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Electric Insights Quarterly

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Headlines

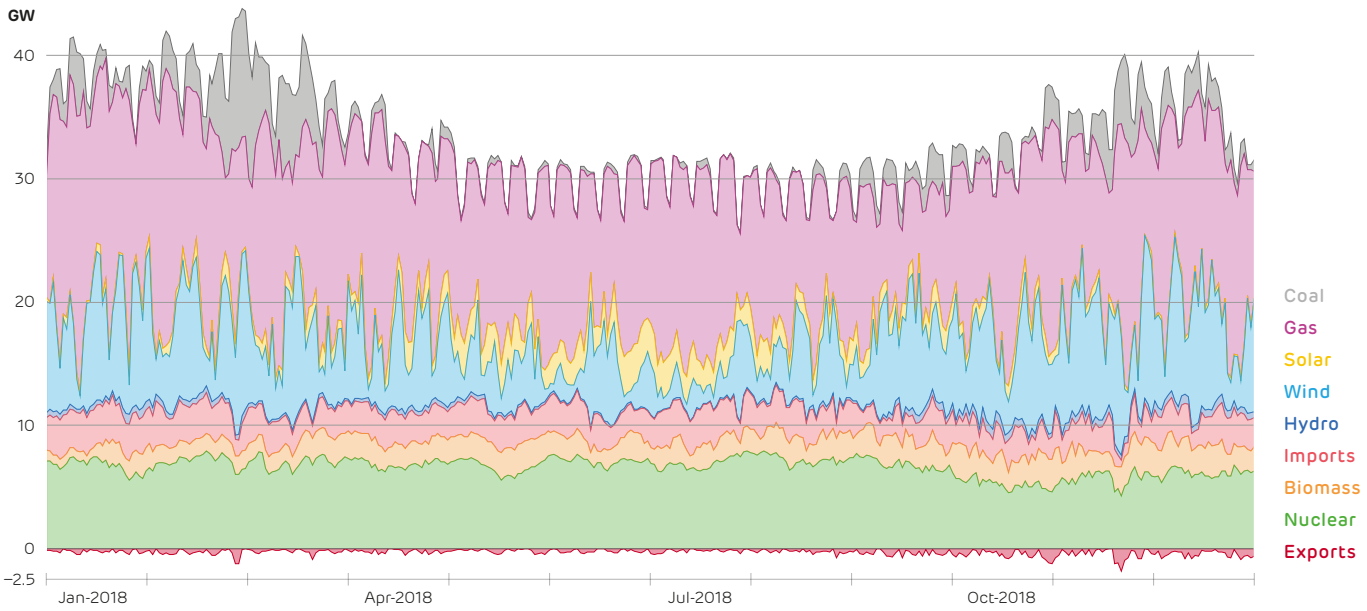
2018 was another strong year for clean power production. 53% of Britain's electricity was produced from low-carbon sources, and fossil fuel generation was down by 7% on the previous year, its 8th consecutive fall.

The carbon intensity of electricity averaged 217 g/kWh over the year, 8% lower than in 2017. This is the slowest rate of decline since 2013, but it still keeps us on track to meet the Committee on Climate Change's target of 100 g/kWh by 2030. Britain's carbon intensity must continue to fall by 6% per year over the coming decade to reach their target, so the current rate of progress must be maintained.

This issue reviews the state of Britain's power system in 2018, looking at how eight key trends have developed over the last decade. The second article looks forwards at what to expect in 2019: the effects of court rulings and corporate pull-outs will start to bite, and many aspects of Brexit may begin to impact on the power sector. 2018 has been a record-breaking year in many ways: wind, solar, biomass and gas generators all hit all-time highs for output. To keep track of all that is going on, we compile all the GB power system records and discuss some of the highlights.

After years of precipitous decline, coal output fell again by a quarter over 2018. Coal has become a cold-weather backup fuel. As shown in the chart below, it was only used in bulk during the Beast from the East in March, and occasional weeks of low wind output during the winter. Between April and August, Britain's 10 GW of coal stations produced an average of just 0.4 GW – running at 4% of peak output. The GB generation mix ranking shows how coal has now slipped two places this year to become the 6th largest source of electricity, behind both imports and biomass. Finally, we report on the capacity and production statistics for the quarter.

