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. Since 2016 it has been delivered independently by a team of academics at Imperial College London using data courtesy of Elexon, National Grid and Sheffield Solar.

1. Introduction

In the first quarter of 2023, the pecking order of Britain's electricity generation mix got turned on its head. Wind overtook natural gas to become the largest source of electricity for the first time ever. At the same time, Britain imported more electricity from abroad than was generated by nuclear power, which fell to its lowest output in 40 years. We cover these important milestones in Articles 2 and 3, reflecting on the very different fortunes of Britain's low carbon generators.

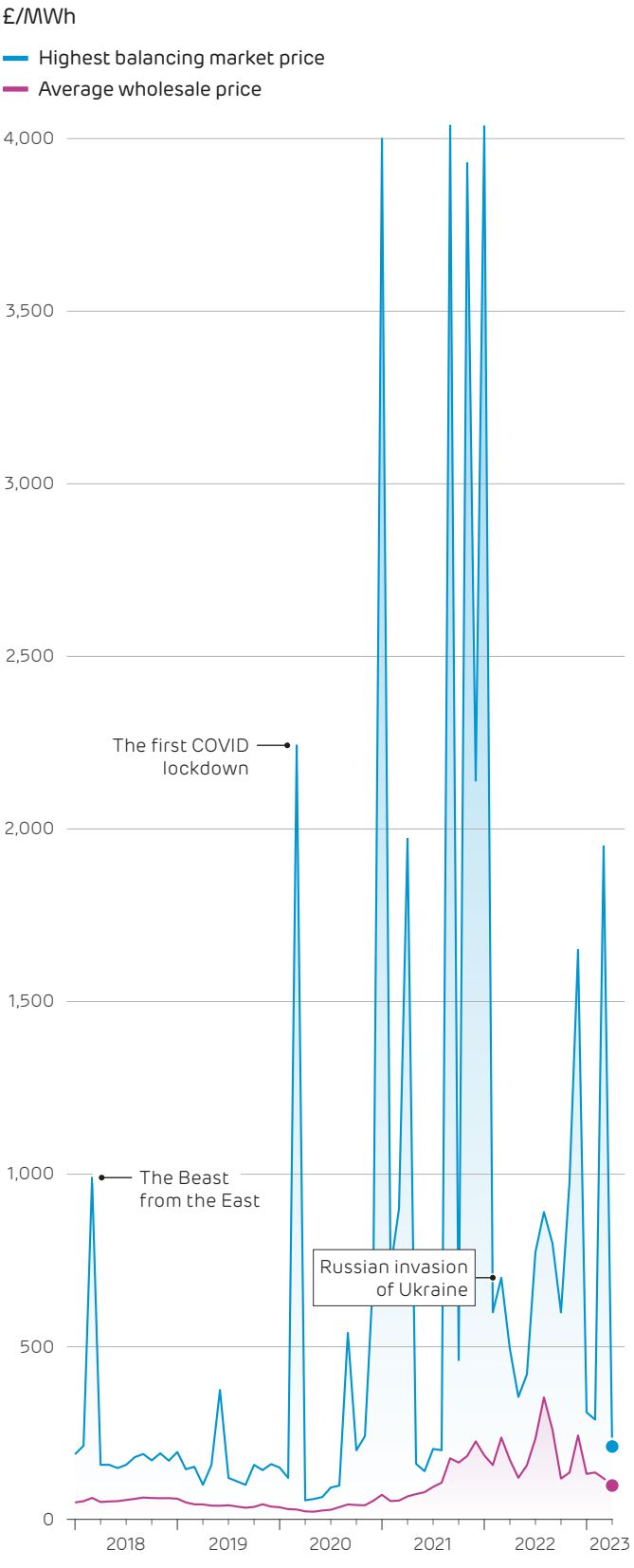
This year saw the US bring in its largest ever legislation for clean energy. The Inflation Reduction Act, along with other bills, will unleash over $500 billion of funding towards renewables, batteries, carbon capture and storage, nuclear, hydrogen, and grid upgrades. In Article 4 we size up the monumental support being given and compare it to the UK government's offering for clean tech.

The US is not just providing more funding, it is working to eliminate the red tape and other bottlenecks that hold back the transition to clean energy. In contrast, a worsening financial climate for UK renewables and restrictive regulation have stifled new installation of solar PV and onshore wind farms. Article 5 looks at how the UK has slid down the global renewable energy rankings. Despite having more solar PV capacity than the entire continent of Africa, the UK didn't even place in the top 100 countries for new installations last year.

In other news, wholesale electricity prices are falling rapidly towards pre-crisis levels. Prices fell by two-thirds over the last seven months, and in April they averaged below £100/MWh for the first time since July 2021 (see chart, right). Consumer bills should therefore fall in the coming months, as there is a 6-month lag between changes in wholesale and retail prices.

