; and
3. For the first time ever, less than a tenth of electricity was produced from fossil fuels.

Going below 100 grams

100 grams of CO_2 per kWh is an important number. Two years ago the Committee on Climate Change recommended it as the target for 2030 that would mean our electricity system is in line with the national commitment to decarbonise.

Britain's electricity has dipped below 100 grams for single hours at a time, but until now it had never done so for a full day. June 30th was a sunny Sunday with a good breeze that brought a 33°C heatwave to an end. Electricity demand was among the lowest seen all year while wind output was at a three-month high. The carbon intensity of electricity sat below 100 g/kWh for half of the day, falling to a minimum of just 73 g/kWh in the mid-afternoon. Carbon emissions averaged over the day were 97 g/kWh, beating the previous record of 104 g/kWh set a year ago.

Minimum daily carbon intensity each month[4]



1 Over the last decade, the carbon intensity of electricity generation in Britain has fallen faster than in any other major economy. Source: Energy Revolution: Global Outlook.
2 In the 12 months to July 2019 carbon dioxide emissions from electricity generation totalled 60.5 million tonnes. In the 12 months to July 2013 these emissions were 160.2 million tonnes. Both figures include emissions from imported electricity, and from producing and transporting biomass. See Electric Insights and our peer-reviewed methodology paper for details of the calculation.
3 In 2017 the UK's cars emitted 70 million tonnes of CO_2 and light-duty vehicles emitted 19 million tonnes. Source: BEIS Final greenhouse gas emissions statistics.
4 Note, the record for lowest daily-average carbon emissions was smashed at the time of going to press, falling from the 97 g/kWh hit in Quarter 2 to just 73 g/kWh.

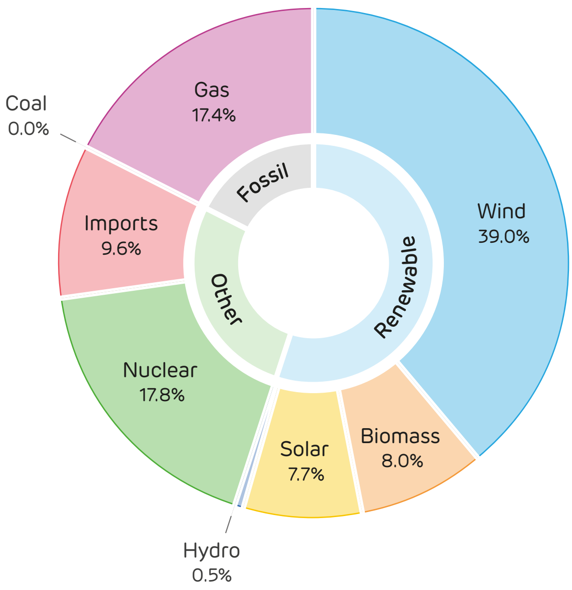
Going above 50% renewables

June 30th was a record-breaker in a second way. Wind, solar, biomass and hydro supplied 55% of electricity demand over the day – smashing the previous daily record of 49% set last summer. For the first day in the national grid's history, more electricity came from renewables than all other sources.

That day, Britain's wind farms produced twice as much electricity as all fossil fuels combined. A quarter of the country's electricity demand was met by onshore wind farms, and 15% from offshore.[5]

Despite several reactors being offline for maintenance, nuclear power provided nearly a fifth of electricity; again, more than was supplied by all fossil fuels.

Britain's generation mix during June 30th that delivered electricity for less than 100g of carbon per kWh

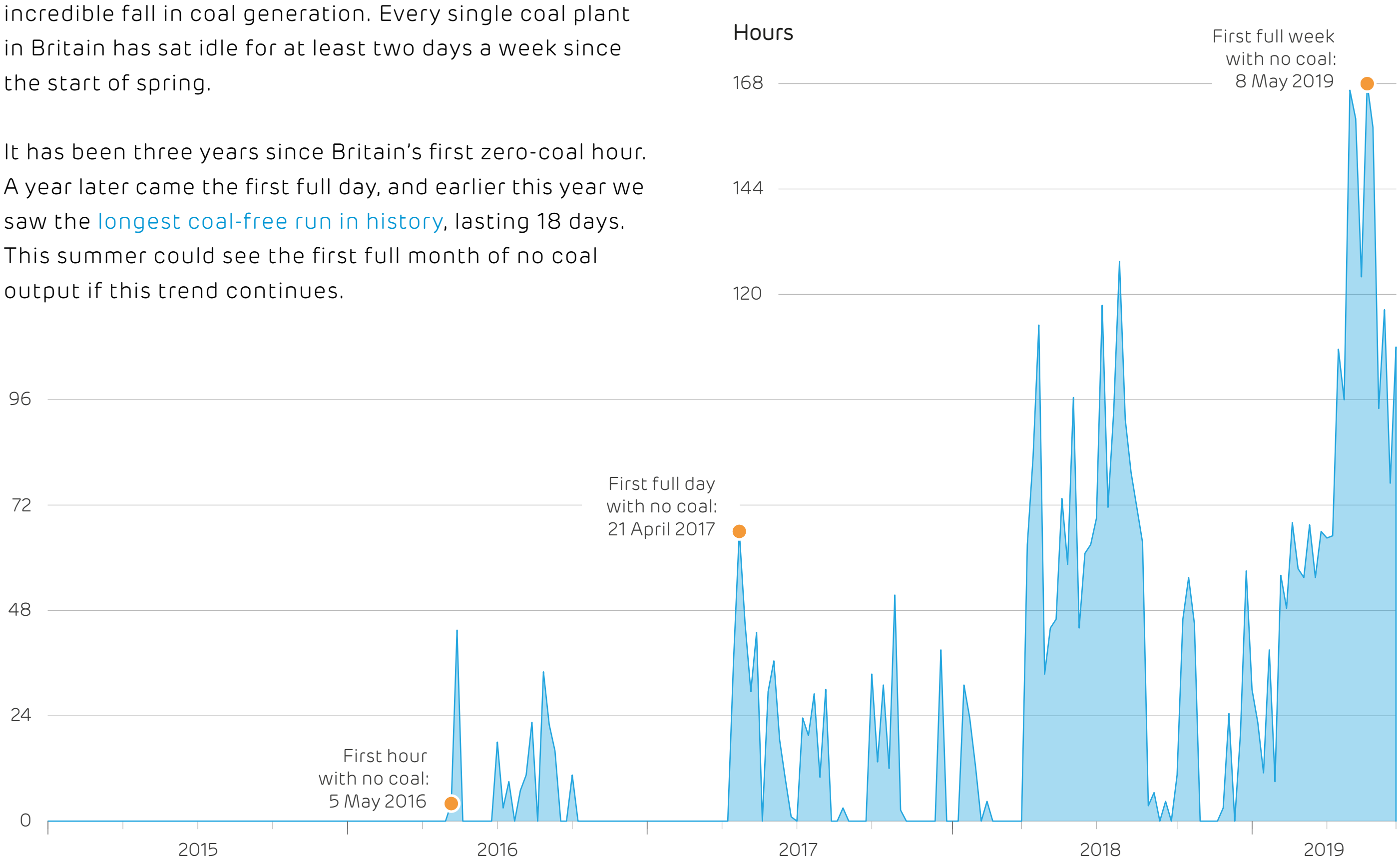


Heading towards fossil-free electricity

The rise of renewable energy has been a major factor in decarbonising Britain's electricity, complemented by the incredible fall in coal generation. Every single coal plant in Britain has sat idle for at least two days a week since the start of spring.