The daily average generation mix during 2018

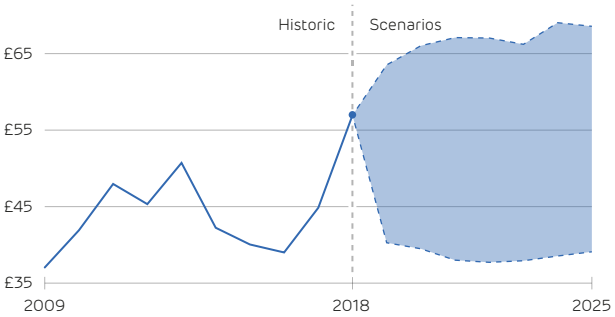


1. The state of Britain's power system in 2018

2018 was another rollercoaster year for Britain's power system. It was tested by the Beast from the East and the hottest summer on record, wind farms and solar panels continued to hit new highs, and the price of fuels and electricity rose sharply over the summer, reversing the fortunes of ailing coal plants.

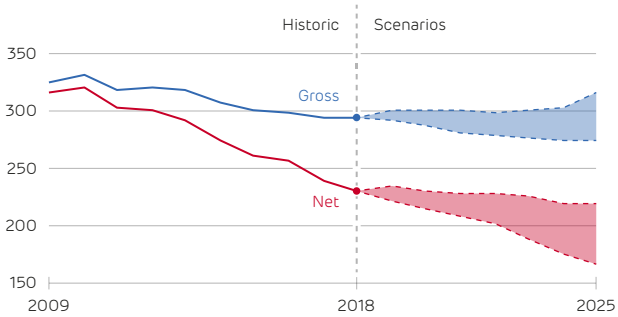
But where do recent events sit in the grand scheme of things? This article looks at the state of Britain's power system, showing what is happening in eight key areas. The following charts show historic data over the last decade, plus projections from National Grid, BEIS and the European Commission[1] for the anticipated direction of travel over the coming years.

Power prices – £56.82 / MWh



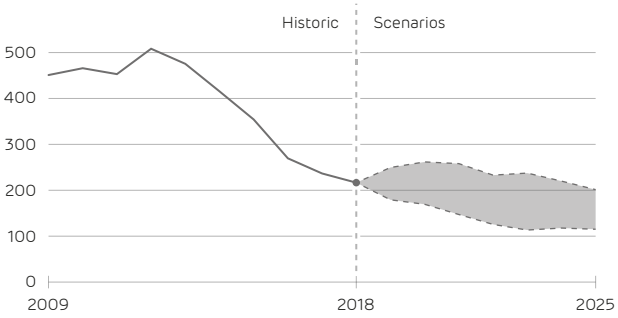
GB day-ahead power prices rose 27% last year to their highest in a decade, adding nearly £10m a day to the nation's electricity generation bill. Fuel and carbon prices rose sharply in 2018, but it is unclear if this will persist so there is wide uncertainty around future power prices.

Net demand – 230 TWh



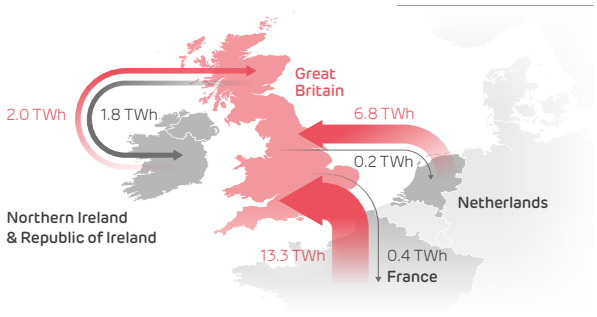
Demand net of wind and solar fell by 4% last year, and is down by over a quarter in the last decade. It is expected to continue falling at a similar pace as more renewables are installed over the coming years. Gross demand was flat at 294 TWh, and is expected to remain so for the near future.

