drax

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Electric Insights Quarterly

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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

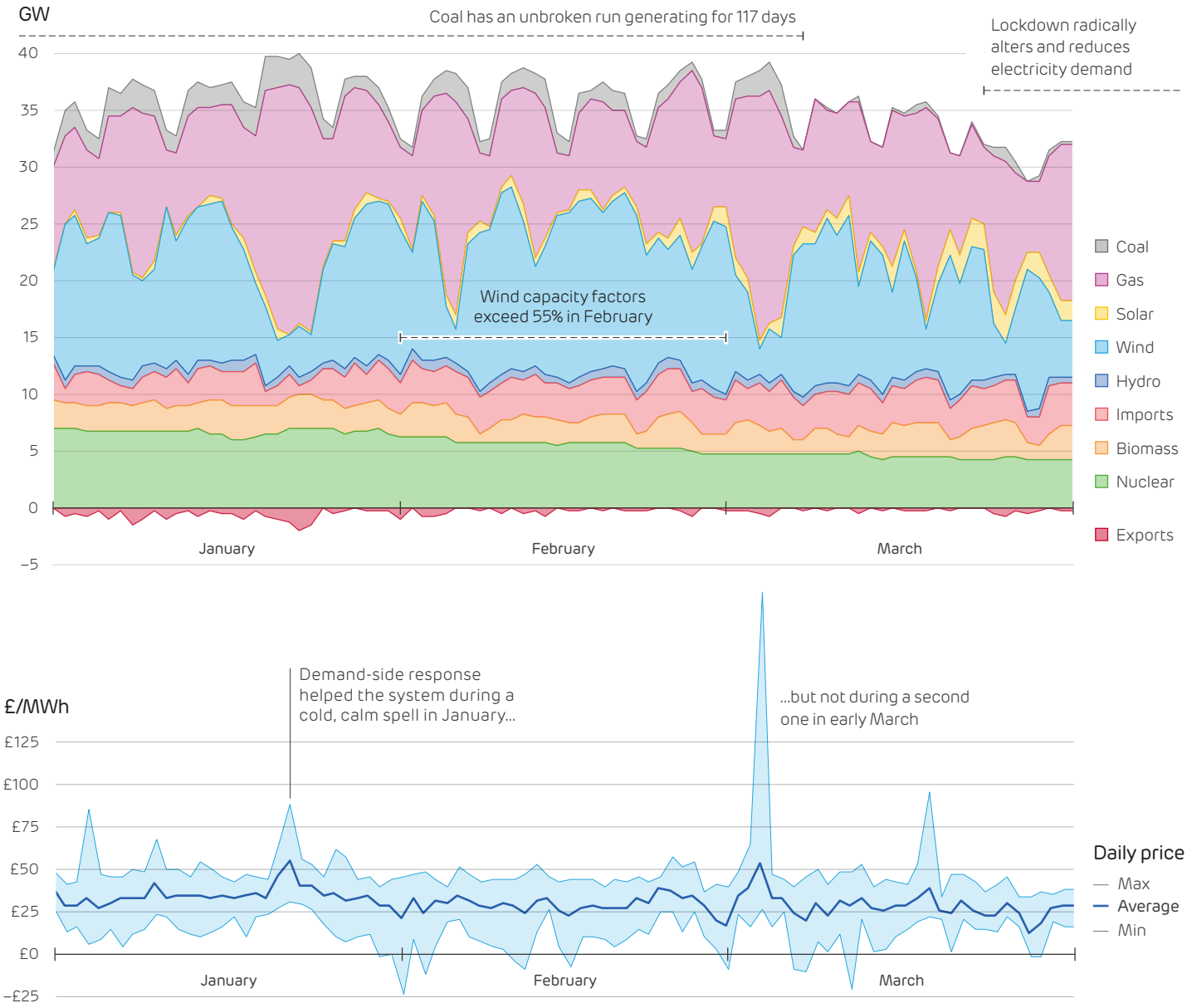
2020 has got off to a pretty poor start. Britain was battered by storms throughout January and February. Unprecedented rainfall flooded thousands of homes, but the accompanying gales sent wind power to new records.

Then in March, the coronavirus pandemic took hold in the UK. Social distancing was followed by a full lockdown. Businesses closed and people stayed home, sending electricity demand down to levels not seen since the 1980s, and power prices to a 12-year low. Day-ahead prices averaged just £28/MWh during March, a fall of one-third over the last year.

Britain moved ever closer to a complete phase-out of coal power. Two coal plants retired at the end of the quarter as they were no longer profitable. Before shutting, they burnt through their remaining stockpiles of fuel, running continuously for 117 days over winter. National output from coal over the quarter was up for the first time in eight years.