While the sky-high energy prices of the last two years were triggered by post-COVID supply chain disruption and Russia's invasion of Ukraine, illegal market manipulation may have made things even worse. Bloomberg report that power trading firms cost UK bill payers nearly £500 million over the last two years. Echoing Enron's role in the 2001 California electricity crisis, traders cut off capacity ahead of periods with high demand, while simultaneously offering power from the same plants to the balancing mechanism – a side market dedicated to balancing the grid – where they could charge four times more to meet the shortfall in demand that they created. Similar investigations are now being launched elsewhere in Europe.

British electricity prices over the past five years



2. Wind becomes our largest electricity source

Over the first quarter of 2023, wind power generated the largest share of Britain's electricity for the first time ever. Wind overtook gas, breaking its 7-year run at the top spot. This ends the 100+ year reign of fossil fuels as the country's largest source of power.

Just 10 years ago, wind was typically only the fifth largest source of power, behind gas, coal, nuclear and imports, but output has quadrupled over the last decade.[1] Wind delivered just under a third of the country's electricity demand from January through to March, supplying 32.4% compared to 31.7% from gas. This was helped by an exceptionally windy January which saw production exceed 21 GW for the first time.

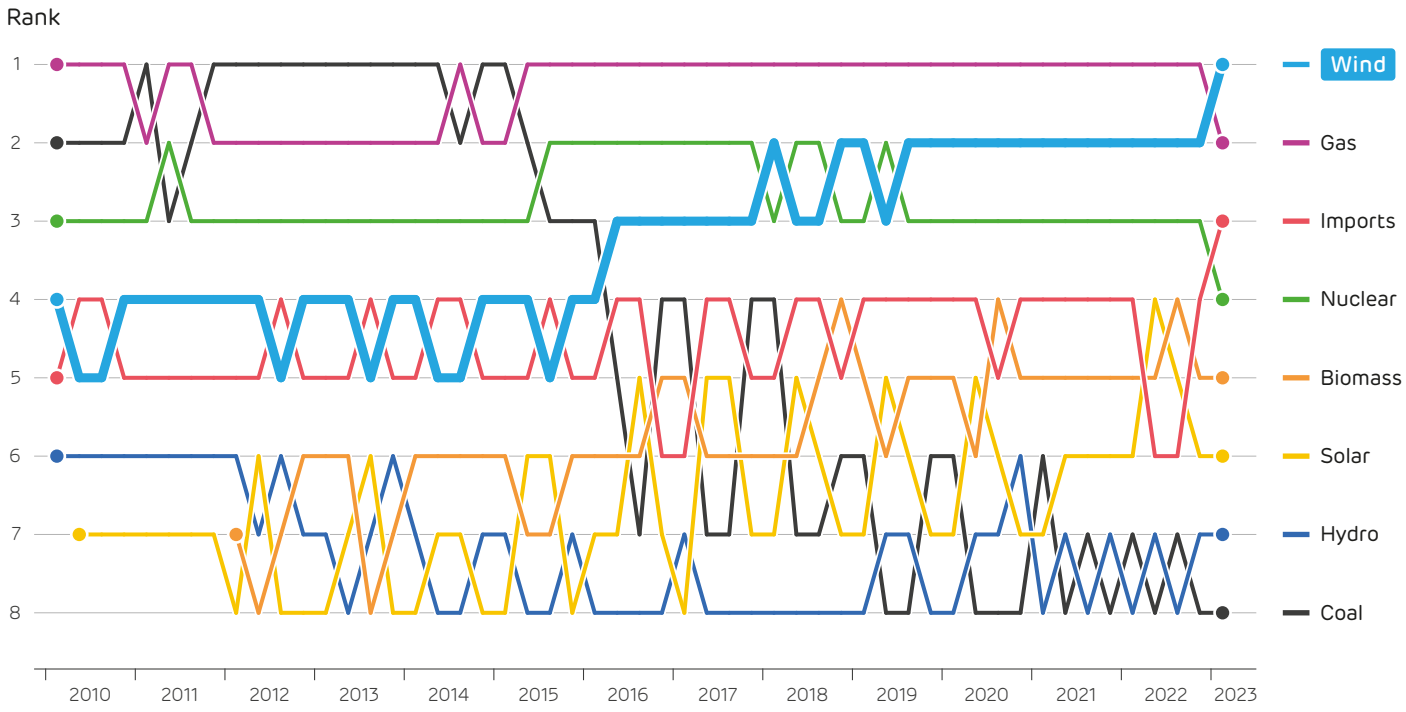
More generally, renewables have had a very productive season, producing enough electricity to 'power every UK home' through the winter. Similarly, March saw a record-breaking 83% low-carbon electricity. In sharp contrast, fossil fuels once again hit a new minimum output, dipping below 1.5 GW output for the first time on 24 March.

Wind overtook gas for two reasons. First, offshore wind capacity has grown by 3 GW over the past year, increasing total installed wind capacity by 14% year-on-year. Secondly, electricity demand fell by 4% from the first quarter of last year, in part due to a mild January, meaning this extra wind production could supply a larger share of electricity demand.

With the UK's offshore wind capacity set to continue growing in the coming years, we should expect to see the majority of our electricity coming from wind during the winter months.[2] This points to a new era of managing the power system, with renewables meeting the bulk of demand and fossil fuels shrinking into the support roles needed to keep the system stable. Eventually these can be made emissions-free with carbon capture and storage, or replaced with low-carbon fuels, batteries, etc.