Carbon content – 217 g/kWh



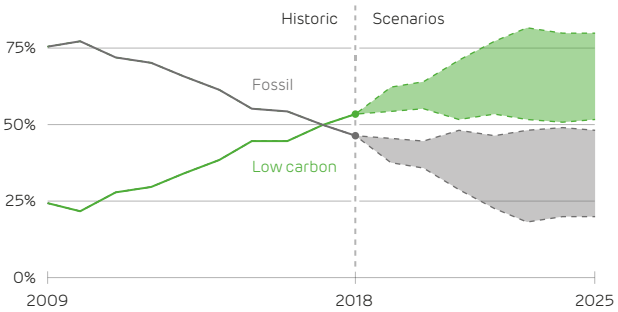
The carbon intensity of electricity fell 8% last year, and now stands well under half the 2012 peak. 66 million tonnes of CO_2 were emitted in 2018. Carbon intensity is expected continue falling 5% per year, reaching 150 g/kWh by 2025. Emissions could increase in the short term though if coal makes a comeback.

Trade balance – 9:1



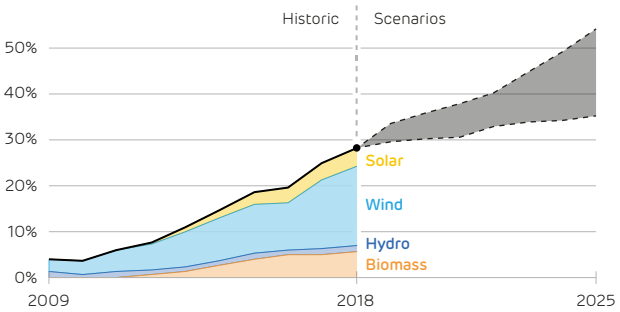
Britain imported 22 TWh of electricity in 2018, nine times more than it exported. France (with its nuclear stations) and The Netherlands (with coal) were the main sources. The amount of electricity generated in Britain fell to its lowest in quarter of a century, as demand is falling and more is imported.

Low carbon share – 53%



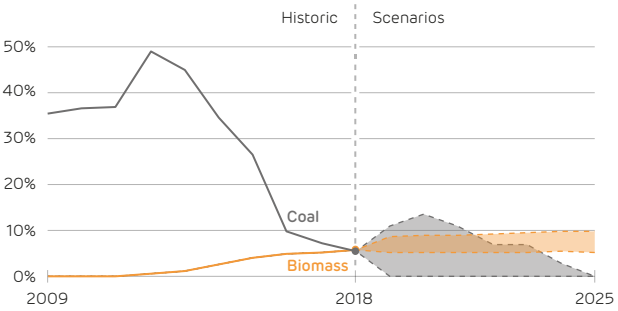
Generation from low-carbon sources grew for the 8th year running. They produced 157 TWh last year, more than from all fossil fuels. It is uncertain whether this share will continue to grow as Toshiba and Hitachi have halted plans to build new nuclear reactors in Britain, and investment in renewables has fallen to its lowest in nearly a decade.

Renewables share – 28%



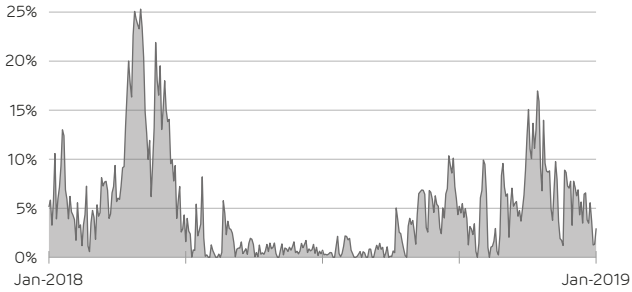
More than a quarter of electricity came from renewables in 2018. Three fifths of this was from wind, one fifth from biomass, and one fifth solar plus hydro power. More ambitious forecasts see this pace continuing, meaning renewables would supply half of Britain's electricity by 2025, and could overtake fossil fuels as early as 2020.

Solid fuels: 17 TWh



Biomass overtook coal as the 5th largest source of electricity in 2018. Biomass output grew by a sixth, while coal fell by a quarter last year. Forecasts see biomass output plateau as no new biomass plants are being planned in the near future, whilst coal will be completely phased out by 2025 at the latest.