With record wind output and depressed demand, electricity generation from fossil fuels was down 25% on this quarter last year, the largest fall on record. This also gave one of the lowest quarterly carbon intensities on record. With an average of 173 g/kWh, emissions were down 20% on this time last year.

The daily average electricity generation mix (top) and day-ahead power price (bottom), illustrating the major events over the last quarter



2. Under lockdown, every day is a Sunday

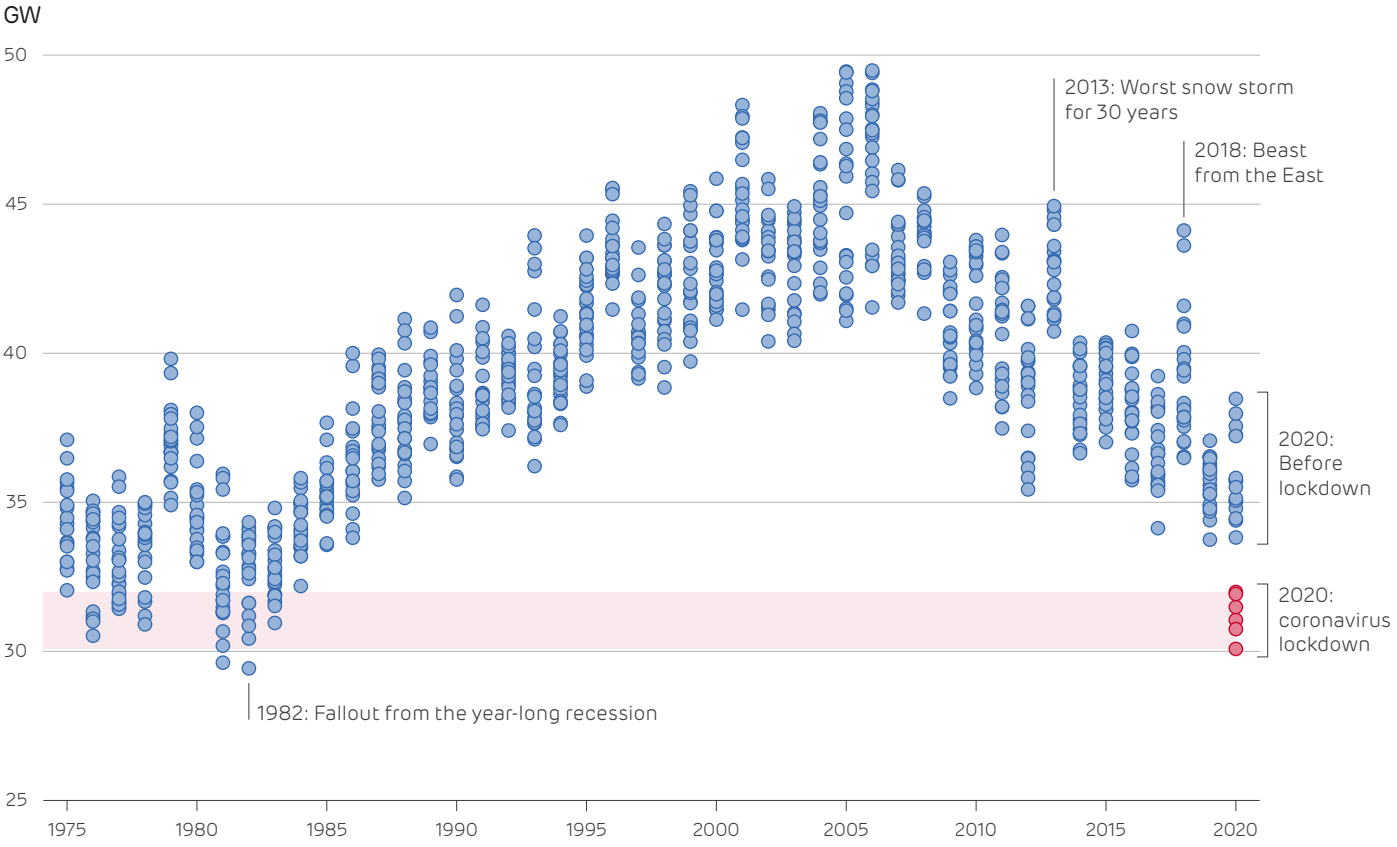
On March 23rd the UK took an unprecedented move to tackle the coronavirus. Most business that had not already closed moved online, with millions of people now working from home. This had a huge impact on electricity demand: consumption on weekdays fell by 13% to its lowest levels since 1982 – a time when there were 10 million fewer people in the country, and GDP was a third lower than today.

Other regions have seen a similar collapse in electricity demand. Spain, Italy and France have all seen electricity demand fall by 10–15% according to analysis by Ember. Across the Atlantic, New York City has seen similar reductions.

