January to March 2018

Electric Insights Quarterly

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What does 3 months of data starting 01/01/2018 look like?
Demand & price
Demand 38.3GW
Price £57.38/MWh
Environment
Emissions 259g/kWh
Temperature 5.2°C
Supply
Coal 3.8GW
Gas 15.1GW
Solar 0.7GW
Wind 7.2GW
Hydro 0.4GW
Imports & storage 3.1GW
Biomass 1.5GW
Nuclear 7.2GW
What is the production breakdown of All sources ?
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Headlines

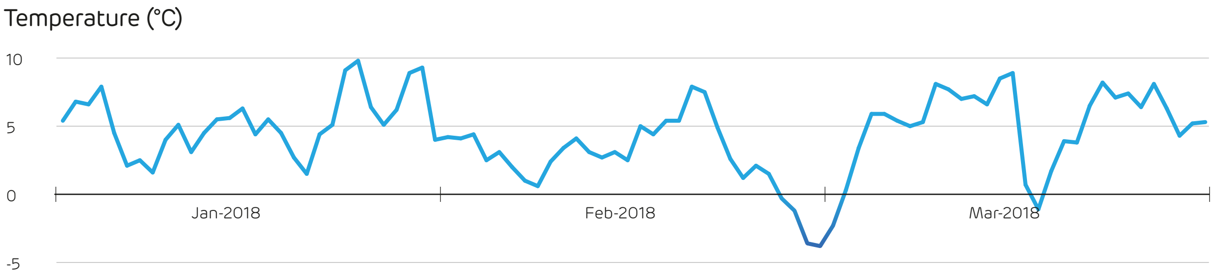
This quarter, Britain's energy system was tested by the Beast from the East: winds from Siberia that delivered the coldest March day on record. Article 1 summarises the impacts this weather had on the electricity system, and Article 2 looks at events on the gas network. The need for heating drove a huge spike in gas demand, National Grid issued an emergency warning as supplies failed to keep up with demand, and gas storage fell to its lowest levels after Britain's biggest storage site was retired.

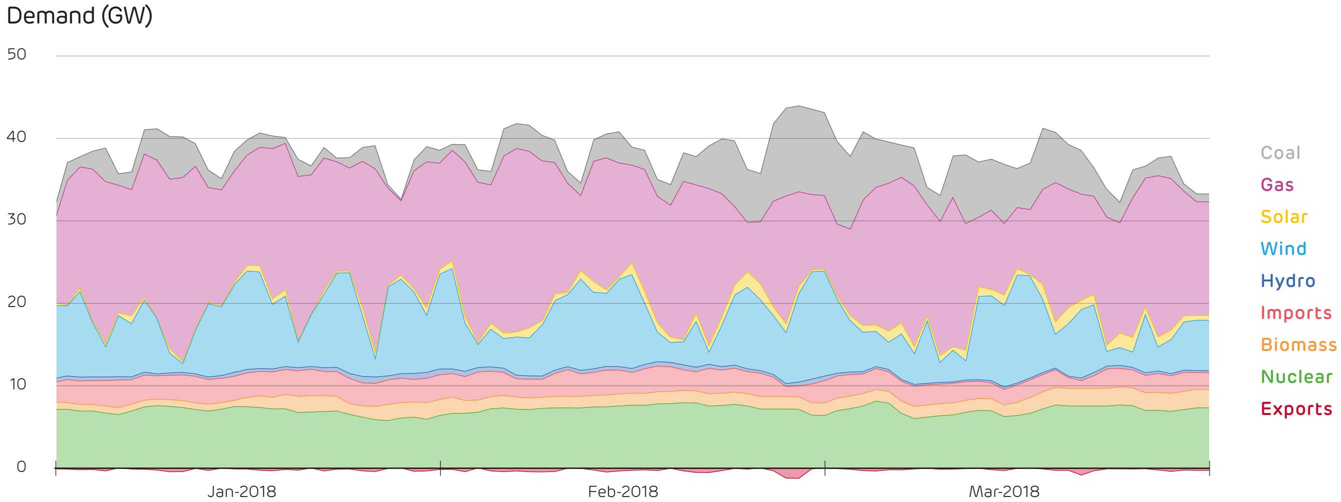
The events of March are an interesting glimpse at the future electricity system's resilience. Article 3 looks at how Britain's interconnectors helped or hindered during the time of stress, and whether the system could have coped without coal.

Britain's wind farms had another record-breaking quarter, exceeding the output of nuclear reactors for the first time (see Article 4). Higher wind speeds and new capacity are two reasons that were explored in last quarter's report. Now, Article 5 shows that the amount of wind energy wasted due to grid constraints has fallen by two-thirds, helping to boost output further.