It has been three years since Britain's first zero-coal hour. A year later came the first full day, and earlier this year we saw the longest coal-free run in history, lasting 18 days. This summer could see the first full month of no coal output if this trend continues.

Number of hours per week with zero generation from Britain's coal power stations

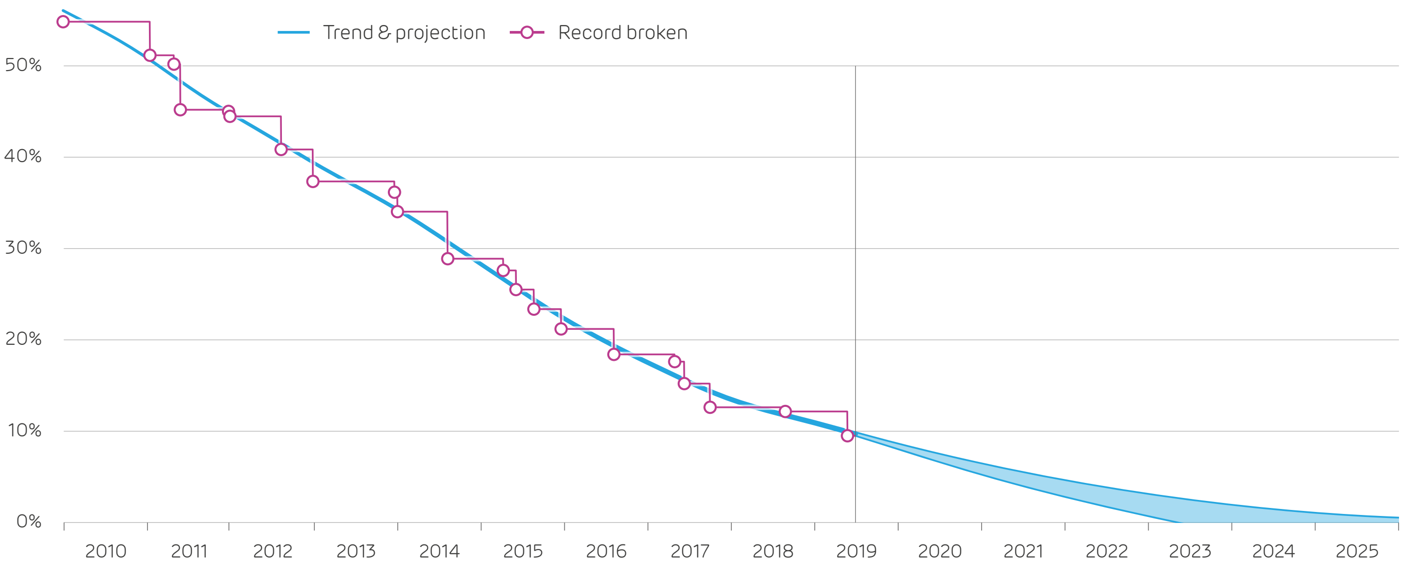


5 Electric Insights now provides data on the split between onshore and offshore wind farms. Typically, around 2/3 of the country's wind power comes from its onshore wind farms.

Attention must now shift from 'zero coal' to 'fossil free'. Unabated natural gas (without carbon capture and storage) needs to be removed from the grid mix by 2050 to tackle the climate crisis and ensure the UK hits net-zero emissions across the whole economy.

At the start of this decade, Britain's power system had never operated with less than half of electricity coming from fossil fuels. As renewables were rolled out across the country the share of fossil fuels has fallen dramatically. By 2014, the grid was able to operate with less than one-third from fossil fuels, and by 2016 it had gone below one-fifth.

The record minimum share of fossil fuels in Britain's electricity mix over the last decade, with projections of the current trend to 2025



On May 26th, the share of fossil fuels in Britain's electricity fell below 10% for the first time ever. This record could have gone further though. During the afternoon, 600 MW of wind power was shed – enough to power half a million homes. National Grid had to turn off a tenth of Scotland's wind farms to keep the system stable and secure.

This wind power had to be replaced by gas, biomass and hydro plants elsewhere in the country, as these could be fully controlled at short notice and were located closer to demand centres. This turn-down coincides with ten straight hours where power prices were zero or negative, going down to a minimum of –£71/MWh in the afternoon. National Grid's bill for balancing the system that day alone came to £6.6m.

If the power system could have coped with all the renewable energy being generated, fossil fuels would have been pushed down to just 8% of the generation mix.

This highlights the challenges that National Grid face in their ambition to run a zero carbon power system by 2025 – and the tangible benefits that could already be realised today. If the trend of the last decade continues, Britain could be on course for its first 'fossil-free' hour as early as 2023. This will only be possible if the technical issues around voltage and inertia at times of high wind output can be tackled with new low-carbon technologies.

Other countries are grappling with questions about whether renewables can be relied on to replace coal and gas. Britain is proof that renewables can achieve things that weren't imaginable just a decade ago.

Zero carbon electricity is "the job that can't wait". Britain only has a few more years to wait before the first "fossil-free" hours become a reality.

3. How clean is my electric car?

Electric vehicles are fast becoming mainstream. There are now well over 200,000 on Britain's roads, and this number is growing by 30% per year. 1 in 40 cars sold in Britain is now electric, around one-third of which are pure battery models, and two-thirds are plug-in hybrids.[1]

This radical shift is just beginning though. Britain's electric vehicle fleet is expected to expand ten-fold over the next five to ten years. In more optimistic scenarios, half of all vehicles on the road could be electric just fifteen years from now.[2]

While many see EVs as the cleanest way to drive, they are still the subject of much speculation. Recent criticisms range from a UK government report saying they won't end air pollution[3] to a string of studies (often debunked) claiming they emit more CO_2 than diesel equivalents.[4]

The arguments are simple: how can it be cleaner to swap a petrol car for electric if it is recharged using electricity from dirty coal or gas? Secondly, how can electric vehicles 'repay' the energy needed for mining lithium and to assemble the huge batteries that power them?