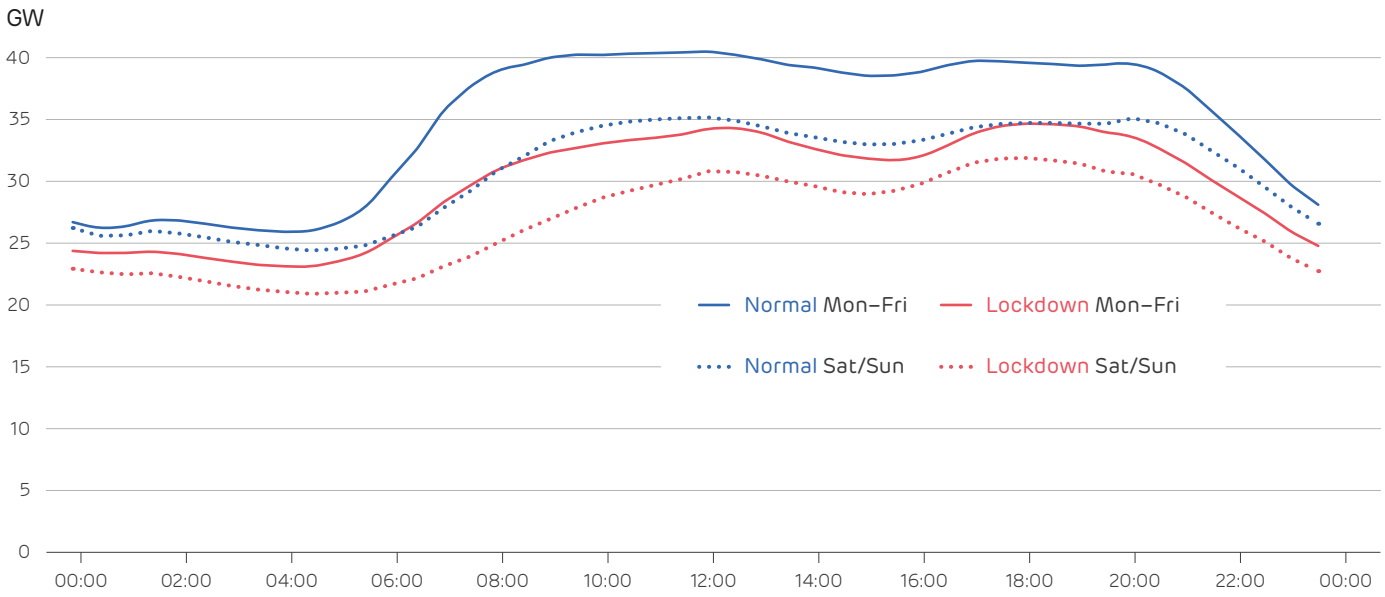
Demand has fallen for a simple reason: with schools and workplaces now closed or running with a greatly reduced staff – machinery, computers, lights and heaters are not drawing power. Electric rail, tram and tube systems are also running a reduced service. On the contrary, with more people at home, household electricity consumption has increased. Octopus Energy estimate that during social distancing (before the stricter lockdown came into effect) homes were consuming up to a third more electricity, adding £20 per month to the typical bill.

The impact of lockdown on Britain's electricity demand is much like living through a month of Sundays. The average profile for a March weekend day in previous years looks very similar to the daily profile for weekdays since lockdown begun – both in the amount of electricity consumed and the structure. Post-lockdown weekends have even lower demand, tracking 11% below weekday demand.

Daily average electricity demand in Britain across all working days in March



Average daily electricity demand profiles during March and April, comparing normal years (2015–19) with the current lockdown



People no longer have to get up at the crack of dawn for work. On a typical weekday morning, demand would rise by 10 GW over two hours from 5:30 to 7:30 AM. Now it takes more than twice as long – until midday – for this rise to occur. At the other end of the day, there would normally be a small peak in demand around 8 PM from people gathering in pubs and restaurants up and down the country. Both on weekdays and weekends, demand begins falling earlier in the evening as the sofa has become the only available social venue.

With lower demand comes lower power prices. Wholesale electricity prices are typically 7% lower on Sundays than on weekdays for this reason. March saw the lowest monthly-average power price in 12 years, down one-third on this month last year. Prices were already heading downwards because of the falling price of gas, but the lockdown has amplified this, and negative prices have become commonplace during the middle of the day. There was not a visible impact on carbon emissions during the first quarter of the year, as only the last week of March was affected.

However, as lockdown continued into April and May, emissions from power production in Britain have fallen by 35% on the same period last year. The effect is slightly stronger across Europe, with carbon emissions falling almost 40% as dirtier coal and lignite power stations are being turned down.