This quarter, Britain moved one step closer to clean energy sources taking over the mantle from fossil fuels.

Britain's sources of electricity ranked in order of electricity produced over each quarter since 2010



1 Wind power generated 12 TWh of electricity during the winter of 2012-13, versus 49 TWh during the winter of 2022-23.
2 It will be a few years before this is a year-round occurrence, as lower wind speeds during the summer months mean wind provides a smaller share of electricity. Wind power produced 22% of electricity during Q2 & Q3 last year, versus 32% during Q1 & Q4.

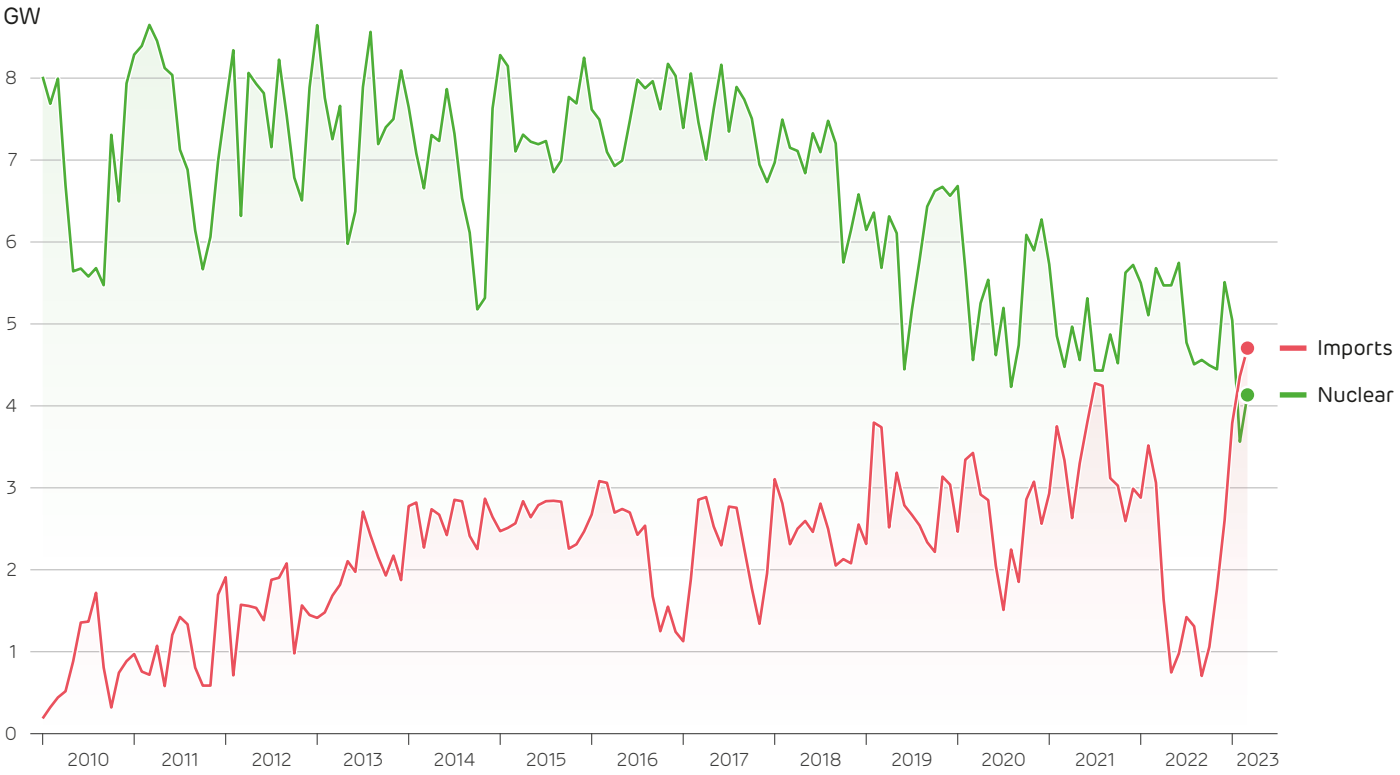
3. Britain's imports overtake nuclear power

In another first for the country's electricity mix, Britain's nuclear fleet has been overtaken by imports from abroad. Nuclear has continued its recent bad run, with output falling to its lowest in 40 years. In contrast, electricity imports reached their highest ever in February, and then March broke that record again.

Electricity imports surged to their highest levels on record, peaking above 8 GW in February as part of the IFA link that was damaged by fire back in 2021 came back online. Imports have quadrupled over the last six months as the capacity crisis that gripped France over last summer has eased off, meaning power prices have fallen further on the continent.