We review academic studies of battery manufacture and use data from Electric Insights to answer these questions. More details on this analysis are given at the end of the article.

On average Britain's EVs emit just one quarter the CO_2 of conventional petrol and diesel vehicles. If the carbon emitted in making their battery is included, this rises to only half the CO_2 of a conventional vehicle. Electric vehicles bought today could be emitting just a tenth that of a petrol car in five years' time, as the electricity system is widely expected to continue moving towards low-carbon sources.

Manufacturing each kWh of battery emits a similar amount of carbon as burning through one full tank of petrol.[5] Electric vehicles typically have a battery capacity ranging from 30 kWh for small city hatchbacks up to 100 kWh for top-end model – manufacturing the latter emits as much carbon as three round-the-world flights. More CO_2 is emitted in building the battery for premium EV model than from the recharging it over a 15-year lifetime.[6]

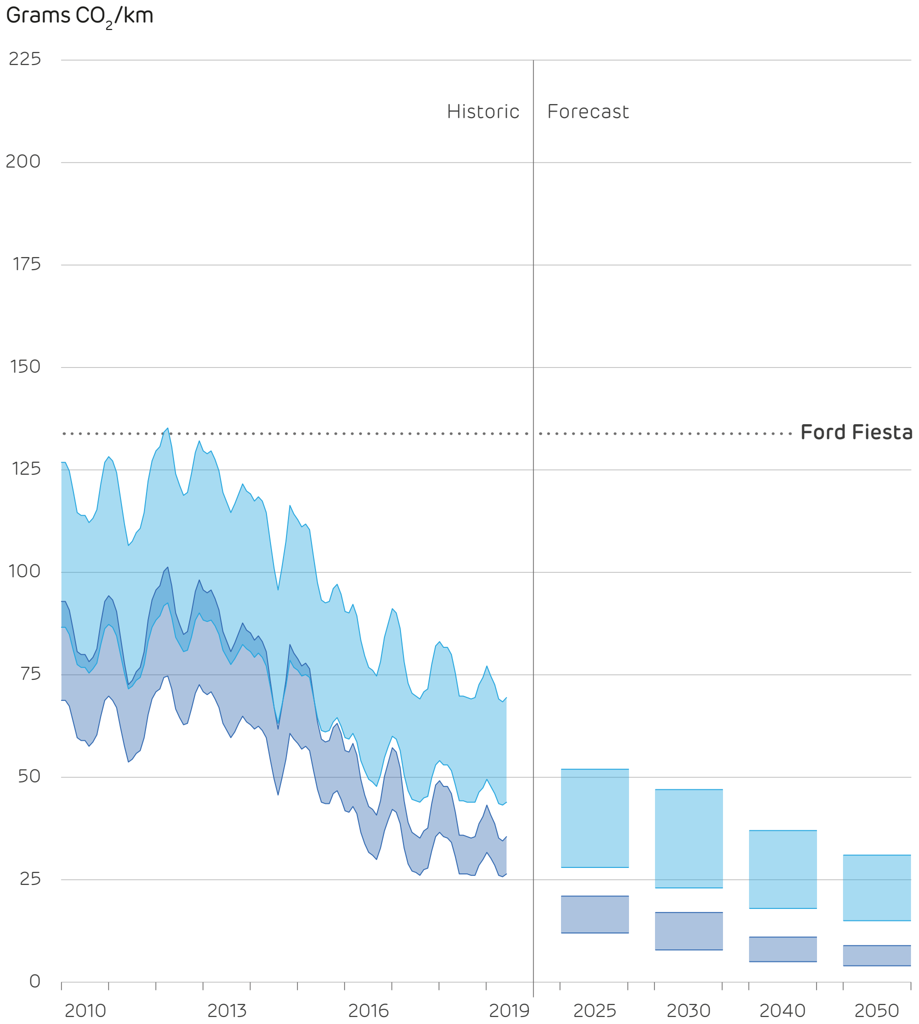
However, the most efficient EV models could need just two to three years of driving to save the amount of carbon emitted in producing their batteries. Smaller EVs with modest battery sizes are better for the environment; whereas the largest luxury EV models could need three times longer to pay back their carbon cost.

1 Source: NextGreencar.
2 Source: National Grid ESO Future Energy Scenarios.
3 Electric cars won't end air pollution.
4 Electric cars' green image blackens beneath the bonnet, or Electric vehicles emit more CO_2 than diesel ones, for example.
5 A 40 litre tank of petrol (costing around £50 to fill up) and holds around 380–390 kWh of chemical energy, which will release 90–100 kg of CO_2 when burnt. Estimates for the CO_2 embodied in lithium-ion battery manufacture centre around 75–125 kg per kWh.
6 Assuming a 100 kWh lithium-ion battery and electricity consumption of 185–225 Wh/km (representative of the Tesla Model S and Model X), charging efficiency of 96%, grid electricity with a carbon intensity of 204 g/kWh (Britain's average for the 12 months to June 2019), transmission and distribution losses of 7.5% (giving 219 g/kWh delivered to the plug), a vehicle lifetime of 150,000 km and carbon emissions from battery manufacture of 75–125 $kgCO_2$ per kWh.

Hatchbacks

Small hatchbacks are the best-selling type of electric vehicles, led by the Nissan Leaf. They are also the cleanest to drive as they are small and light. Electric models currently emit around 33 grams of CO_2 per km driven, which is one quarter that of the most popular conventional vehicle, a 2019 Ford Fiesta. These electric models typically come with a 30-45 kWh battery, which pushes their lifetime emissions up around 60 g/km. This is still less than half the emissions of a petrol or diesel car. With the projected changes to the grid mix, this will fall to less than one-third of a standard car in just five years' time.