Coal: 0–25%



Coal provided less than 1% of Britain's electricity during 100 days of 2018. In total, there were 1,900 hours with zero coal output, triple the number seen in 2017. However, coal provided much-needed flexible capacity during the cold weather in March when gas prices spiked, supplying more than a quarter of the country's electricity.

1 Forecasts for supply, demand and emissions show the upper and lower range across all trajectories in the 2017 and 2018 Future Energy Scenarios and Energy and Emissions Projections, and the 2016 EU Reference Scenario.

2. What to expect in 2019

The New Year brings new challenges to Britain's power system. The capacity market was unexpectedly suspended, new low-carbon capacity has stalled and no-deal Brexit may disrupt carbon prices and the operation of interconnectors.

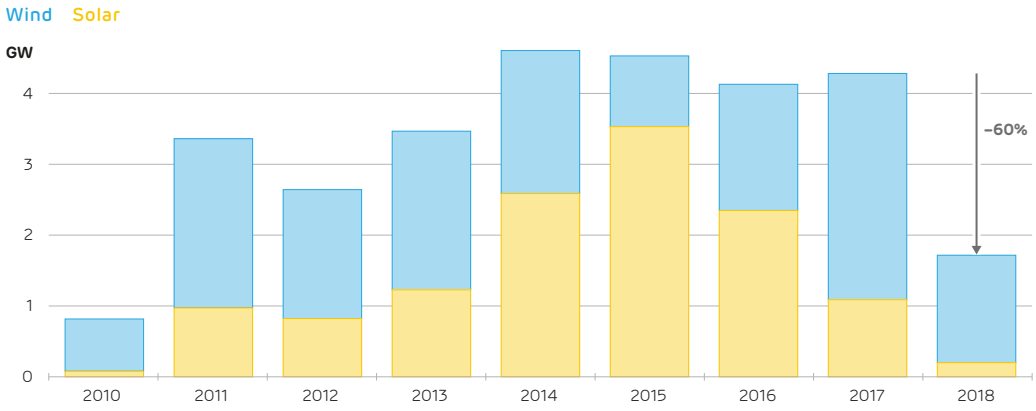
After a legal challenge by Tempus Energy (a smart grid start-up),[1] the European Court of Justice brought the UK's capacity market to a standstill in November,[2] suspending £1 billion per year worth of capacity payments. These were supposed to go to generators and flexible consumers for ensuring availability at times of peak demand, leaving many firms in the electricity market with a hole in their finances. The UK Government believes this will not impact security of supply this winter,[3] and analysts agree that the effects won't be felt until later this year. Some older power stations may resort to closing early on financial grounds.[4] This would lead to tighter supply margins, giving higher and more volatile prices next winter, possibly offsetting any reduction in consumer bills that would come from halting the capacity payments.

In the space of three months, Toshiba and Hitachi have shelved plans to build 9 GW of new nuclear reactors. Their combined capacity would have been sufficient to replace Britain's entire fleet of aging nuclear reactors. Toshiba is closing its UK nuclear business after it failed to find a buyer for NuGen, and so "the economically rational decision is to withdraw from the UK nuclear power plant construction project".[5] Hitachi have formally suspended investment into nuclear stations at Wylfa Newydd in Anglesey and Oldbury in Gloucestershire, describing them as "incompatible with the company's economic rationality".[6]

Unless new partners or financing deals can be found, these announcements place a 9 GW hole in the amount of low-carbon capacity that will be available in the coming decade. One view is that this collapse "should be seen as an opportunity rather than a risk, for the UK to prioritise renewables instead".[7] However, the growth in wind and solar capacity has slowed down dramatically. In the last twelve months, fewer wind and solar projects were built than at any time since 2010 (see chart overleaf). The government believes this slump will continue into the next decade.[8]