Together, these events mean that whilst gross electricity demand was up 2% on this quarter last year, the demand net of renewables (which had to be met by conventional power stations) was 4% lower. Despite the strong switch toward coal in March, coal output over the quarter was one-sixth lower than in Q1 2017, and consequently carbon emissions were 7% lower. Article 6 finishes with statistics on the capacity and production for the quarter.

Daily average temperature and generation mix over the quarter





1. The Beast from the East

March 1st was the coldest spring day on record, averaging –3.8°C. This pushed electricity demand up 10%, and prices up by 50%. The six days from February 26th to March 3rd (highlighted in grey) were the coldest Britain has been since Christmas 2010.

This pushed electricity demand up 10%, as people used more electric heating to keep warm. The evening peak demand on March 1st was 53.3 GW: the highest in three years, but not enough to stretch the system to its limits.

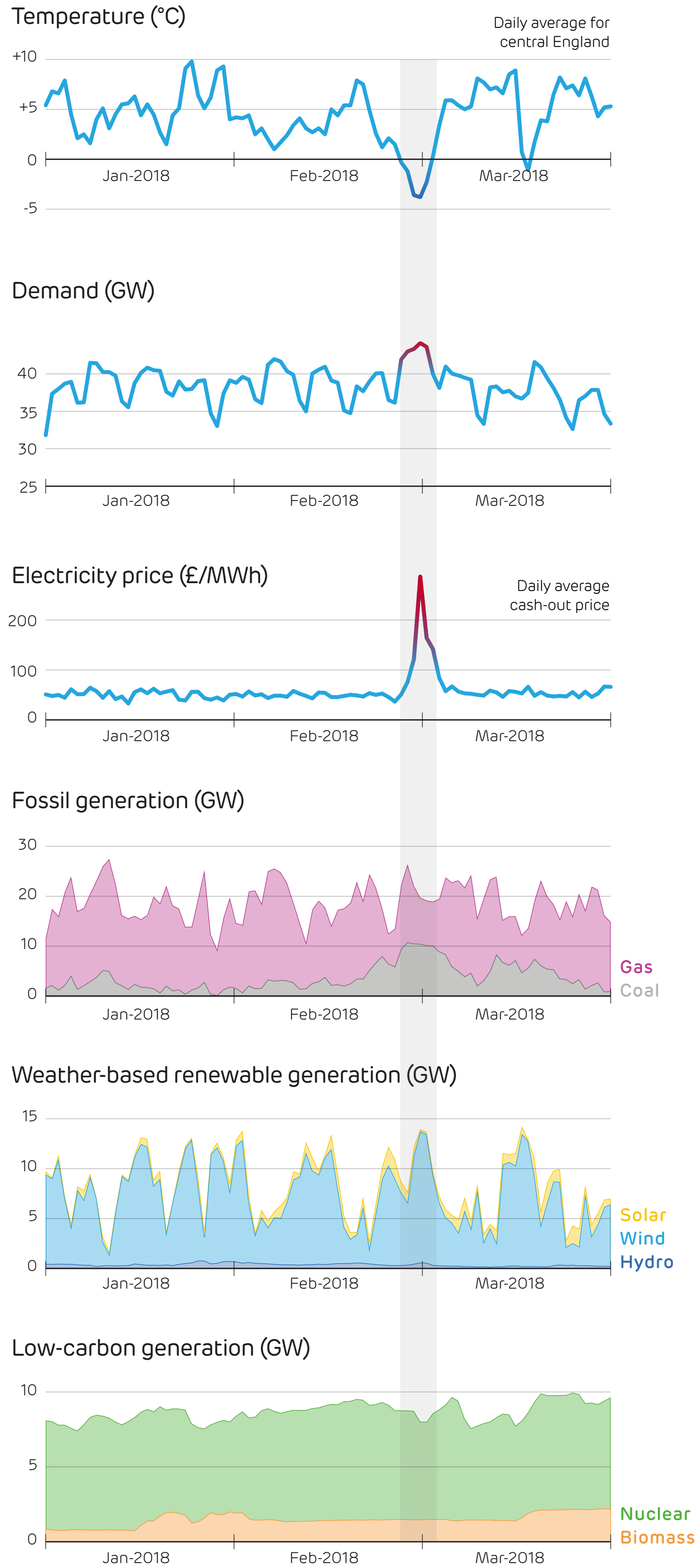
Electricity prices reacted sharply though, peaking at £990 per MWh for half an hour, and also falling to –£150 per MWh as the market became volatile. The average power price in March was 50% higher than March 2017 as a result.