Carbon emissions from driving hatchback electric vehicles in Britain



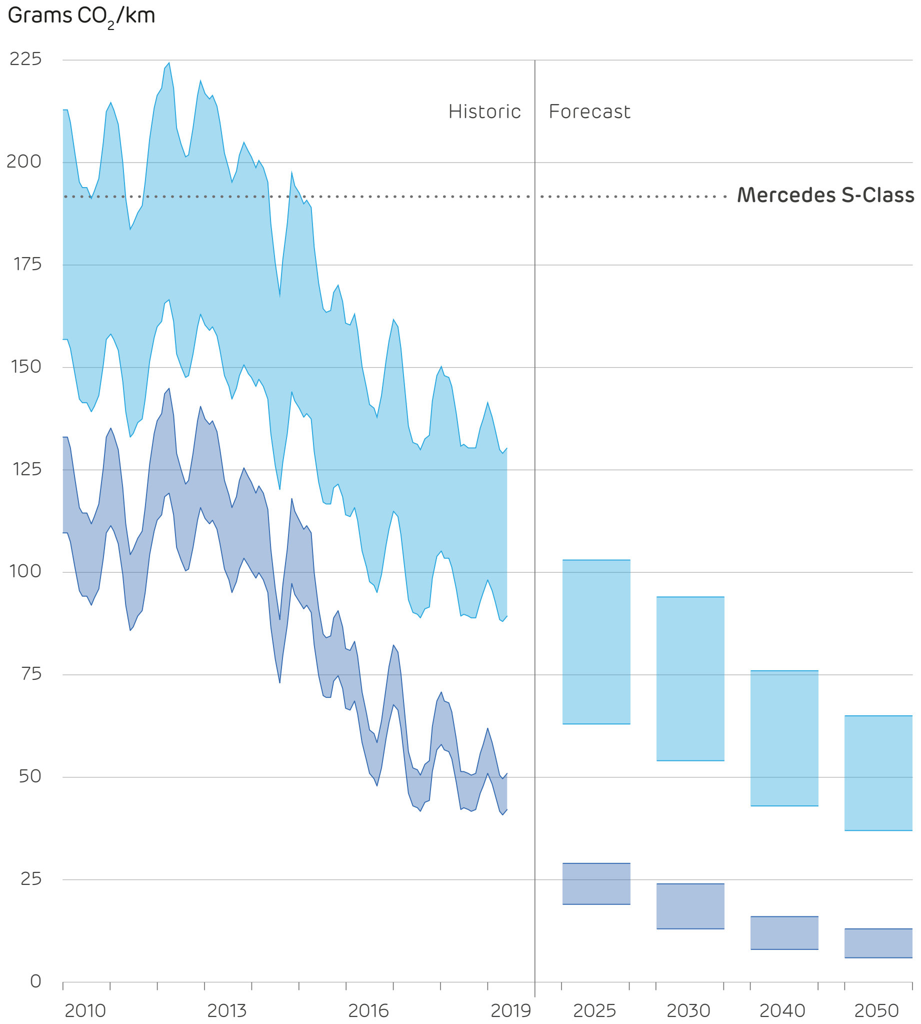
EV models: Nissan Leaf, Renault Zoe, Volkswagen e-Golf and e-Up, Hyundai Kona and BMW i3

Battery size: 39 kWh on average (31–46 kWh central range)
Lifetime carbon content of the battery: 26 g/km driven on average (18–34 g/km central range)
Emissions with 2018/19 grid mix: 28–38 g/km from recharging, 45–72 g/km including battery
Emissions with 2025 grid mix: 12–20 g/km from recharging, 28–52 g/km including battery

Luxury Cars

Luxury saloons and SUV models include the iconic Tesla Models S and X, and the new Jaguar i-Pace. These are much larger and need more energy to move, meaning they have higher emissions than hatchbacks, at 44-54 g/km. This is still just a quarter of the emissions from a comparable conventional car (a top of the range Mercedes S-Class). The lifetime emissions of these luxury EVs are notably higher though, pushed up by the enormous 90-100 kWh batteries they use to provide a driving range of over 250 miles. These batteries are responsible for more CO_2 emissions than driving the car over its entire lifetime; however, the lifetime emissions are still around 40% lower than a conventional luxury saloon.

Carbon emissions from driving SUV and saloon electric vehicles in Britain



Models considered: Jaguar i-Pace, Tesla Model S and Model X

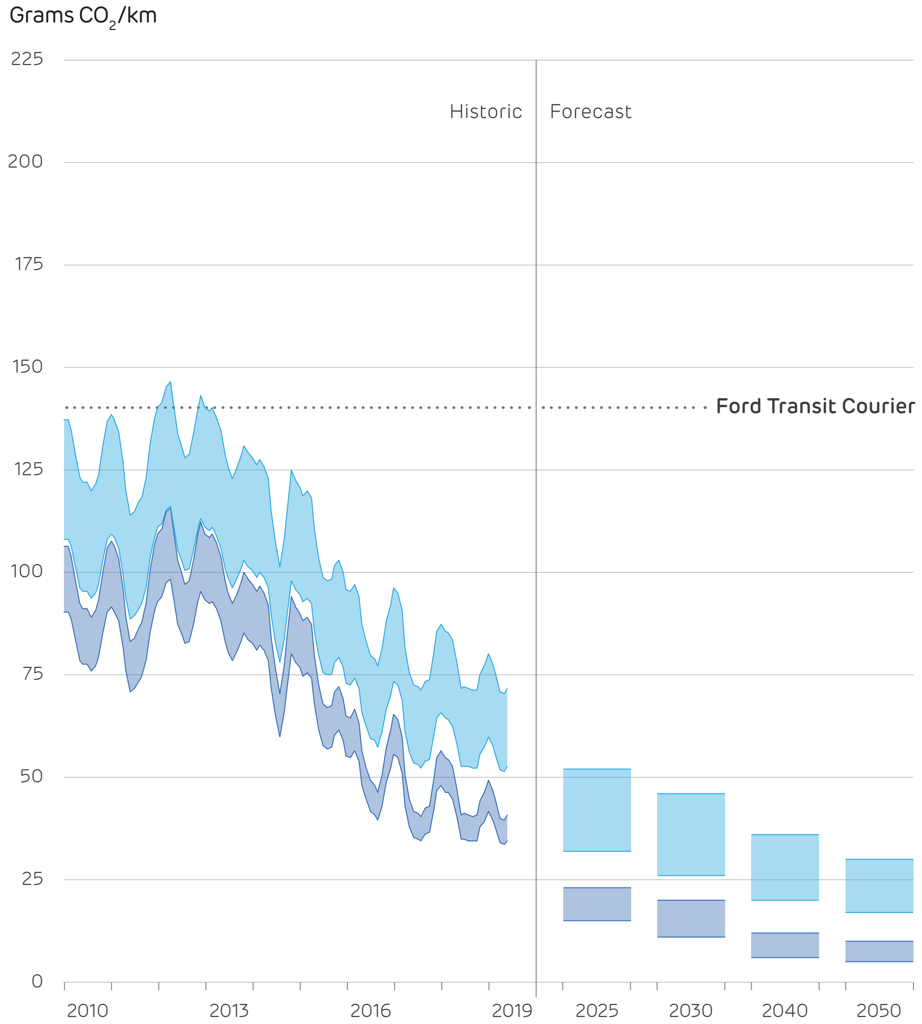
Battery size: 97 kWh on average (90–100 kWh central range)
Lifetime carbon content of the battery: 63 g/km driven on average (47–80 g/km central range)
Emissions with 2018/19 grid mix: 44–54 g/km from recharging, 92–133 g/km including battery
Emissions with 2025 grid mix: 19–29 g/km from recharging. 63–103 g/km including battery

Chart key: Lifetime emissions (inc. battery) | Direct emissions from recharging | Highest emitting EV model / Lowest emitting EV model

Vans

Electric vans are quickly taking off, with over 8,000 sold in Britain to date. Their performance is comparable to small hatchbacks, and they also currently emit around a quarter of the CO_2 of the most popular conventional van, with around 40 g/km. With their 30–40 kWh battery pack included, this rises to just below half the CO_2 of a small Ford Transit.