1 http://www.nortonrosefulbright.com/knowledge/publications/171502/tempus-energy-and-the-capacity-market-in-the-uk
2 Tempus argued that the scheme privileges generation over demand side response (DSR) due to the duration of contracts offered (up to 15 years, versus 1 year) and the means of cost recovery for DSR (all weekday winter evenings, rather than the specific periods of highest demand).
3 https://www.gov.uk/government/collections/electricity-market-reform-capacity-market
4 https://theenergyst.com/the-money-and-the-power-what-next-for-capacity-market/
5 https://www.bbc.co.uk/news/business-46122255
6 https://www.economist.com/britain/2019/01/26/hitachis-exit-puts-britains-nuclear-policy-in-meltdown
7 https://www.theguardian.com/environment/2018/nov/08/toshiba-uk-nuclear-power-plant-project-nu-gen-cumbria
8 https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2017

New solar PV and wind capacity installed in each calendar year



Finally, Brexit is just weeks away and will potentially have the biggest impact on Britain's power system. If the UK leaves with no deal it will leave the Emissions Trading Scheme, the EU-wide market which puts a price on carbon. Government plans to replace this with a carbon tax of £16 per tonne, which would start in April 2019.[9] However, the European Commission has already suspended Britain's access to ETS carbon permits in an effort to limit disruption to the scheme.[10] This leaves a potential gap from January through to March 2019, where Britain has no underlying carbon price, and so power stations are only subject to the Carbon Price Support.[11]

Until Britain's relationship with the European Union is known, it is unclear what price fossil-fuelled power stations should be paying for carbon emissions during Quarter 1: around £40 if there is a deal (ETS plus CPS) or £18 if there is no deal (CPS only). Based on emissions during Q1 of 2018, this difference could amount to £450 million for Britain's coal and gas power stations.[12] If generators anticipate lower carbon prices, coal could make a comeback at the start of the year. Britain may also become a net exporter of electricity, including over the new interconnector to Belgium, as British generators will face lower carbon prices than those on the continent for the first time in five years.

However, those interconnectors may not be used as efficiently as they are today. Power flows over Britain's interconnectors would go from being automatic to being decided by traders.[13] At present, power implicitly flows from low- to high-priced countries: "buy cheap, sell dear". While this would be the aim of traders, they are not perfect, and the loss of efficiency is expected to add "a couple of percent" onto the cost of generation.[14] This may, of course, be lost in the noise of currency fluctuations, which affect the cost of imported coal, gas and electricity. Sterling is widely forecast to move by 10% either way against the euro and dollar, depending on how smooth the transition is.[15]

All in all, don't expect 2019 to be a quiet year for Britain's power system.

9 https://www.gov.uk/government/publications/carbon-emmisions-tax/carbon-emmisions-tax
10 https://uk.reuters.com/article/uk-eu-britain-carbon/britain-says-it-will-not-auction-eu-carbon-permits-in-first-quarter-2019-idUKKBN1OI1LT
11 The Carbon Price Support of £18 per tonne of CO2 is levied on British power stations on top of the ETS (or carbon tax).
12 If Britain's coal and gas stations emitted 20.5 million tonnes of CO2 (as they did in Q1 2018), they could expect to pay £370m for the Carbon Price Support (under no-deal), or £820 million if we stay in the ETS based on permit prices of £22 per tonne (the average during January 2019).
13 https://www.gov.uk/government/publications/trading-electricity-if-theres-no-brexit-deal/trading-electricity-if-theres-no-brexit-deal
14 http://www.ukerc.ac.uk/news/elecxit-could-cost-270-million-a-year.html, Chatham House: Brexit – Deal or No Deal (25th January 2019)
15 https://www.telegraph.co.uk/financial-services/currency-exchange/international-money-transfers/pound-forecast-post-brexit/, https://www.theweek.co.uk/98984/what-the-brexit-vote-could-mean-for-sterling

3. GB power system records

2018 was a record-breaking year for Britain's power system. A common theme in recent years has been demand falling to new lows and renewables reaching their highest ever levels. If the power system continues to be transformed, such milestones will keep on being surpassed.

This quarter, Britain's wind farms broke through the 15 GW barrier and biomass plants produced more than 5 TWh for the first time. 2018 as a whole has seen the highest ever output from wind, biomass, solar and gas power stations, and the lowest coal output and carbon intensity for decades. All in all, 62 new records were set this year, showing just how far into new territory Britain's power system is moving.