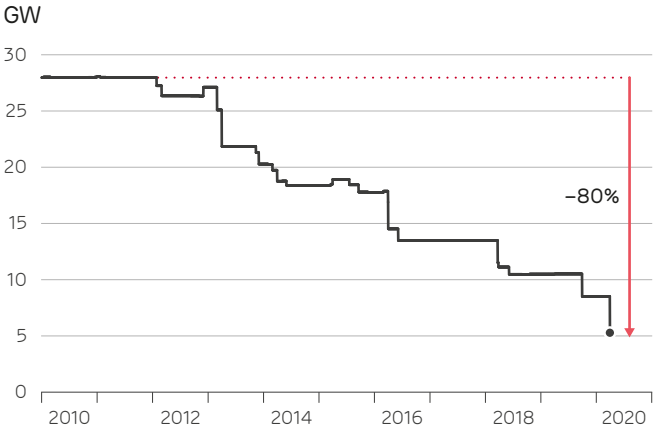
Will some of these effects persist after lockdown restrictions are eased? It is too early to tell, as it depends on what long-lasting economic and behavioural changes occur. Electricity demand is linked with the country's GDP, which is set to face the largest downturn in three centuries. Whether the economy bounces back, or is afflicted with a lasting depression will be key to future electricity demand. It will also depend on behavioural shifts. People are of course craving their lost freedoms, but many may appreciate not going back to a lengthy daily commute – and the rise of video conferencing and collaboration apps has shown that remote working may finally have come of age. With even a small share of the population continuing to work from home on some days, there could be a lasting impact on electricity demand for years to come.

3. A final fling with coal power

Two of Britain's oldest coal power stations closed on March 31st, leaving just three left on the mainland. But before shutting down they burnt through their remaining stockpiles of fuel, pushing up Britain's coal consumption for the first time since 2012.

Coal phase-out took another huge step this quarter. 3.5 GW of capacity was retired, leaving just over 5 GW – a far cry from the 28 GW that were operating just 10 years ago. 80% of the coal power stations once operating in Britain have now fallen silent, with capacity halving over the last twelve months.

Installed coal power station capacity over the last decade



Fiddler's Ferry in Cheshire and Aberthaw B in south Wales were built in the late 1960s and early 1970s, and had operated for nearly 50 years. Both closures were announced last summer on financial grounds, as the UK's strong carbon price[1] meant they could no longer compete with the lower cost of gas and renewables.

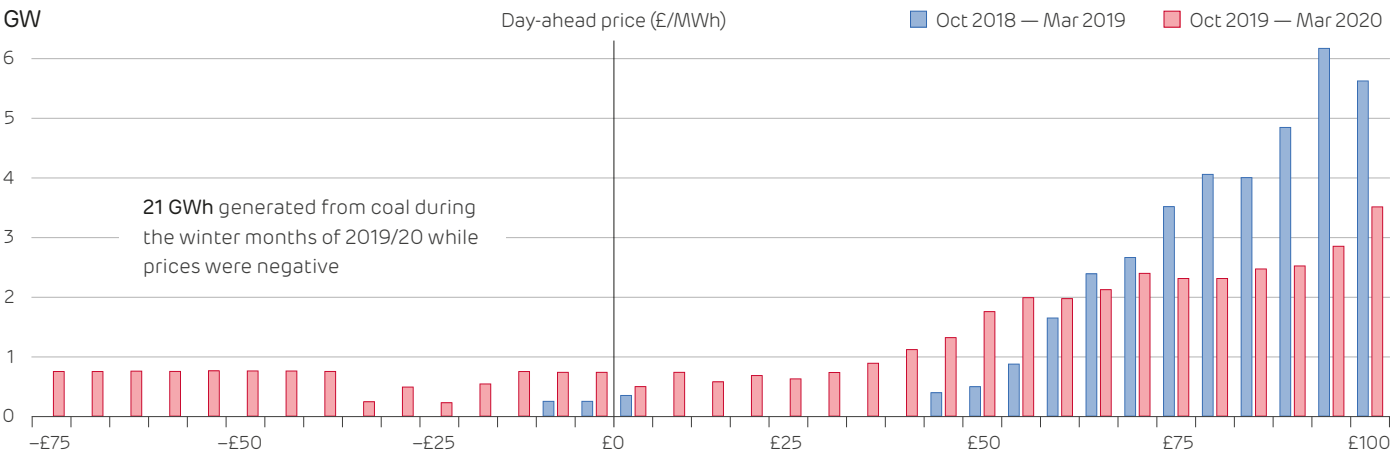
Rather than go out with a whimper, these stations increased their output over winter. Coal power generation was up 3% on the same quarter last year. While absolute output was small (4% of electricity consumed over the quarter), this was the first year-on-year rise in eight years. For the first time since 2017, there was not a single hour with zero coal generation over the majority of winter. Coal continued generating without pause for 117 days straight, from November 12th through to March 8th. The previous winter saw almost 400 coal-free hours during the same period.