Carbon emissions from driving electric vans in Britain



Models considered: Nissan e-NV200 and Renault Kangoo

Battery size: 37 kWh on average (33–40 kWh central range)
Lifetime carbon content of the battery: 24 g/km driven on average (18–31 g/km central range)
Emissions with 2018/19 grid mix: 37–43 g/km from recharging, 54–74 g/km including battery
Emissions with 2025 grid mix: 15–23 g/km from recharging, 32–52 g/km including battery

Payback time

A typical driver filling their car up once a month and driving around 7,500 miles per year will produce one and a half tonnes of CO_2 per year in a modern petrol or diesel hatchback. An electric vehicle doing the same mileage would take 4 years to produce this amount.

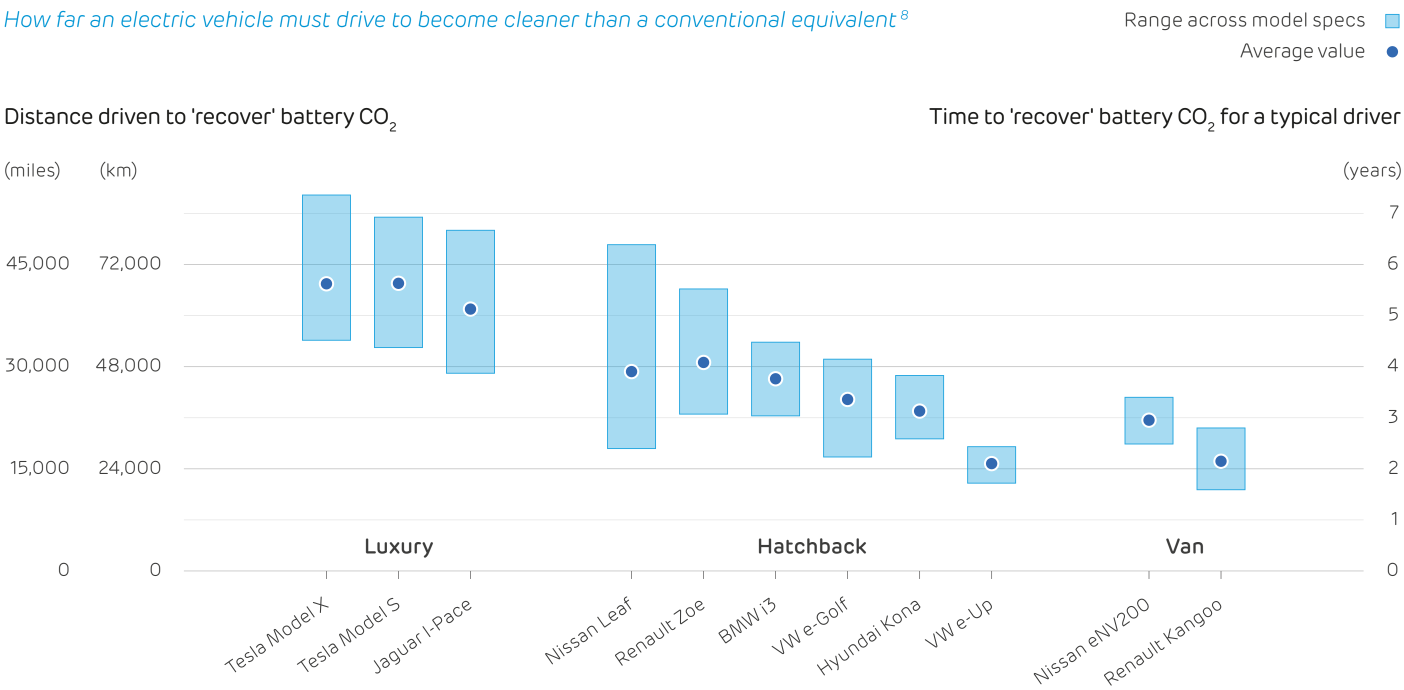
With a conventional vehicle, there is no scope for reducing emissions over its lifetime, as petrol and diesel fuels cannot become carbon-free. On the contrary, National Grid expect the carbon content of Britain's electricity to continue falling, so that an electric vehicle bought now will be emitting half as much CO_2 in 2025 as it does today.

It is inconceivable that an electric vehicle in the UK could be more polluting than its conventional equivalent. This would require electricity to have a carbon intensity of around 850–950 g/kWh, values not seen since the 1960s.[7]

Electric vehicles can be thought of as having an upfront 'carbon cost' for manufacturing the battery, which can then be 'repaid' through lower emissions as they are driven. With Britain's current grid electricity (producing 205 g/kWh), smaller electric cars and vans will take between 2 and 4 years to have saved the amount of CO_2 than was emitted in making their batteries. For the larger luxury models, it will take more like 5–6 years of driving to pay back that carbon.

With each passing year as the electricity mix gets cleaner, this payback time will continue to fall, and the environmental credentials of electric vehicles will keep growing stronger.

How far an electric vehicle must drive to become cleaner than a conventional equivalent[8]



7 This includes the 'carbon cost' of manufacturing the battery. If just the emissions from driving are considered, electric vehicles would need to be charged with electricity containing 900-1000 g/kWh to emit more CO_2 than petrol or diesel equivalents.

8 Each electric vehicle model was matched to an approximate equivalent. The average and range across all model variants (both diesel and petrol) was considered, and all vehicles used emissions measured under the WLTP test. Where WLTP test data were not available, emissions were estimated from the NEDC test cycle using CO2MPAS. The comparisons are: Nissan Leaf vs Nissan Micra. Renault Zoe vs Renault Clio. VW e-Golf vs VW Golf. VW e-Up vs VW Up. Hyundai Kona vs Hyundai Tuscon. BMW i3 vs Smart fortwo. Tesla Model S vs Mercedes S-Class. Tesla Model X vs Range Rover Evoque. Jaguar i-Pace vs Jaguar F-Pace. Nissan e-NV200 vs Nissan NV200. Renault Kangoo vs Renault Kangoo.