Coal generation surged for the weeks surrounding the cold spell. Not because more output from conventional plants was needed: total generation from fossil fuels remained steady, averaging 20–25 GW. Instead, rising gas prices made it temporarily more economical to burn coal.

Wind output was particularly high when it was most needed, ranging from 11.8 to 13.8 GW during March 1st. On the other hand, solar panels averaged just 0.2 GW on that day, as the blanket of snow shielded them from the sun.

Biomass ran solidly throughout the cold spell, while two nuclear reactors were down for routine maintenance, and seaweed forced a third to shut on the coldest day!

Finally, Electric Insights itself was not immune to the cold weather. Traffic to the website surged to 10 times its usual level on March 1st and 2nd.



2. Running low on gas

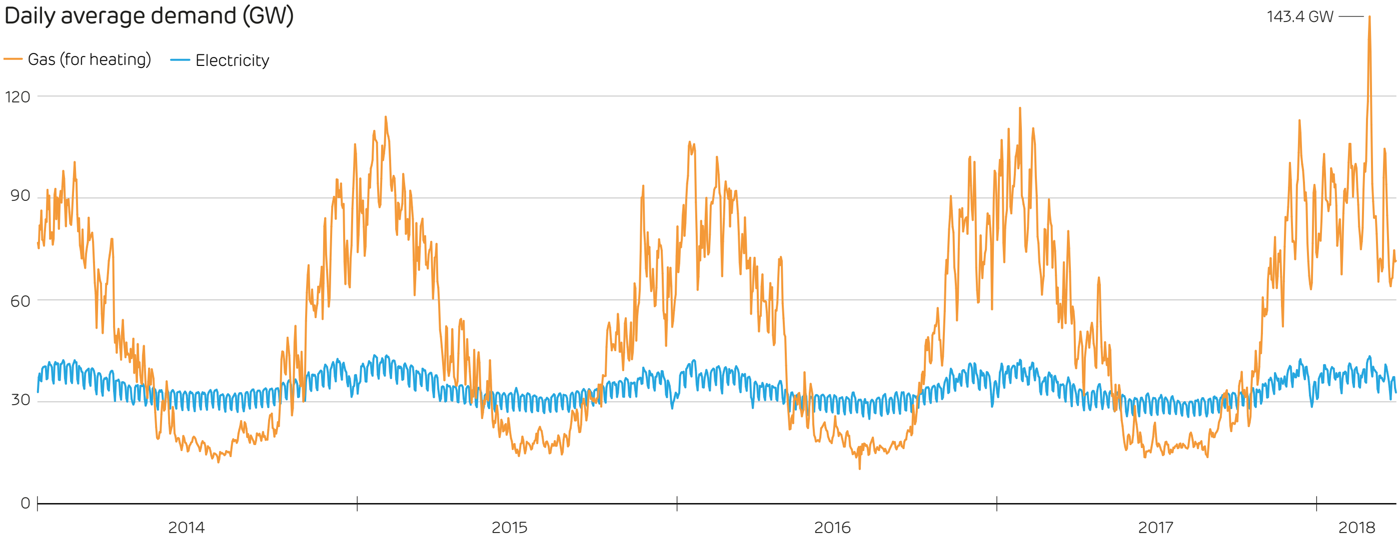
The cold weather in March not only affected the power system, Britain's gas network was also stretched as demand outstripped supply. On March 1st, National Grid forecast that the amount of gas in pipelines was going to fall below the normal operating range. This forced them to trigger the first 'Gas Deficit Warning' in eight years.

This helped push the spot price of gas to 11.2 p/kWh – compared to an annual average of just 1.5 p/kWh. The price increase brought more supplies of gas into the system, and persuaded gas power stations to reduce their output, to be replaced by cheaper coal. By March 2nd the warning was removed and the spot price of gas returned to normal over the next few days.

The shortage was partly due to unusually high demand for gas during the cold weather (see chart below). Five in six of Britain's homes and offices are heated by gas.[1] On the coldest day (March 1st), daily gas demand spiked to 4,600 GWh, a level not seen since 2010. For a sense of scale, the *extra* gas demand due to the cold weather was comparable to the entire country's electricity demand.

A further worry for the gas system was the historically low levels of gas held in storage. This was not helped by the cold weather coming unusually late into the heating season; gas in storage is likely to be at a greater level earlier in the winter months. Last year, Britain's largest inter-seasonal gas storage site (Rough) reached the end of its economic life, and was deemed unprofitable. It discharged for the last time over winter, and was finally emptied by mid-January.