In contrast, nuclear output has fallen to a 40-year low. Britain's reactors produced 42 TWh over the twelve months to March, their lowest since 1982. February's output averaged below 4 GW, less than half the levels seen just five years ago. Britain's newest reactor, Sizewell B, was switched off for two months for maintenance and refuelling. This coincided with one reactor being offline at every one of Britain's nuclear power stations, also for refuelling. On the 17th, when the second unit at Sizewell B shut down, nuclear output reached a minimum of just 2.1 GW – less than the expected output of Hinkley Point C alone when it comes online.

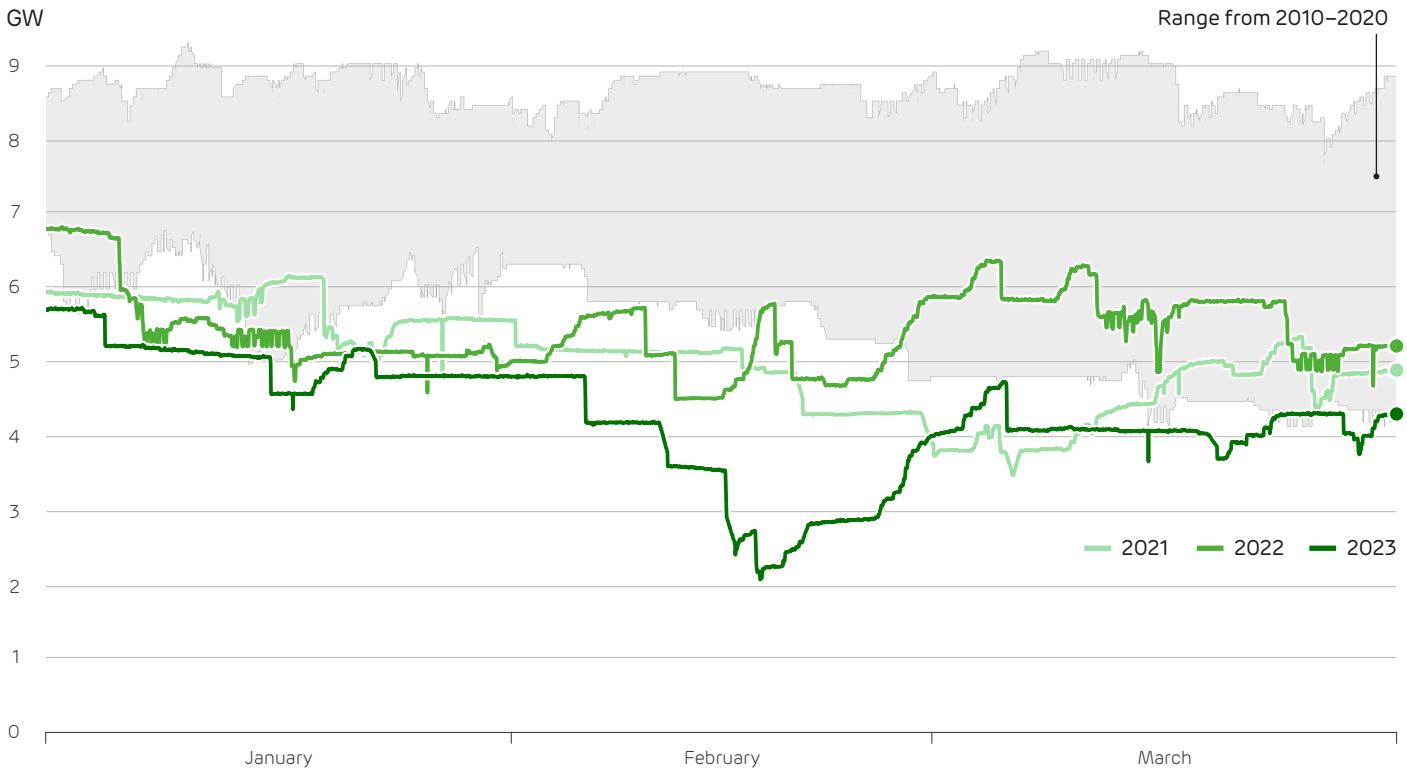
Monthly average electricity imports and generation from nuclear



It has been a difficult year for nuclear power across Europe. Germany brought fifty years of nuclear power generation to an end, closing its final power stations in April. Meanwhile, nuclear power generation hit a 30-year low in France last year as half of its fleet was offline due to delayed maintenance outages. There are signs of a nuclear renaissance though. In April, Finland finally opened Olkiluoto 3, Europe's first new nuclear station in 16 years. Globally, 60 nuclear power reactors under construction and due to come online by 2030, mostly in China, with hundreds more on order, planned or proposed.

While importing more electricity has helped to counter falling nuclear output, this increased reliance on Europe takes energy security issues out of the hands of the National Grid. The government's Energy Security Plan aims to more than double interconnection capacity by 2030 (to at least 18 GW). Just increasing interconnection capacity is only part of the puzzle – there must also be surplus electricity available across Europe to meet shortfalls in the UK. As European nations contend with their own shortfalls in electricity supply, and as major weather systems (both stormy and calm) tend to affect our neighbouring countries simultaneously, plentiful exports cannot always be relied on. The natural gas crisis prompted by the Russian invasion of the Ukraine has brought energy security issues into sharp focus, and may change the thinking around increasing, rather than decreasing, our reliance on other countries for energy supply.