To help keep track of all these records, they are collated in the tables below. For each technology and metric, the tables below look over the past decade (2009 to 2018) and report the highest and/or lowest instantaneous value, and sustained averages over a day, a month and a year. Cells highlighted in blue are records that were broken in 2018.

Renewables:

Wind – Maximum	Output (MW)	Share (%)
Instantaneous	15,085	48%
Daily average	13,265	39%
Month average	8,403	24%
Year average	5,901	18%

Solar – Maximum	Output (MW)	Share (%)
Instantaneous	9,390	29%
Daily average	3,386	12%
Month average	2,464	8%
Year average	1,319	4%

Biomass – Maximum	Output (MW)	Share (%)
Instantaneous	3,171	13%
Daily average	3,094	9%
Month average	2,361	7%
Year average	1,921	6%

Hydro – Maximum	Output (MW)	Share (%)
Instantaneous	1,403	4%
Daily average	1,127	3%
Month average	842	2%
Year average	468	1%

All renewables – Maximum	Output (MW)	Share (%)
Instantaneous	21,343	58%
Daily average	16,558	49%
Month average	11,653	34%
Year average	9,507	28%

With the exception of hydro power, every conceivable record for renewable energy generation was broken in 2018. Britain operated with over 50% renewables for nearly 200 hours in 2018.

Low carbon:

Nuclear – Maximum	Output (MW)	Share (%)
Instantaneous	9,342	43%
Daily average	9,320	32%
Month average	8,649	27%
Year average	7,604	22%

All low carbon – Maximum	Output (MW)	Share (%)
Instantaneous	30,107	88%
Daily average	24,800	76%
Month average	19,038	62%
Year average	17,902	53%

Low-carbon sources of electricity (which we define as renewables and nuclear, both from Britain and imported from France) supplied nearly 18 GW of electricity averaged over last year. They have supplied over three-quarters of electricity for a day, and hit a peak of almost 90% during the night of August 24th last year.

Fossil:

Coal – Maximum	Output (MW)	Share (%)
Instantaneous	26,044	61%
Daily average	24,589	52%
Month average	20,746	48%
Year average	15,628	42%

Coal – Minimum	Output (MW)	Share (%)
Instantaneous	0	0%
Daily average	0	0%
Month average	193	1%
Year average	1,757	5%

Gas – Maximum	Output (MW)	Share (%)
Instantaneous	27,001	66%
Daily average	22,817	60%
Month average	20,828	55%
Year average	17,930	46%

Gas – Minimum	Output (MW)	Share (%)
Instantaneous	1,556	5%
Daily average	3,071	9%
Month average	6,775	20%
Year average	9,159	25%

All fossil fuels – Maximum	Output (MW)	Share (%)
Instantaneous	49,307	88%
Daily average	43,085	86%
Month average	36,466	81%
Year average	29,709	76%

All fossil fuels – Minimum	Output (MW)	Share (%)
Instantaneous	2,421	10%
Daily average	5,079	19%
Month average	11,102	36%
Year average	14,951	44%

Coal output first fell to zero for four hours in May 2016, and the first day with zero coal was in April 2017. Last year, coal fell to its lowest monthly and annual average. Gas power stations on the other hand reached a new record high, producing over 27 GW during the evening peak on the 26th of January. That was a cold day with low wind and much of the nuclear fleet out of action, showing the increasing need for flexible capacity. At the other extreme, the combined output of fossil-fuelled generators fell to a minimum of just 2.4 GW this year, on a windy Sunday night in August.

Imports and storage:

Imports – Maximum	Output (MW)	Share (%)
Instantaneous	5,412	18%
Daily average	3,490	12%
Month average	2,824	9%
Year average	2,235	7%

Exports – Maximum	Output (MW)	Share (%)
Instantaneous	-5,305	-14%
Daily average	-2,721	-6%
Month average	-1,361	-3%
Year average	-54	0%

Pumped storage – Maximum[1,2]	Output (MW)	Share (%)
Instantaneous	2,660	6%
Daily average	259	1%

Pumped storage – Minimum[1,2]	Output (MW)	Share (%)
Instantaneous	-2,782	-11%
Daily average	-622	-2%

At its peak, Britain has imported nearly one fifth of its electricity. Import and export records are likely to be broken in the coming year as the 1 GW Nemo Link to Belgium is due to open.