About this study

The fuel economy and climate impact of vehicles are measured by the government through the amount of CO_2 they release for every kilometre driven. The UK's most popular car, the Ford Fiesta, emits around 120 g/km in its cleanest models and 160 g/km in the sportier versions.[9] Electric vehicles don't emit any CO_2 while driving, but the power system does when producing the electricity needed to recharge them.

Britain's power system has changed dramatically over the last five years, with carbon emissions halving and the share of coal generation falling from 36% to just 3%. One kWh of electricity in Britain is now contains 204 grams[10] of CO_2, less than the carbon released from burning one kWh of petrol. An electric vehicle can drive up to four times further on 1 kWh than a petrol or diesel car could, because electric motors are so much more efficient.

The charts above look at three categories of vehicle – small hatchbacks, luxury saloons and SUVs, and small commercial vans. Each chart shows how the carbon emissions from an electric vehicle have fallen over the past decade, and how they are expected to continue falling in the years to come. The charts consider changes to the electricity generation mix used for recharging,[11] and a gradual reduction in emissions from battery manufacture as the electricity mix changes in other countries.[12]

The range in direct emissions from recharging (the dark blue bands) covers the main EV models currently on sale in each segment, and variants on each model available. The top of each band (highest emissions) shows the least efficient EV model, the bottom of each band (lowest emissions) shows the most efficient. In the forecast, these bands also include the range of emissions factors for electricity production coming from National Grid's scenarios.

There is a larger range in the estimated whole-lifecycle emissions (the lighter blue bands) due to the additional uncertainty in the emissions caused by manufacturing 1 kWh of battery capacity, and the range of battery sizes seen across EV models.

Studies have estimated a wide range of emissions, depending on the type of battery type, its design, where it is manufactured and how old the study is. Current estimates range from 40 up to 200 kg of CO_2 emitted per kWh of battery capacity.[13] We take the average across eight studies and assume 75–125 kgCO_2 per kWh. The true value may be less than this, as end-of-life batteries could be recycled,[14] or could be repurposed as second-life residential or grid storage batteries. It will also reduce in future as the electricity used to make batteries is decarbonised, or as more factories switch to 100% renewable energy (as has the US Tesla Gigafactory).

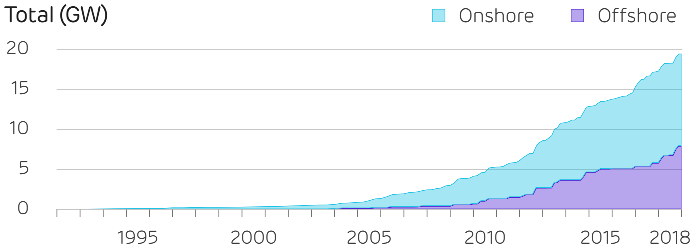
9 All values in this report are based on the new WLTP testing method, which aims to represent real-world driving.
10 12 month average to June 2019, having fallen from 444 g/kWh in the 12 months to June 2014.
11 Using the four scenarios presented by the National Grid ESO Future Energy Scenarios: http://fes.nationalgrid.com/
12 Assuming a 1% per year reduction in the carbon intensity of electricity worldwide, based on historic progress over the last decade. Note, that decarbonisation will be much quicker if the world is to hit the Paris climate agreement targets.
13 Ellingson, 2013; GREET, 2018; Hao, 2017; Hoekstra, 2019; Kim, 2016; Regett, 2019; Romare, 2017; Yin, 2019.
14 This saves emissions for making the next generation of batteries, just as recycling a glass bottle reduces the energy needed to make a new one.

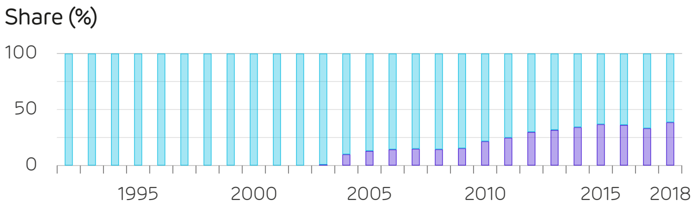
4. The role of onshore and offshore wind

The UK is the world's leader in offshore wind, with more capacity installed than any other country. However, three-fifths of our wind energy still comes from the country's 900+ onshore wind farms.

The Electric Insights website now shows the split between onshore and offshore wind, although the feature is still experimental as the data feed from Elexon (who run the electricity market) is intermittent. This new data shows that even with the world-leading rise of offshore wind farms, the UK's onshore wind farms are still very much pulling their weight. From 2015 until present, onshore wind farms have consistently supplied 55–65% of the country's wind power.