It appears these plants ran consistently whether or not they could make a profit from selling power. During the winter (October 2019 to March 2020), coal plants continued producing 750 MW all the way down to prices of –£75/MWh. The winter before that, coal plants almost never ran when power prices fell below £45/MWh.

Why might they have been willing to pay handsomely to dispose of their electricity? Coal stockpiles must be actively managed to prevent uncontrolled fires. Coal power stations can sit on several months' worth of fuel, and there are relatively few buyers of coal left in the country. Generating power (even at times of low or negative power prices) may have proven less costly than safe disposal of fuel after the plants had shut.

Going forwards, coal generation is likely to be lower than ever. With reduced demand and growing renewable output, Britain had already gone 35 days without any coal generation at the time of going to press. Of the three remaining coal stations, Drax's coal units will cease operating in March 2021. The other stations may well retire before the government's 2025 deadline; marking the end of an era.

Average coal generation over winter months at times of different power prices



1 The carbon price paid by British power stations averaged £37.60 per tonne of CO_2, averaged over the quarter.

4. Wind power surges to new records

Britain's wind farms had a bumper quarter, with output up 40% on this time last year. A succession of severe winter storms battered the country, giving the wettest and windiest February since records began. This helped make February the first month on record when more electricity was produced by wind farms than gas-fired power stations across the country.

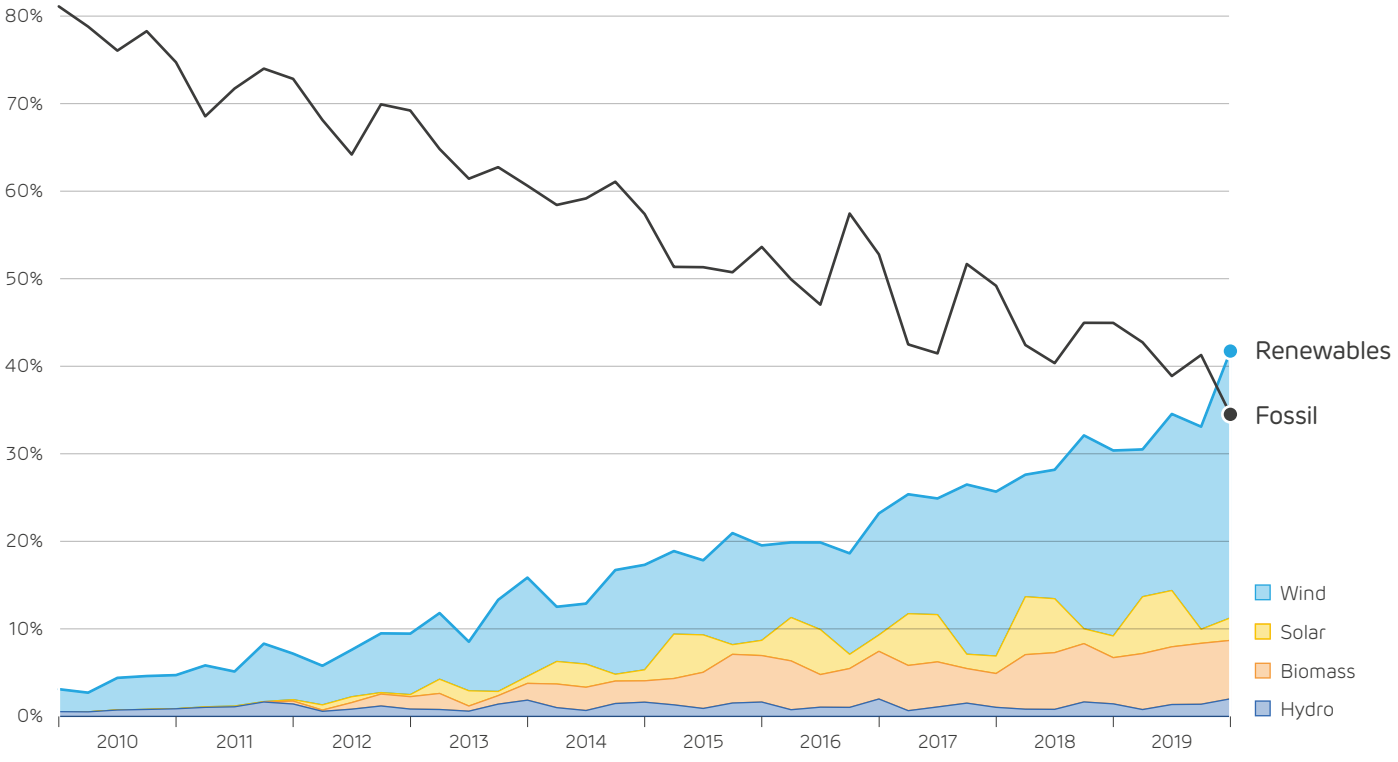
The two were neck and neck over the whole quarter: wind supplied 30.5% of Britain's electricity, versus 30.6% from gas. This pushed the supply from all renewables to over 40% of electricity consumed, overtaking output from fossil fuels for the first time. The exceptional output was driven for a large part by extreme weather. Storm Ciara hit in early February, and was followed just days after by Storm Dennis, one of the most intense ever recorded in the UK. Together these killed eight people, left half a million without power and brought devastating flooding across Wales, the Midlands, Cumbria and Yorkshire.