1 Note that Britain has no inter-seasonal electricity storage, so we only report on half-hourly and daily records.
2 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.

Demand:

	Gross demand	
	Maximum (MW)	Minimum (MW)
Instantaneous	60,070	18,320
Daily average	49,203	24,704
Month average	45,003	29,598
Year average	37,736	33,525

	Demand (net of wind and solar)	
	Maximum (MW)	Minimum (MW)
Instantaneous	59,563	9,852
Daily average	48,823	16,341
Month average	43,767	22,477
Year average	36,579	26,305

Gross demand for electricity includes all generation, except for small thermal generators which are embedded in customer premises and so are invisible to the power system. Net demand for electricity excludes wind and solar generation (which are weather dependent), and is what must be met by large thermal power stations (nuclear, biomass and fossil), imported from abroad or released from storage devices. Every statistic for net demand reached its lowest level in the past decade during 2018.

Price and Emissions:

	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	104
Month average	591	183
Year average	508	217

Power prices have risen by a quarter in the last year, and so the most expensive day, month and year of the past decade were all experienced in 2018. Conversely, the carbon content of electricity was down 7% on last year, so the lowest-carbon day, month and year were also all in 2018. The highest price and lowest carbon for a single half-hour in 2018 were £320/MWh and 61 g/kWh.

4. The GB generation mix ranking

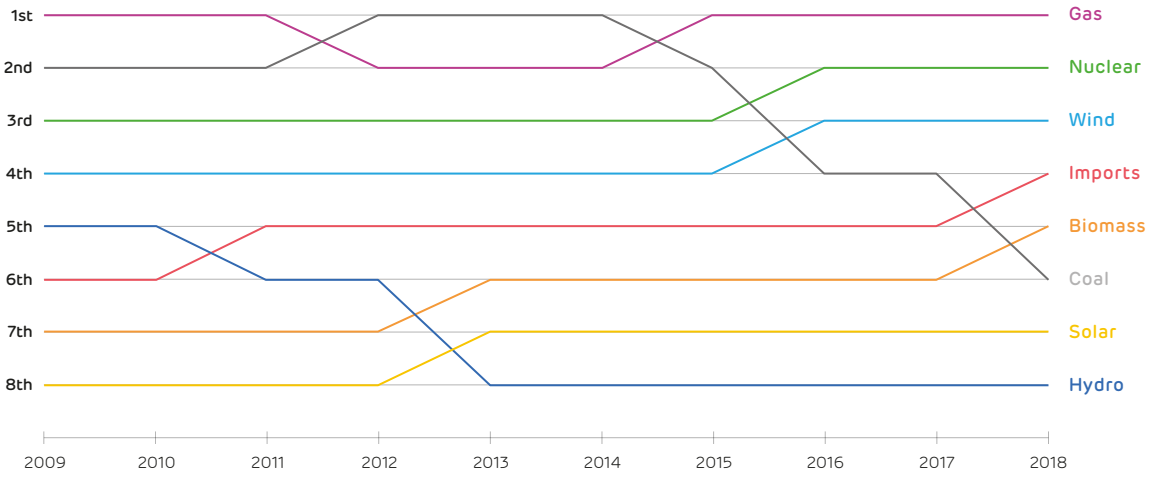
It's all change in the ranking of Britain's electricity mix. Last year, coal fell from 4th to being the 6th largest source of power, overtaken by both imports and biomass. Until 2015, Britain's electricity generation was dominated by fossil fuels, with coal and gas as the two largest sources. They traded places depending on relative fuel prices, but then in 2016 nuclear overtook coal to become the second largest source of electricity, with wind farms taking 3rd place.

For the first time since the industrial revolution, biomass is the predominant solid fuel used in Britain, as several power stations have converted from burning coal to wood pellets. This part of the ranking is very close, as Britain imported 19 TWh of electricity, generated 17 TWh from biomass and 15 TWh from coal.