Operating wind capacity



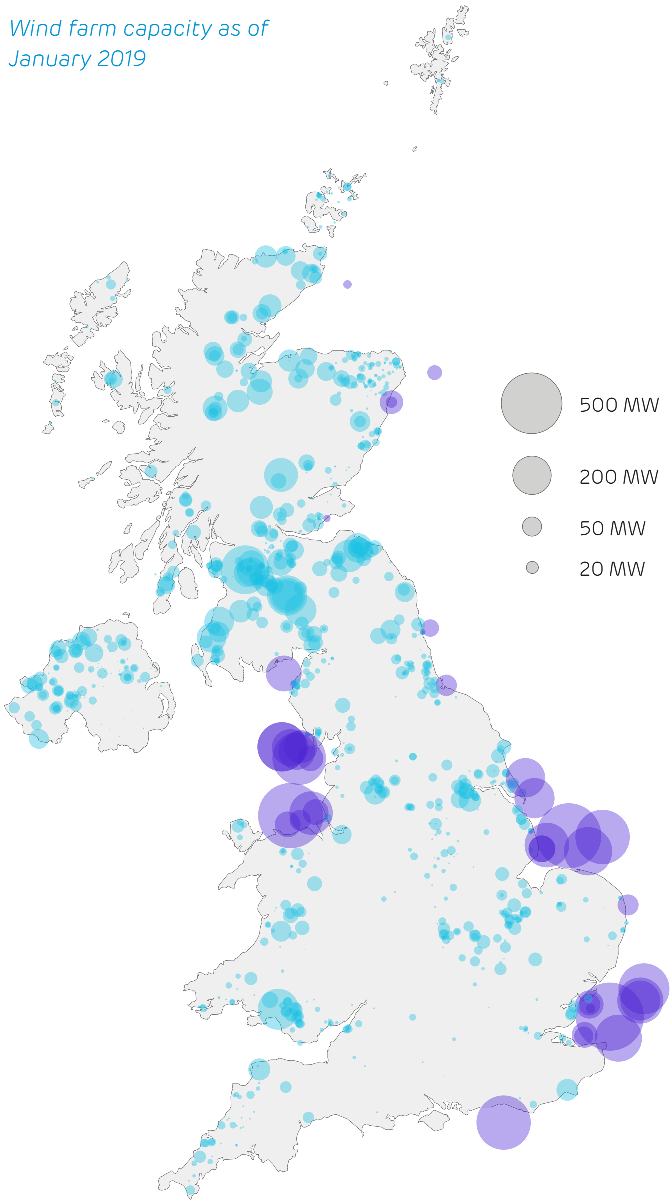


The UK has over 900 onshore wind farms ranging from 1 up to 322 MW in capacity. Together these have nearly 8,000 individual wind turbines and a capacity of almost 13 GW, enough to supply around 10 million homes.

In contrast, there are only 40 offshore wind farms, ranging from a single 7 MW turbine in Fife up to the world's largest – the 659 MW Walney Extension off the coast of Cumbria. Although there are only 2,000 turbines offshore, they are much larger than their onshore neighbours, so the total capacity is 8.5 GW, enough to power 6 million houses. For a sense of scale, Britain's offshore wind capacity overtook the functioning capacity of the country's 15 nuclear reactors earlier this year.[1]

Half of the UK's wind capacity is in England, most of which is offshore. Despite having only 8% of the UK's population Scotland has one-third of its wind capacity. Wales and Northern Ireland have 4% of the population and a sixth of the wind capacity.

Wind farm capacity as of January 2019



> Click to view an animated version

1 Although the nameplate capacity of Britain's nuclear reactors is 9.5 GW, many of the older reactors have been de-rated as they approach the end of their lives. The national fleet has not produced more than 8 GW at any point in the last twelve months.

5. Capacity and production statistics

This quarter saw new lows for both nuclear and coal power plants, and wholesale prices return to 2017 levels.

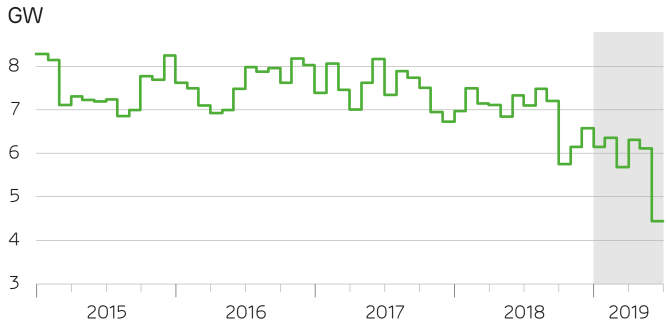
Nuclear power hit its lowest output levels in over a decade, falling by one-fifth on last year to supply just 3.7 GW in mid-June. Several plants were offline for their annual summer maintenance, but Sizewell B suffered an unexpected ammonia leak, and Hunterston B was unable to come back online after further cracks were discovered in its reactor core. A third of the country's nuclear fleet remained offline for the entire three months of Q2.

Coal supplied the smallest share of any generating technology, behind even run-of-river hydro plants, which rarely supply more than one percent of Britain's electricity.[1]

Wind output was one-fifth higher than this quarter last year, boosted by the offshore fleet. Similarly, imports and exports were both up on last year as the new link to Belgium continues to push up import dependency.

Wholesale power prices fell back to below £40/MWh for the first time in two years as gas prices fell by a third. Ofgem reacted by lowering the cap on retail power bills by £75 per year for a typical household.

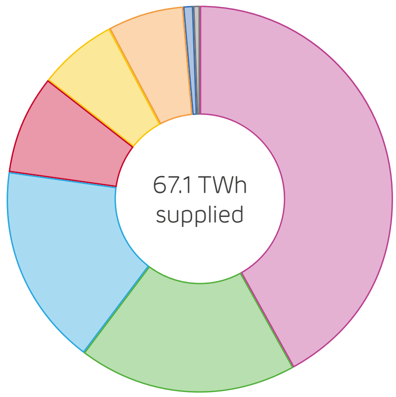
Monthly average nuclear output



Britain's electricity supply mix in the second quarter of 2019

Share of the mix

Gas	42.2%
Nuclear	18.3%
Wind	16.8%
Imports	8.4%
Solar	6.5%
Biomass	6.4%
Hydro	0.8%
Coal	0.5%



Installed capacity and electricity produced by each technology [2] [3]

	Installed Capacity (GW)		Energy Output (TWh)		Utilisation / Capacity Factor	
	2019 Q2	Annual change	2019 Q2	Annual change	Average	Maximum
Nuclear	9.5	~	12.3	–3.2 (–21%)	60%	68%
Biomass	3.2	+0.6 (+24%)	4.3	+0.0 (+1%)	63%	98%
Hydro	1.1	~	0.5	–0.0 (–6%)	22%	90%
Wind	21.2	+1.4 (+7%)	11.3	+1.8 (+19%)	25%	57%
– of which Onshore	12.7	+0.7 (+6%)	6.4	+0.5 (+8%)	24%	62%
– of which Offshore	8.5	+0.7 (+9%)	4.9	+1.3 (+38%)	27%	81%
Solar	13.1	+0.2 (+1%)	4.4	–0.2 (–3%)	15%	73%
Gas	28.1	+0.4 (+1%)	28.3	+0.3 (+1%)	47%	80%
Coal	10.5	~	0.4	–0.6 (–60%)	2%	14%
Imports	5.0	+1.0 (+25%)	6.2	+0.7 (+12%)	57%	97%
Exports			0.5	+0.1 (+21%)	5%	51%
Storage discharge	3.1	~	0.3	–0.3 (–48%)	5%	58%
Storage recharge			0.3	–0.4 (–56%)	5%	52%

1 About 60% of Britain's hydro plants are connected to the national grid and reported on here, another 800 MW is 'embedded' and thus invisible to us.
2 Other sources give different values because of the types of plant they consider. For example, BEIS Energy Trends records an additional 0.7 GW of hydro, 0.6 GW of biomass and 3 GW of waste-to-energy plants. These plants and their output are not visible to the electricity transmission system and so cannot be reported on here.
3 We include an estimate of the installed capacity of smaller storage devices which are not monitored by the electricity market operator. Britain's storage capacity is made up of 2.9 GW of pumped hydro storage, 0.6 GW of lithium-ion batteries, 0.4 GW of flywheels and 0.3 GW of compressed air.