The contribution of wind would have been even higher if the Western Link (which connects Scotland, Wales and England) had been functioning normally. The £1.3bn subsea cable went fully operational in December, but suffered an unplanned outage between 10th January and 8th February which impacted around 2.2 GW of wind farms, or 10% the UK's wind capacity. Ofgem is currently investigating the performance of the cable, which should help to alleviate constraints that force Scottish wind farms to turn off when their output cannot be transported down to the rest of the country.

Britain's wind farms ran at all-time high capacity factors, in February averaging 50% for onshore and 60% for offshore wind farms. This was significantly higher than fossil-fuelled power stations (34% for gas and just 17% for coal), and higher even than the country's nuclear reactor fleet (59%).

Looking ahead, wind generation records will continue being broken as two major offshore wind farms are due to come online later this year. Hornsea One (1,218 MW) and East Anglia One (714 MW) will both dwarf the world's largest operating wind farm (Walney Extension, also in the UK). Together they will power over 1.5 million homes, and bring the UK's total offshore wind capacity to over 10 GW – the largest fleet in the world.

The share of electricity supplied by renewables and fossil fuels each quarter over the past decade



5. Demand-side response to the rescue

Two cold, calm spells punctuated the record wind output last quarter. Demand-side response operated full force to help during the first event in January. It was much less prominent during the second event in March, giving very different consequences for the power system.

The first spell happened in mid-January. Wind output fell to a low of 2.6 GW across Wednesday 22nd. One week either side of this it was five times higher at over 14 GW. Gas and coal output increased to fill the void, but also the evening peak in demand disappeared.

At that time of year, demand typically rises 5–6 GW between 2:30 and 5:30 PM, but on these days the rise was less than half of this. Factories, supermarkets and a host of other consumers automatically reduced their demand during the peak hours. This prevented demand on the transmission system (the thick line in the chart below) from going above 47.5 GW, and meant that day-ahead power prices remained normal – peaking at just £86/MWh on the 22nd.

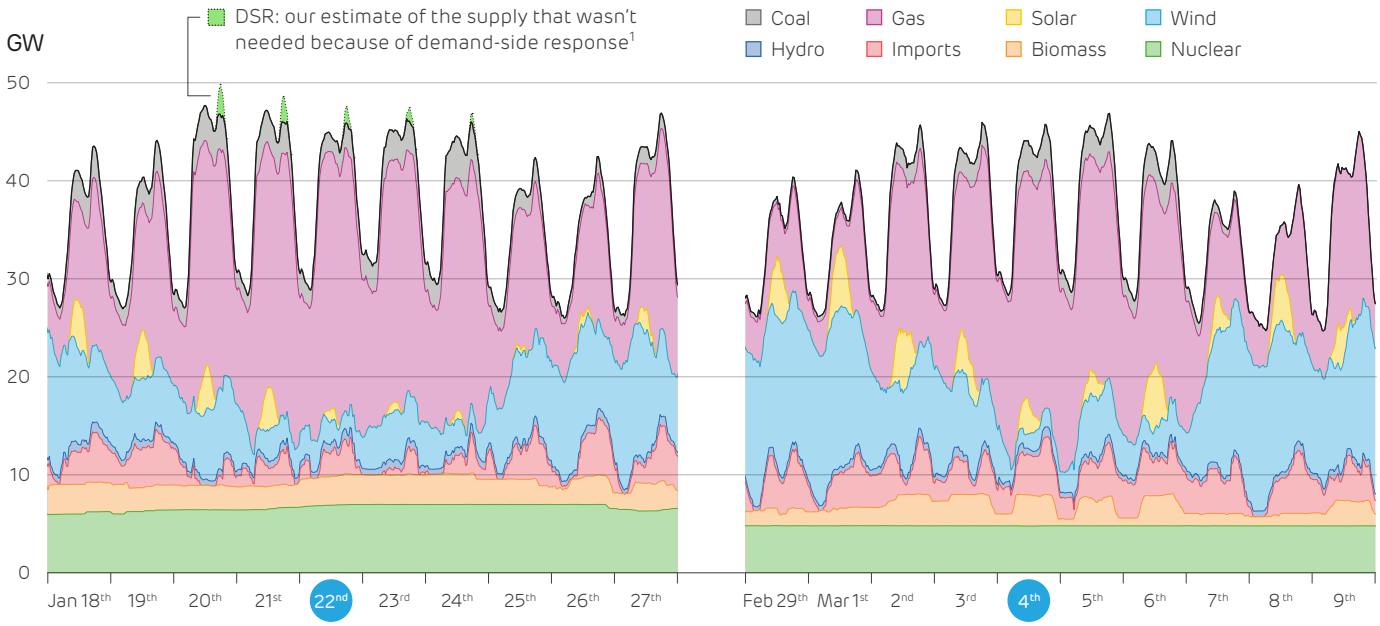
The second event came on Wednesday the 4th of March. Again, wind output fell to just 2.2 GW, from highs of 14 GW a few days either side. And although it was a couple of degrees warmer and demand was lower, the system became extremely stressed in the late evening.