Half-hourly output from nuclear reactors over the first quarter of each year since 2010



4. Sizing up the US clean energy boom

On January 1st, the humbly named United States Inflation Reduction Act (USIRA) came into force. This spearheads a new wave of clean energy legislation which puts America at the heart of the new green industrial revolution. As Europe prepares to respond with its ambitious Green Deal Industrial Plan, does the UK risk getting left behind?

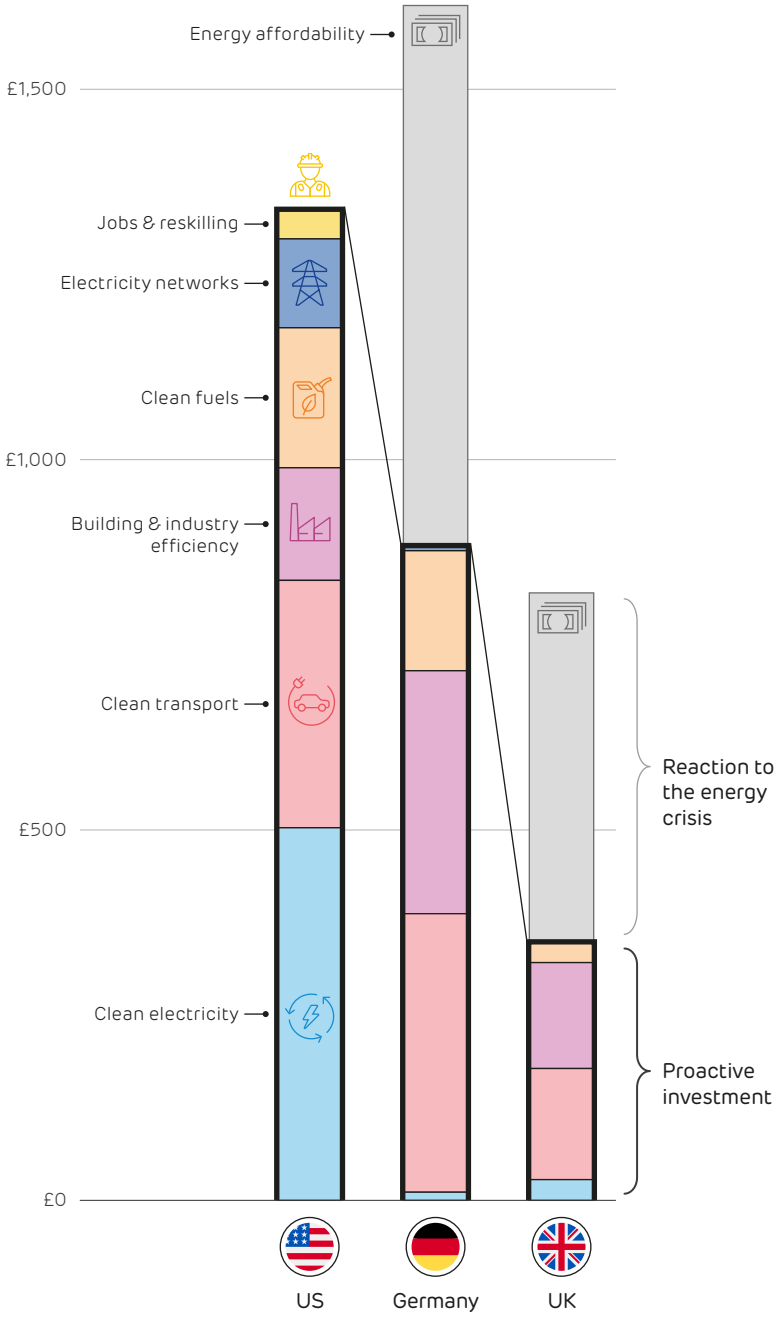
The USIRA commits $370 billion of new spending and tax breaks towards decarbonisation and clean energy activities. This complements two other recent laws. First, the 2021 US Bipartisan Infrastructure Law (BIL) sets out $1 trillion in new funding to revitalise US infrastructure, including $76 billion for clean energy. Second, the 2022 CHIPS and Science Act targets R&D and commercialisation of advanced technologies, with almost a third of the $280 billion going to clean energy and transportation. This alone outstrips federal government spending on climate issues over the last fifteen years.

Overall, the IRA, BIL and CHIPS provide over half a trillion dollars towards decarbonisation over the next decade. This is spread across a range of sectors: renewable generation, carbon capture and storage, nuclear, batteries and hydrogen all see well in excess of $25 billion each.

The US package of clean energy spending amounts to $1,650 (or £1,350) per person. The UK would have to commit over £80 billion to match this. Currently, the UK government is spending only two-thirds as much, but rather than funding proactive investment in the future, the majority of UK spending has been in reaction to the recent energy crisis, providing enormous sums of money to protect consumers by capping energy bills. While this was absolutely necessary to protect households and the national economy from disaster, it has cost 4% of the country's GDP, and does not put UK industry in a stronger position going forwards.