Daily demand for gas and electricity over the last four years. Non-daily metered gas demand is shown (excluding power stations and heavy industry), as a proxy for domestic heat demand



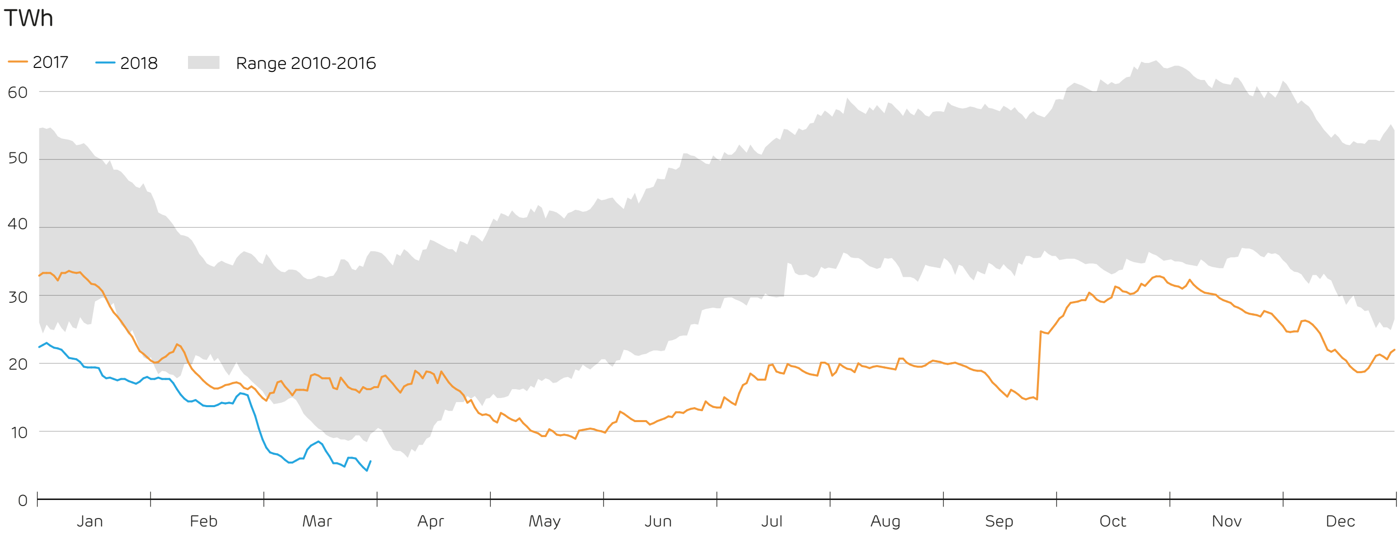
1 DECC, 2013. https://www.gov.uk/government/statistics/united-kingdom-housing-energy-fact-file-2013

The UK has historically worked with less gas storage than neighbouring countries, as domestic supplies from the North Sea provided a dependable source. This is being replaced by imports, including liquid natural gas (LNG) ships which provide flexibility in deliveries, at a price. France, Germany and the US typically hold 2–3 months of gas in storage. In contrast, Britain's 64 TWh of storage used to satisfy just 20 days of demand, but with the closure of Rough this has fallen to around 25 TWh, or just 8 days of storage.

The amount of stored gas is at its lowest since 2010 (see chart below). In the week surrounding the Beast from the East, 26.7 TWh of gas was consumed, 8.4 TWh of which came from storage (see the sharp dip at the start of March). In comparison, total electricity demand in that week was just 6 TWh.

The ability of the gas system to accommodate significant swings in energy demand over daily, weekly and seasonal timeframes is one of its major strengths. As coal continues to be phased out, gas becomes ever-more important for electricity generation, as well as heating. Maintaining this flexibility and the ability to cope with unusual weather is as critical as ever.

The amount of gas available as LNG and storage throughout the year. The shaded area shows the historic range, the two lines show the most recent years. For comparison, all of Britain's pumped hydro storage facilities can hold 0.03 TWh of electricity.



3. Who helped and hindered the system?

How much can Britain rely on its neighbours in times of stress? Would the lights have gone out if it were not for coal power? The Electric Insights data helps us understand who helped, and hindered, the power system during the extreme weather.

The power flowing over Britain's links to other countries are shown to the right. Britain had been largely importing from France all year, but began exporting solidly through the 27th and 28th of February. France was also experiencing severe cold, and a greater share of French homes use electric heating. On the two coldest days, Britain exported at an average of 0.9 GW (28th, –3.6°C) and then imported an average of 1.2 GW (1st, –3.8°C).