The 'loss of load probability' rose to 37%, meaning a one-in-three chance of widespread blackouts as supply and demand were cutting close. There was just 0.2 GW of spare capacity available on the evening of the 4th, compared to over 4 GW the next day. This sent the balancing price to a high of £2,234/MWh – numbers not seen for over a decade.

Demand-side response had not activated to such an extent on the evening peaks. Between November and February, large consumers can save money by avoiding power consumption during 'the triads' – the three half-hour periods of the year with the highest system demand. Avoiding these triads reduces their network charge for the coming year, which can be a significant portion of their total bill. As this financial incentive to avoid peaks doesn't exist in March, facilities kept on running – at the risk of creating power outages.

The triads will be phased out two years from now, pushing up energy costs for large electricity consumers such as industry, water treatment and supermarkets. New markets for flexibility will be required if we wish for these firms to continue contributing towards security at times of peak demand.

The half-hourly electricity supply mix during the two cold-calm spells this quarter



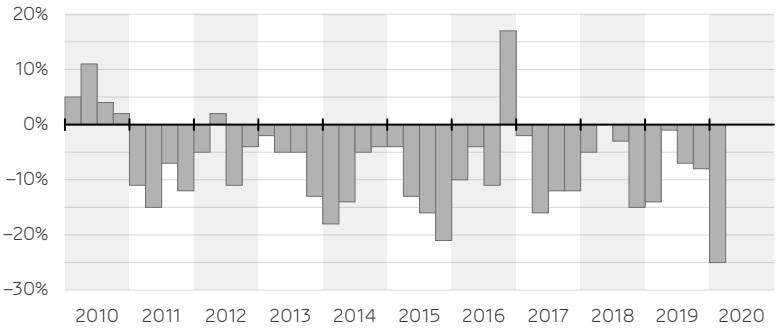
1 Electricity which was not consumed due to triad avoidance is not recorded and so must be estimated. We used the typical daily profile for each day of the week from recent years with similar temperatures to reconstruct a demand estimate.

6. Capacity and production statistics

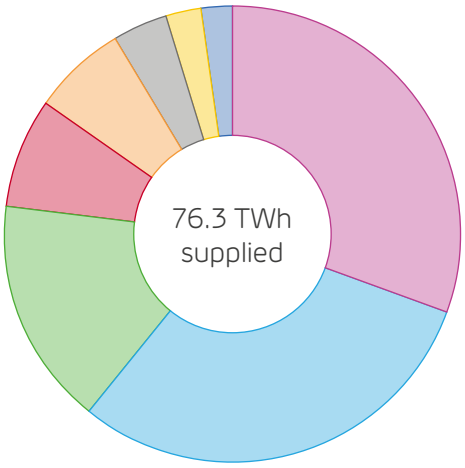
This quarter saw wind come within striking distance of beating gas for the first time ever – with just 0.1 TWh separating them. Wind farm capacity factors averaged nearly 50% over the quarter, well above their long-run average of 30% (26% for onshore and 37% for offshore).

Electricity generation from fossil fuels was down an incredible 25% on this quarter last year – the largest single fall on record. Gas-fired power stations ran at an average of just 38% of their installed capacity over the quarter – a lower utilisation than onshore wind farms. However, at their peak, fossil fuel plants needed to run at near-full capacity at some point during the quarter (96% for gas, 83% for coal). This shows there is still a need to keep these assets around for times when demand is high and renewable output is low, at least until other flexible technologies can take their place.