Currently, the UK is only spending one-quarter as much as the US per person on clean energy. Even compared to Germany, which has also paid dearly to curb energy bill rises, the UK is spending 60% less. As well as the scale of investment, the direction of travel is a cause for concern. Overall investment in the UK's clean energy transition fell by 10% last year, compared with nearly a 25% increase in the US.

Government spending per capita on energy in the US, Germany and UK. Data up to December 2022 from the IEA Government Energy Spending Tracker



The UK risks falling behind the competition unless there is a drastic change of course. The 2023 budget does not suggest this is so. Carbon capture and storage will receive "up to" £20 billion over 20 years, but not before 2025 (after the next election). Energy efficiency is set to receive a little over £12 billion over the five years to 2028. On a positive note, the government have mirrored the US in announcing temporary 100% capital allowances in 12 new investment zones. This will particularly help renewables, which have heavy upfront capital costs.

The UK's position in offshore wind manufacturing is also promising, owing to the £160 million of funding pledged under the government's Offshore Wind Manufacturing Investment Support scheme. For example, Siemens have committed to doubling the size of their offshore blade factory in Hull, and plans were recently approved for the world's largest turbine tower factory to be built on Teesside.

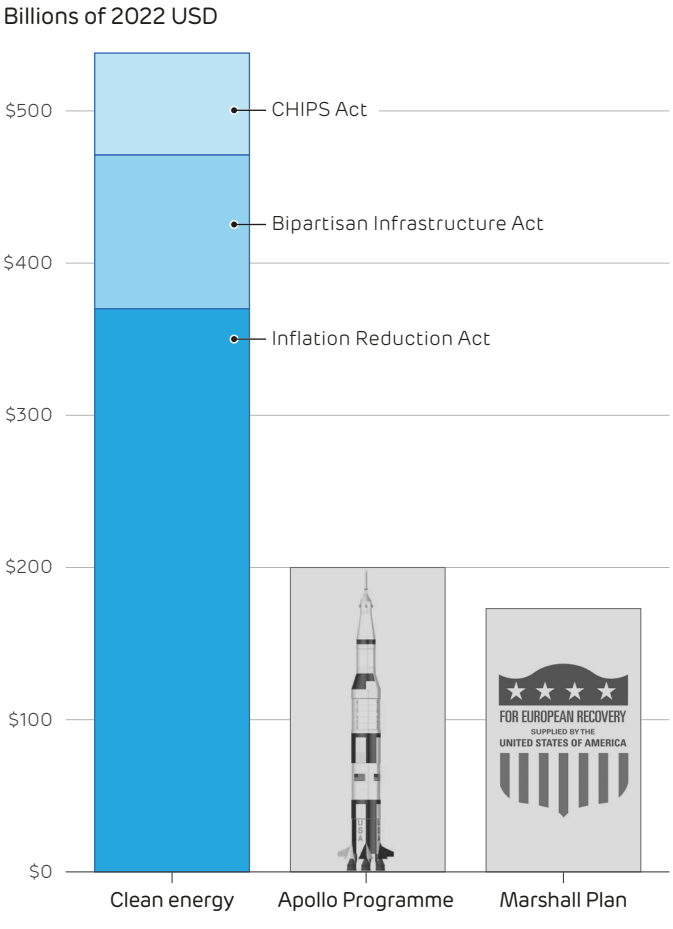
However, delays to the government's Zero Emissions Vehicle (ZEV) mandate created considerable uncertainty around future rates of EV uptake and demand for batteries in the UK, which made it difficult for UK-based EV and battery manufacturers to attract investment. Britishvolt, an EV battery firm, went into administration after failing to secure private investment for their £4 billion gigafactory, while several EV manufacturers have announced plans to relocate elsewhere in Europe. The UK's share of EV production in Europe is now expected to fall from 25% in 2018 to just 4% in 2030.

This gets to a key aim of the USIRA and other legislation: boosting American manufacturing and creating American jobs to counter China's growing dominance in clean energy. China manufactures 80% of the world's solar PV panels, 60% of all wind turbines, and 75% of all lithium ion batteries. The US administration was keen to reverse the decline in manufacturing and in-shore jobs in these growing sectors. In the six months since the IRA passed, clean energy companies announced more than 90 new projects and 100,000 new jobs across the US. These projects include a $4 billion Panasonic battery plant to supply Tesla EVs which alone will create 4,000 jobs, and a $4 billion green hydrogen production facility in Texas which will add another 1,500 jobs. Recent analyses project that the IRA is set to create more than 9 million new clean energy and climate-related jobs over the next decade.

Reshaping a nation's industrial policy is no small feat. It will not be easy for the UK and Europe to respond to this US package: at $538 billion it is one of the largest investment programmes ever seen. One has to look back to the largest infrastructure investments ever made by a country to find suitable comparisons. It cost $25 billion to put a man on the moon in 1969: the Apollo Programme was equivalent to around $200 billion in today's money invested into technology R&D. Similarly, the Marshall Plan devoted $13 billion in 1948 to rebuilding Europe after World War II, equivalent to $173 billion today.