6. Power system records

The last three months have seen another 24 records broken by Britain's power system. We saw the first ever day with a carbon intensity below 100 g/kWh, the share of fossil fuels fell below 10% for the first time ever, and demand for electricity fell to its lowest level in 25 years.

The tables below look over the past decade (2009 to 2019) and report the record output and share of electricity generation, plus sustained averages over a day, a month and a calendar year.[1] Cells highlighted in blue are records that were broken in the second quarter of 2019. Each number links to the date it occurred on the Electric Insights website, allowing these records to be explored visually.

Wind – Maximum	Output (MW)	Share (%)
Instantaneous	15,324	49.7%
Daily average	14,209	41.5%
Month average	8,403	24.0%
Year average	5,901	17.3%

Solar – Maximum	Output (MW)	Share (%)
Instantaneous	9,550	29.4%
Daily average	3,386	12.0%
Month average	2,464	8.1%
Year average	1,319	3.9%

Biomass – Maximum	Output (MW)	Share (%)
Instantaneous	3,171	12.8%
Daily average	3,094	9.7%
Month average	2,361	7.1%
Year average	1,921	5.6%

All Renewables – Maximum	Output (MW)	Share (%)
Instantaneous	22,730	64.8%
Daily average	16,749	55.3%
Month average	12,188	35.0%
Year average	9,507	27.9%

As reported in Article 2, renewables supplied more than half of electricity for a whole day for the first time, providing 55.3% of Britain's electricity on June 30th. This beat the previous record of 49.4% set last autumn. Peak output from renewables also edged up from 22.4 to 22.7 GW, boosted by a new record for solar panel output.

1 The annual records relate to calendar years, so cover the period of 2009 to 2018.

Nuclear – Maximum

	Output (MW)	Share (%)
Instantaneous	9,342	42.8%
Daily average	9,320	32.0%
Month average	8,649	26.5%
Year average	7,604	22.0%

Nuclear – Minimum

	Output (MW)	Share (%)
Instantaneous	3,705	8.7%
Daily average	3,754	10.3%
Month average	4,446	12.9%
Year average	6,679	17.2%

Coal – Maximum

	Output (MW)	Share (%)
Instantaneous	26,044	61.4%
Daily average	24,589	52.0%
Month average	20,746	48.0%
Year average	15,628	42.0%

Coal – Minimum

	Output (MW)	Share (%)
Instantaneous	0	0.0%
Daily average	0	0.0%
Month average	28	0.1%
Year average	1,757	5.1%

Gas – Maximum

	Output (MW)	Share (%)
Instantaneous	27,131	66.3%
Daily average	24,210	59.6%
Month average	20,828	54.8%
Year average	17,930	46.0%

Gas – Minimum

	Output (MW)	Share (%)
Instantaneous	1,556	4.9%
Daily average	3,071	9.5%
Month average	6,775	19.9%
Year average	9,159	24.6%

Nuclear output fell to its lowest levels in a decade. Monthly average output fell to 4.4 GW in June, down from a previous low of 5.2 GW set back in 2014. Both instantaneous and daily-average output fell below 4 GW for the first time since records began.

Coal also had its worst ever month, averaging just 28 MW output in May, from over 10,000 MW installed. This is a fall of three-quarters on the previous lows seen last summer. Coal supplied just 0.1% of Britain's electricity during May.

All low carbon – Maximum	Output (MW)	Share (%)
Instantaneous	30,107	88.0%
Daily average	24,800	78.0%
Month average	19,714	60.7%
Year average	17,902	52.4%

All low carbon – Minimum	Output (MW)	Share (%)
Instantaneous	3,395	8.3%
Daily average	5,007	10.8%
Month average	6,885	16.7%
Year average	8,412	21.6%

All fossil fuels – Maximum	Output (MW)	Share (%)
Instantaneous	49,307	88.0%
Daily average	43,085	86.4%
Month average	36,466	81.2%
Year average	29,709	76.3%

All fossil fuels – Minimum	Output (MW)	Share (%)
Instantaneous	2,421	9.5%
Daily average	4,020	15.4%
Month average	11,102	35.9%
Year average	14,951	43.8%

Fossil fuels supplied less than 10% of Britain's electricity for the first time ever, falling to a 9.5% share in the afternoon of May 26th. The lowest ever one-day average share of fossil fuels also fell by nearly four percentage points to 15.4% on the same day.

	Imports – Maximum	
	Output (MW)	Share (%)
Instantaneous	4,857	18.3%
Daily average	4,323	14.3%
Month average	3,796	10.6%
Year average	2,630	7.5%

	Exports – Maximum	
	Output (MW)	Share (%)
Instantaneous	–3,870	–11.5%
Daily average	–2,748	–6.1%
Month average	–1,690	–3.8%
Year average	–731	–1.9%

	Pumped storage – Maximum[2]	
	Output (MW)	Share (%)
Instantaneous	2,660	6.0%
Daily average	259	0.9%

	Pumped storage – Minimum	
	Output (MW)	Share (%)
Instantaneous	–2,782	–10.8%
Daily average	–622	–1.7%

Imports and exports continued to break previous records after the Nemo link to Belgium opened. Britain got closer to having imported a fifth of its electricity demand overnight on May 18th.

	Gross demand	
	Maximum (MW)	Minimum (MW)
Instantaneous	60,070	18,320
Daily average	49,203	24,704
Month average	45,003	29,402
Year average	37,736	33,525

	Demand (net of wind and solar)	
	Maximum (MW)	Minimum (MW)
Instantaneous	59,563	9,427
Daily average	48,823	13,732
Month average	43,767	22,042
Year average	36,579	26,305

	Day ahead wholesale price	
	Maximum (£/MWh)	Minimum (£/MWh)
Instantaneous	792.21	–45.70
Daily average	197.45	0.00
Month average	63.17	30.83
Year average	56.82	36.91

	Carbon intensity	
	Maximum (g/kWh)	Minimum (g/kWh)
Instantaneous	704	56
Daily average	633	97
Month average	591	180
Year average	508	217

Britain had its first ever day with a carbon intensity below 100 g/kWh. June 30th averaged 97 g/kWh, down from the previous record of 104 g/kWh set last summer. June also saw the lowest monthly demand for 25 years, at 29.4 GW. The lowest value seen in recent times was 29.6 GW back in August 2017.

2 Note that Britain has no inter-seasonal electricity storage, so we only report on half-hourly and daily records. Elexon and National Grid only report the output of large pumped hydro storage plants. The operation of battery, flywheel and other storage sites is not publicly available.

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