Year-on-year change in electricity generation from fossil fuels



Britain's electricity supply mix in the first quarter of 2020



	Share of the mix
Gas	30.6%
Wind	30.5%
Nuclear	16.1%
Imports	7.6%
Biomass	6.7%
Coal	3.9%
Solar	2.6%
Hydro	2.0%

Installed capacity and electricity produced by each technology [1] [2]

	Installed Capacity (GW)		Energy Output (TWh)		Utilisation / Capacity Factor	
	2020 Q1	Annual change	2020 Q1	Annual change	Average	Maximum
Nuclear	9.5	~	12.3	–0.8 (–6%)	60%	73%
Biomass	3.2	~	5.1	+1.0 (+24%)	69%	100%
Hydro	1.1	~	1.5	+0.4 (+37%)	64%	97%
Wind	21.9	+1.2 (+6%)	23.3	+6.7 (+41%)	49%	77%
– of which Onshore	13.2	+0.5 (+4%)	13.1	+4.0 (+45%)	46%	79%
– of which Offshore	9.1	+0.7 (+8%)	10.1	+2.7 (+36%)	51%	81%
Solar	13.2	+0.1 (+1%)	2.0	+0.0 (+2%)	7%	68%
Gas	28.1	~	23.4	–8.8 (–27%)	38%	96%
Coal	5.3	–5.2 (–50%)	3.0	+0.1 (+4%)	16%	83%
Imports	5.0	~	6.7	–0.3 (–5%)	64%	97%
Exports			0.8	+0.0 (+4%)	8%	64%
Storage discharge	3.1	~	0.4	–0.1 (–24%)	6%	61%
Storage recharge			0.5	–0.1 (–23%)	7%	61%

1 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.
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.

7. Power system records

This was a record-breaking quarter for renewables and low-carbon power sources. Britain's wind farms broke all records, most notably by supplying an average of 12.3 GW through February, smashing previous record of 9.3 GW set back in December 2019.

Biomass supplied more than a tenth of electricity over a day for the first time on 27th March. Instantaneous output from all renewables exceeded 25 GW for the first time ever for a period on 12th March, up 11% on the previous record set one year ago.

March saw the lowest monthly-average power prices for more than a decade. The impact of the coronavirus lockdown is not yet breaking all-time record lows for demand, as these tend to happen in summer when people are away on holidays.

The tables below look over the past decade (2009 to 2020) and report the record output and share of electricity generation, plus sustained averages over a day, a month and a calendar year. Cells highlighted in blue are records that were broken in the first quarter of 2020. 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	16,962	58.8%
Daily average	15,962	47.2%
Month average	12,346	34.1%
Year average	6,682	20.1%

Solar – Maximum

	Output (MW)	Share (%)
Instantaneous	9,550	29.4%
Daily average	3,386	12.0%
Month average	2,464	8.1%
Year average	1,331	4.0%

Biomass – Maximum

	Output (MW)	Share (%)
Instantaneous	3,452	13.0%
Daily average	3,298	10.1%
Month average	2,839	7.9%
Year average	2,053	6.2%

All Renewables – Maximum

	Output (MW)	Share (%)
Instantaneous	25,225	68.0%
Daily average	19,700	57.2%
Month average	16,030	44.3%
Year average	10,475	31.5%

Gross demand

	Maximum (MW)	Minimum (MW)
Instantaneous	60,070	18,214
Daily average	49,203	24,704
Month average	45,003	28,592
Year average	37,736	32,659

Demand (net of wind and solar)

	Maximum (MW)	Minimum (MW)
Instantaneous	59,563	8,118
Daily average	48,823	12,308
Month average	43,767	20,212
Year average	36,579	24,646

Day ahead wholesale price

	Maximum (£/MWh)	Minimum (£/MWh)
Instantaneous	792.21	–72.84
Daily average	197.45	–4.62
Month average	63.17	28.50
Year average	56.82	36.91

Carbon intensity

	Maximum (g/kWh)	Minimum (g/kWh)
Instantaneous	704	43
Daily average	633	76
Month average	591	157
Year average	508	192

All low carbon – Maximum

	Output (MW)	Share (%)
Instantaneous	32,688	89.0%
Daily average	27,282	79.3%
Month average	23,276	64.3%
Year average	17,902	53.4%

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	9.1%
Daily average	3,921	14.9%
Month average	10,020	30.3%
Year average	13,756	41.3%

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	6,023	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	678	2.0%

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%

Imports – Maximum

	Output (MW)	Share (%)
Instantaneous	4,884	18.3%
Daily average	4,490	14.3%
Month average	3,796	10.6%
Year average	2,850	8.6%

Exports – Maximum

	Output (MW)	Share (%)
Instantaneous	–3,870	–11.8%
Daily average	–2,748	–6.1%
Month average	–1,690	–3.8%
Year average	–731	–1.9%

Pumped storage – Maximum[1]

	Output (MW)	Share (%)
Instantaneous	2,660	6.0%
Daily average	362	1.2%

Pumped storage – Minimum[1]

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

1 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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