The UK requires a step-change in funding levels, and more consistent support across all elements of the transition if it wants to remain a clean energy superpower.

Size of the current US clean energy spending in comparison to major historical investment projects, in today's money



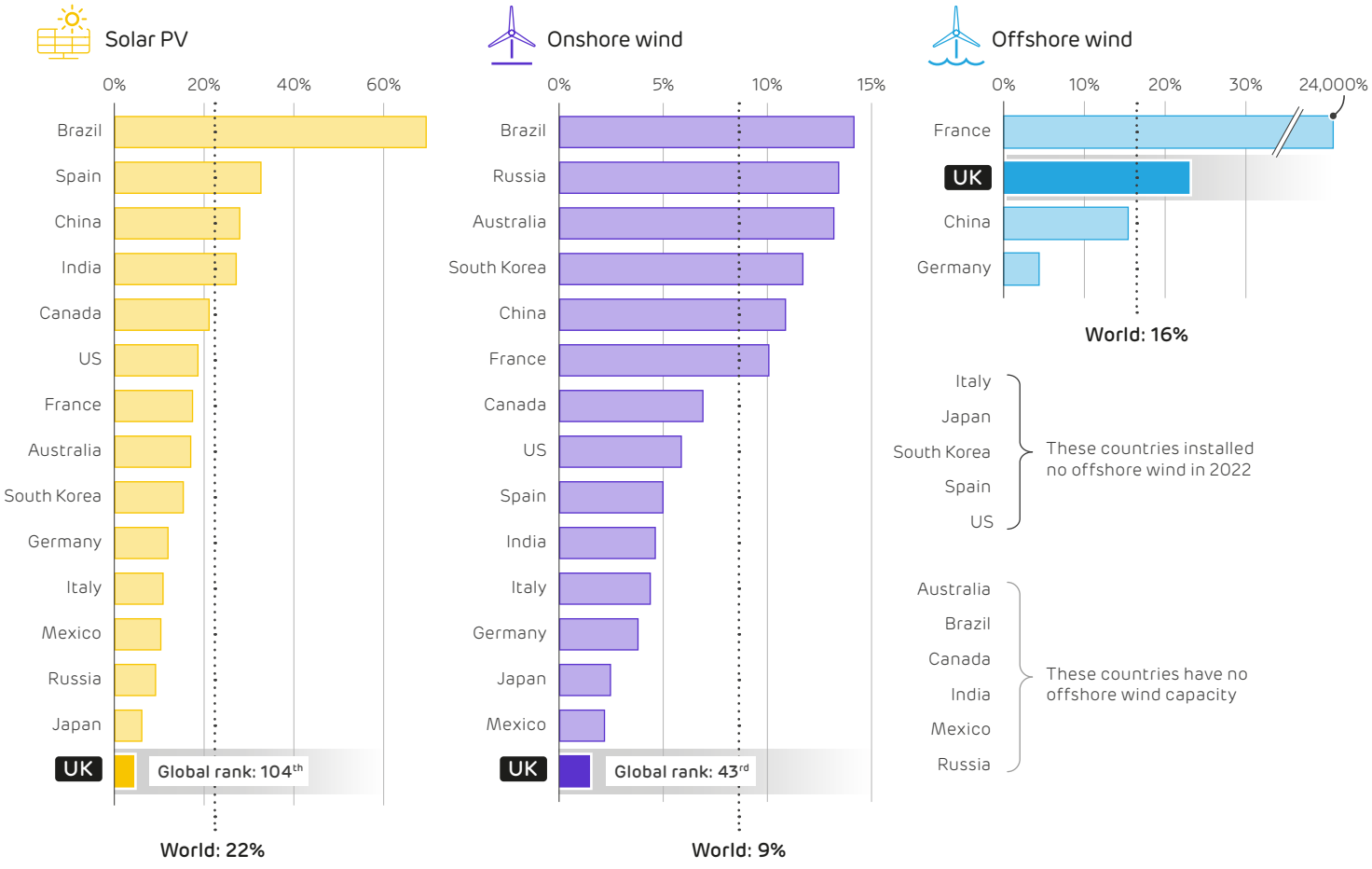
5. UK losing wind and solar leadership

Money is not the only thing that the USIRA and other acts will provide. They also seek to remove the debilitating regulatory barriers to building more clean energy infrastructure. Such barriers have ground the UK onshore wind and solar industries to a halt, so the UK now has among the lowest growth rates in the world.

Regulatory barriers are stifling investment in the UK's clean energy transition. Onshore wind is a prominent example: tight planning restrictions and guidance on where turbines can be sited has ground the once-booming industry to a standstill. Only two onshore wind turbines were built across England in 2022, and despite the incoming Sunak government pledging to lift the ban, only one single turbine has begun construction this year. As onshore wind is one of the cheapest forms of electricity generation in the UK, blocking new onshore wind projects translates to higher costs for billpayers with a recent estimate putting this cost at a 'staggering' £182 per household last year. This has prompted calls for the government to put onshore wind projects back into the Nationally Significant Infrastructure Projects framework which would enable them to bypass local planning requirements. As with fiscal support, regulation needs to change drastically to make the UK an attractive destination for clean energy investors.