Wind has been the largest source of renewable energy for the last decade, and the third largest source of electricity since 2016. In contrast, despite having 13 GW of solar installed (more than nuclear), it is only the 7th largest source of generation. The British weather means solar panels only generate for the equivalent of 2.5 hours at full output per day.[1]

Looking forwards, we could expect more changes in the coming years, as we eventually need cleaner sources to overtake all fossil fuels. If current trends continue, we expect solar to overtake coal in 2019, meaning it would have fallen from 1st to 7th in just five years. Overtaking gas will take much longer. It generated 115 TWh in 2018, more than both nuclear and wind combined.

The sources of electricity generation in Britain, ranked from largest to smallest annual output



1 This average over the summer months (Q2 and Q3) is 3.6 hours of full output per day, and over the winter months (Q1 and Q4) is 1.3 hours per day.

5. Capacity and production statistics

This quarter, four-fifths of Britain's electricity came from gas, wind and nuclear power plants. Low-carbon generation supplied 53% of Britain's electricity (50% from British, and 3% from French plants).

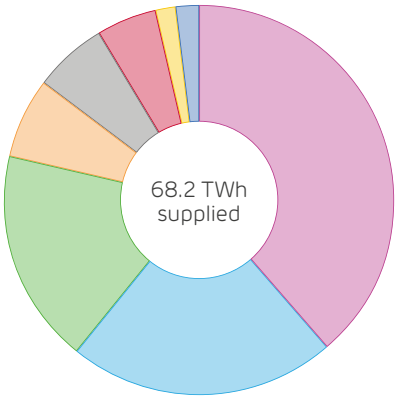
Generation from fossil fuels in the fourth quarter was down 15% year-on-year, pushed out by lower demand, more imports, and increased generation from biomass and wind farms. Coal and gas power stations each produced 3 TWh less over the quarter than they did in Q4 2017 – an average reduction of 1.4 GW each. For coal, this represents a 40% decline on this time last year.

2018 smashed the record for the number of zero-coal hours on the system. No coal generation was used for 1,900 hours during the year (equivalent to 79 days), versus just 600 hours in 2017.

However, less than 0.2 GW of solar panels were installed in 2018, meaning the annual growth has flatlined at just 1%. Earlier this year we asked whether Britain's power sector decarbonisation has stalled, and this is another signal of the slowdown.

Wholesale electricity prices edged up by £2 from last quarter to again hit a 10-year high of £61.45/MWh averaged over the quarter. This price is 25% higher than one year ago, and 66% higher than in Q4 2015.

Britain's electricity supply mix in the fourth quarter of 2018



	% of mix
Gas	38.9%
Wind	22.1%
Nuclear	17.8%
Biomass	6.7%
Coal	6.1%
Imports	5.1%
Solar	1.7%
Hydro	1.7%

Installed capacity and electricity produced by each technology[1]

	Installed Capacity (GW) 2018 Q4	Annual change	Energy Output (TWh) 2018 Q4	Annual change	Utilisation / Capacity Factor	
					Average	Maximum
Nuclear	9.5	+0.2 (+2%)	13.6	–2.0 (–13%)	65%	73%
Biomass	3.2	+1.0 (+46%)	5.1	+2.0 (+65%)	73%	100%
Hydro	1.1	~	1.3	+0.1 (+6%)	52%	95%
Wind	20.3	+1.3 (+7%)	16.8	+1.7 (+11%)	38%	74%
Solar	12.9	+0.2 (+1%)	1.3	+0.0 (+1%)	5%	52%
Gas	27.8	+0.1 (+0%)	29.6	–3.0 (–9%)	49%	91%
Coal	10.5	–3.0 (–22%)	4.6	–3.1 (–40%)	20%	85%
Imports	4.0	~	5.0	+1.2 (+33%)	57%	94%
Exports			1.0	–1.2 (–54%)	12%	84%
Storage[2]	4.2	+0.9 (+29%)	0.5	–0.2 (–28%)	8%	67%

1 Other statistical 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 small waste-to-energy plants. These plants and their output are not visible to the electricity transmission system and so cannot be reported on here.
2 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.

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