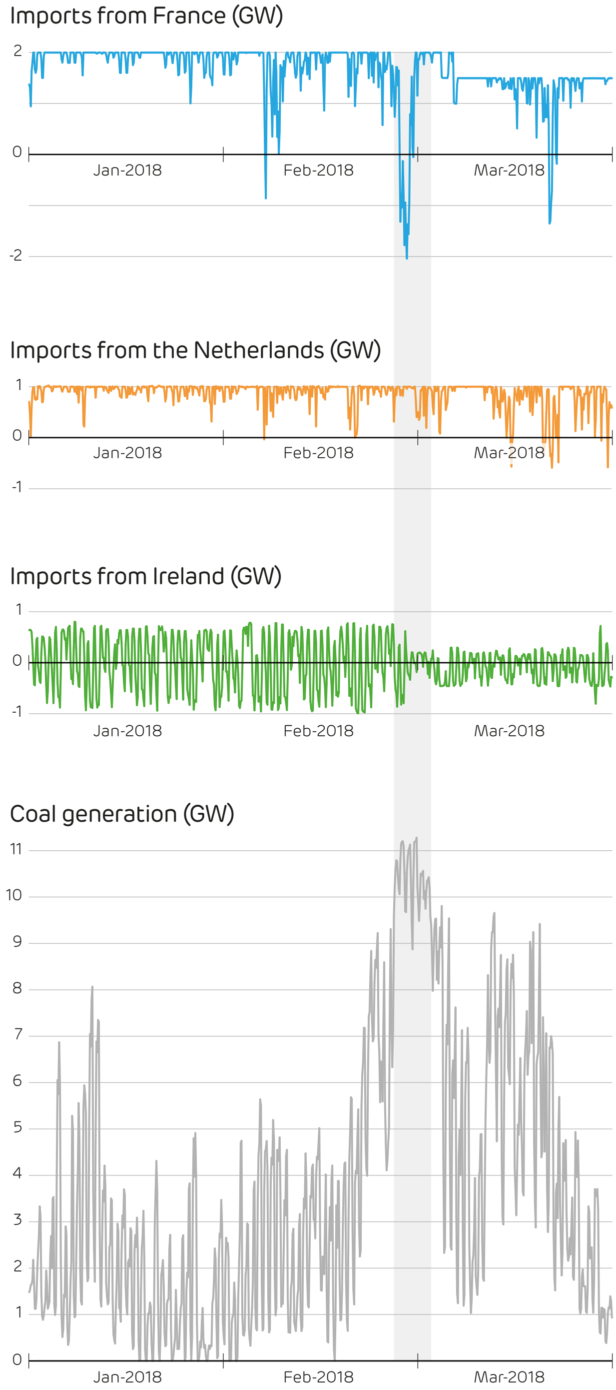
Britain imported steadily from the Netherlands, and traded power back and forth with Ireland[2] to help balance both systems. On March 3rd the East-West link between North Wales and Dublin was taken offline for (unrelated) maintenance.

The output from coal during this period dwarfed these exchanges with our neighbours (chart below right). The cold spell saw the return of 'king coal', which reverted to being a baseload generator. Coal operated solidly day and night for a week as high gas prices made it briefly more economical.

The system would likely have coped without this coal. 12–19 GW of spare gas capacity was available, albeit at a high price. While this means we were not short of capacity, if the extra coal output had been met by gas, it would have consumed around an extra 6 TWh of fuel – more than was available in storage by the end of March.

More coal units are going offline as Britain moves to a complete phase-out by 2025, meaning this source of backup and flexibility will not be available for long.

Hourly electricity supply from Britain's interconnectors (top) and coal power stations (bottom) over the quarter



2 This refers to the island of Ireland as both Northern Ireland and the Republic of Ireland are on a separate electricity system to the National Grid.

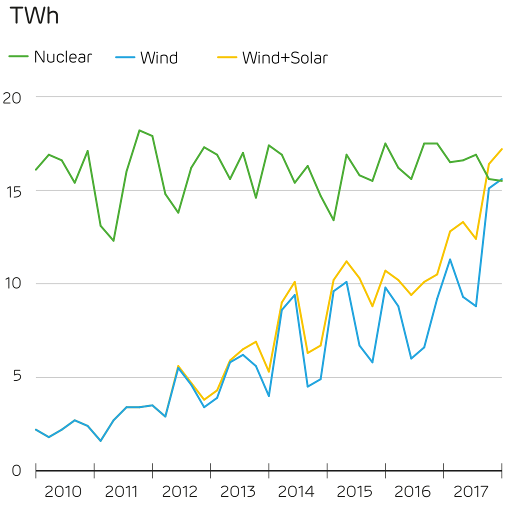
4. Wind power breezes past nuclear

Britain's wind farms have enjoyed another record-breaking three months. Peak output surpassed 14 GW for the first time, and wind produced more electricity than nuclear over the quarter.

Last quarter, wind and solar overtook nuclear generation in Britain, but now wind by itself has beaten nuclear for the first time. In the first quarter of 2018, wind produced 15,560 GWh of electricity – 30 GWh more than nuclear *(see chart, right).*

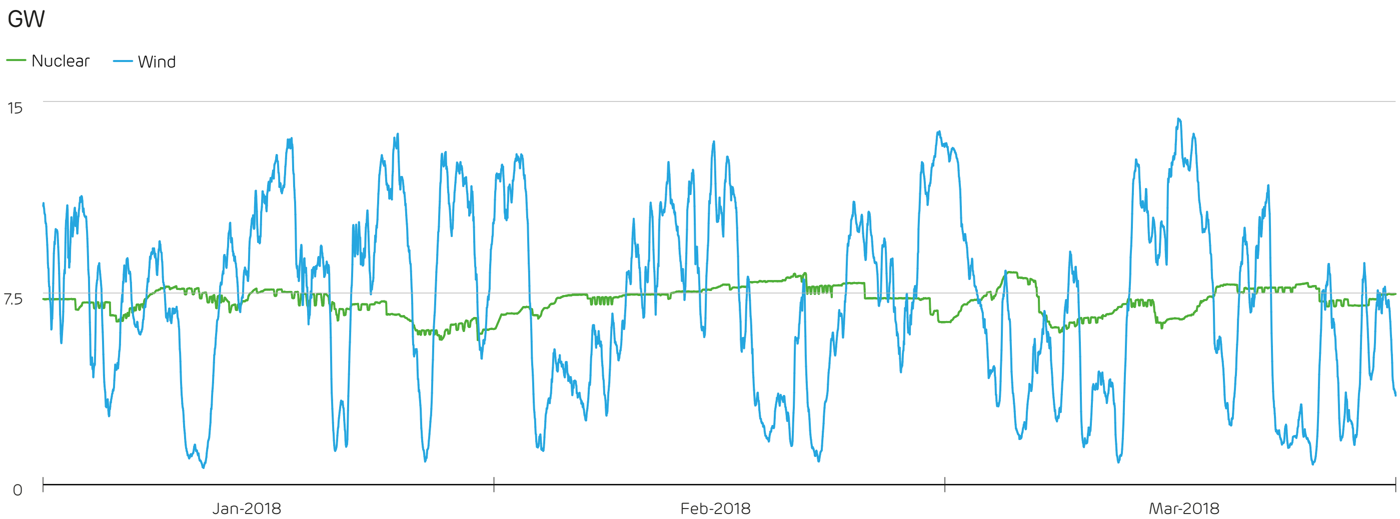
After surpassing 11 GW and 12 GW of peak output last quarter, this quarter wind broke through 13 GW on January 17th and then 14 GW on March 17th *(see chart below).*

Britain's wind farms produced 18.8% of electricity over the quarter, and at their peak they supplied 47.3% of the country's demand (another new record). This happened overnight on March 17th, when temperatures once again dipped below freezing. There has been much debate on whether wind can be relied upon during a cold, calm spell. During the six sub-zero days this quarter, wind provided between 12% and 43% of electricity demand, operating at a minimum of 4.4 GW.



Quarterly energy production from wind farms, solar and nuclear reactors

Half-hourly power output from wind and nuclear during the quarter



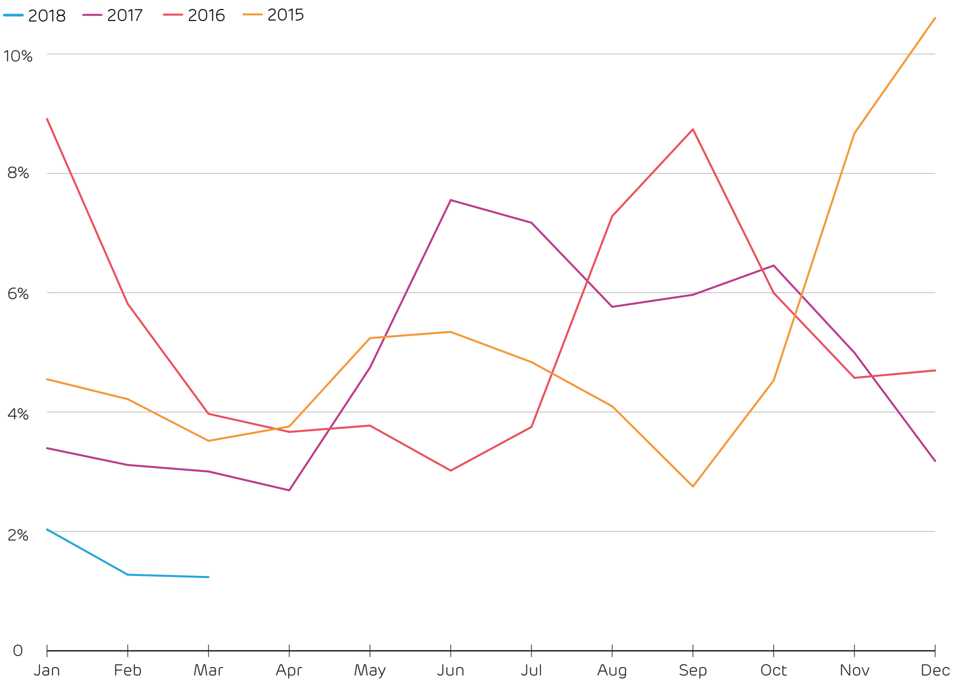
5. Wind farm curtailment falls by two-thirds

It has been a familiar headline over the years: "Britain's wind farms paid millions to sit idle". Last year, National Grid paid over £100m to turn wind farms off when their output could have overloaded the transmission system. But now that a new link between Scotland and Wales has come online, the amount of money (and clean energy) that was lost has quietly fallen by two-thirds.

Power stations can only sell their output if the electricity can be handled by the transmission grid, otherwise they have to be 'constrained' off. Nationwide, constraints have risen from almost nothing five years ago to over 5% of wind generation (see chart, below).[3] This is not a problem unique to Britain though, constraint rates average 4–5% in Germany and 12–15% in China, with some Chinese provinces seeing 40% of wind generation lost.[4]

Wind constraints are a particular problem in Scotland, where 7.7 GW of wind capacity feeds a demand that averages just 3 GW. Until recently there were only three lines connecting Scotland to England and Northern Ireland, totalling around 3.25 GW. This helps to explain why a sixth of Scotland's available wind energy was lost in 2015/16, with curtailment rates of up to 30% at individual farms.[4] Seven Scottish wind farms accounted for half of all the wind energy constrained across Britain.

The share of wind energy lost to curtailment in Britain. A new transmission link between Scotland and Wales came online in December 2017. Curtailment is often higher in summer months when demand is lower, as high wind output becomes harder to manage.



3 We measure this against transmission-connected wind output. Constraints in the 'embedded' wind farms (smaller farms and those in England & Wales) are not monitored, or paid for.
4 Joos & Staffell, 2018. Wind curtailment and balancing in Britain and Germany. National Energy Administration, 2017. www.nea.gov.cn

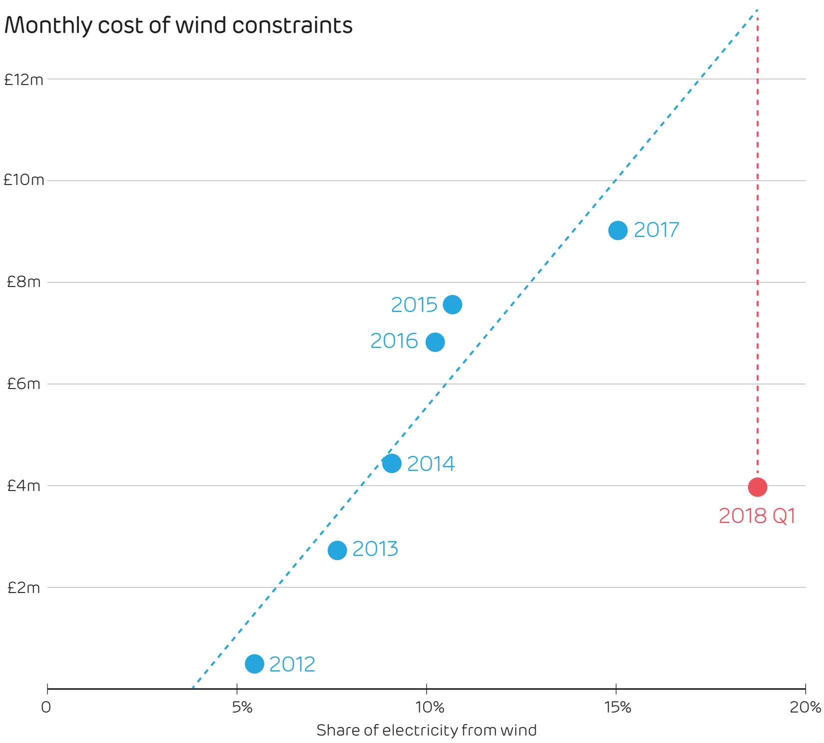
Wind farms are not the only type of power station to be constrained, but they matter because reducing their output costs money, rather than saving it. Wind farms lose their subsidy payments if they are forced to turn off, so they request payment from National Grid as compensation. The average wind farm charged £69/MWh to be curtailed in 2017, a price which has halved in the last four years.

Since 2012, National Grid has spent over £380 million on constraining wind farms: around £1 per person per year. The cost has risen in line with the amount of wind generation: once wind had reached 4 percent of Britain's electricity supply, each additional percent of wind energy added £1m per month to the cost of constraint payments (see chart, below).

However, this trend appears to have been broken, as the payments this quarter were the lowest since Q1 2013, despite wind production more than doubling since then. In December 2017 the 'Western HVDC Link' came online, a new 2.2 GW cable connecting Scotland to North Wales.[5] The £1bn link was built in the Irish Sea rather than on land, to minimise visual impact.

From the figure below, a crude estimate is that this link saved National Grid around £9m per month during Quarter 1 on constraint payments. These savings could pay back the construction cost in under 10 years if they continued. The benefits are not just financial though – if we could have utilised all of Scotland's wind power last year by eliminating grid constraints, the annual capacity factor of Scottish wind farms would have improved by a sixth, from 27% to 32%.

The monthly cost of constraining wind farms to National Grid versus the share of electricity generated from wind



5 The link has only operated at half power whilst it is commissioned. It is expected to be offline for final testing between April and June.

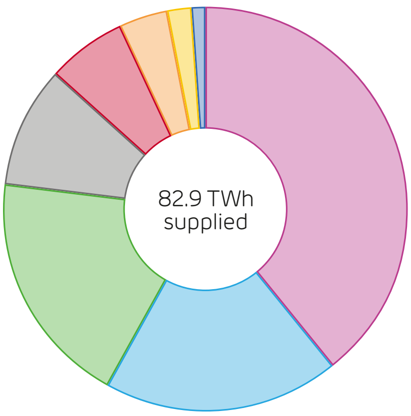
6. Capacity and production statistics

This quarter, wind was the second largest source of electricity behind gas. Renewables made up 26% of the generation mix, and all low carbon sources made up 49%. Generation from coal and gas were both down on this quarter last year due to the growth in renewable energy output.

Gross electricity demand was a tenth lower than in the first quarter of 2010. Demand net of renewables was down by 27% though, indicating just how the market for fossil fuels is shrinking.

Electricity prices averaged £54/MWh over the quarter, one-sixth higher than last year. The real-time cash out price fell below its previous minimum of –£100/MWh on three occasions. Prices hit –£130 to –£150/MWh in periods when wind and coal output was high, and gas output was low.

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



	% of mix
Gas	39.4%
Wind	18.8%
Nuclear	18.7%
Coal	9.8%
Imports	6.3%
Biomass	3.9%
Solar	2.0%
Hydro	1.0%

Installed capacity and electricity produced by each technology[6]

	Installed Capacity (GW) 2018 Q1	Annual change	Energy Output (TWh) 2018 Q1	Annual change	Utilisation / Capacity Factor 2018 Q1	
					Average	Maximum
Nuclear	9.5	~	15.5	–0.9 (–6%)	77%	88%
Biomass	2.2	~	3.2	–1.2 (–28%)	69%	100%
Hydro	1.1	~	0.9	–0.8 (–47%)	36%	89%
Wind	19.7	+3.1 (+19%)	15.6	+4.3 (+38%)	38%	73%
Solar	13.1	+1.3 (+11%)	1.7	+0.1 (+9%)	6%	60%
Gas	27.8	–0.6 (–2%)	32.6	–0.6 (–2%)	55%	97%
Coal	13.5	~	8.1	–1.6 (–16%)	28%	84%
Imports	4.0	~	5.9	+1.7 (+40%)	69%	95%
Exports			0.6	+0.5 (–46%)	7%	58%
Storage	3.1	~	0.7	–0.05 (–6%)	11%	76%

6 Other statistical sources give different values because of the types of plant they consider. For example, BEIS Energy Trends records an additional 900 MW of wind, 600 MW of biomass and 500 MW of solar, respectively producing 1.4, 1.2 and 0.2 TWh extra per quarter. These plants and their output are not visible to the electricity system and so cannot be reported on here.

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