Last year's government sought to ban ground-mounted solar farms, but even though that was taken off the table, some projects are stuck in eternal limbo as they are told to wait more than 10 years to receive a connection to the grid. In contrast, wind and solar power are both booming across Europe, in an effort to reduce reliance on imported natural gas and reduce expensive fuel bills.

Ranking of the world's 15 largest economies in terms of annual growth in wind and solar PV capacity in 2022



The UK installed just 3 watts of onshore wind and 9 watts of solar per person in 2022, not enough to run a single low energy lightbulb. In contrast, Finland and the Netherlands installed over 400 watts of wind and solar capacity respectively in the last year.

The UK took an early lead with renewables, and is ranked 14th in the world for installed solar PV capacity. There is more PV in the UK than in the whole continent of Africa (14.4 GW versus 11.6 GW). However, this impressive lead is being squandered. The UK crashed out of the top 100 countries for growth of solar PV, with capacity increasing just 4% last year, well below the global average of 22%. Both Bulgaria and Switzerland (each with populations smaller than London) installed more than the 0.6 GW of PV that the UK managed last year.

The situation is not much better for onshore wind. The UK is ranked 9th in the world for installed capacity, but only 43rd for growth. Capacity increased by just 0.2 GW last year (less than was added in Kazakhstan), giving a growth rate of just 1%, compared to the global average of 9%.

Perhaps a slowdown is inevitable, as the UK invested heavily in renewables early on, and is now 'full' and cannot take any more capacity. While that sounds plausible, Germany has 4 times more solar PV per person than the UK, but capacity also grew a 3 times the pace. The Netherlands is even more extreme, it has 6 times the PV capacity per person, (22.6 GW in a population of less than 20 million), and capacity grew by 50% last year. Similarly, Sweden has recently caught the UK up in terms of onshore wind capacity, meaning it has 6x more per capita, yet capacity still grew 20% last year, 15x faster than in the UK.

Offshore wind is the one area where the UK retains its global standing. With nearly 14 GW of capacity installed, the UK is second only to China, which now stands at over 30 GW installed. Offshore wind is still a growth industry for the UK, with capacity increasing by 2.6 GW last year (more than the entire EU27 combined). Of the world's largest economies, the UK also had the second highest growth rate, increasing capacity by 23%.

The UK is falling behind with its renewable energy expansion, leavings families and businesses vulnerable to escalating bills if natural gas prices continue to move unpredictably. As Europe capitalises on wind and solar resources to achieve energy independence and economic stability, the UK must swiftly re-evaluate and redouble its efforts towards reaching net-zero. Dithering and delay may result in long-term economic repercussions and a diminished role in the global race towards a cleaner energy system.

6. Capacity and production statistics

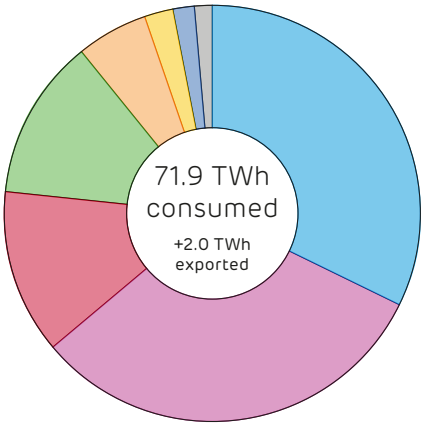
Wind farms produced 24 TWh of electricity over the quarter, up 3% on last year. Gas output fell by 5%, allowing wind to become the largest source of electricity for the first time.

Electricity demand fell by 4% compared to the same quarter last year, in part due to a milder January, but likely also due to high energy prices pushing people to use less. The Department for Energy Security and Net Zero report that overall consumption across all fuels is down by 12% compared to pre-pandemic levels.

Britain now has just a single coal-fired power station in operation, following the closure of West Burton A in Nottinghamshire and the last coal units at the Drax power station in Yorkshire. Half of the country's remaining coal power station capacity retired in the last year.

These announcements coincide with the forthcoming closure of the UK's largest opencast coal mine in Merthyr Tydfil. Britain's last remaining coal-fired power station, Ratcliffe-on-Soar, is due to close in September 2024 following a two-year extension to its availability, marking the definitive end of coal-fired electricity in Britain.

Britain's electricity supply mix in the first quarter of 2023



	Share of the mix
Wind	32.4%
Gas	31.7%
Imports	12.6%
Nuclear	12.5%
Biomass	5.7%
Solar	2.3%
Hydro	1.5%
Coal	1.3%

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

	Installed Capacity (GW)		Energy Output (TWh)		Utilisation / Capacity Factor	
	2023 Q1	Annual change	2023 Q1	Annual change	Average	Maximum
Nuclear	6.4	–1.0 (–12%)	9.2	–2.5 (–22%)	67%	89%
Biomass	3.8	~	4.2	–0.8 (–16%)	51%	99%
Hydro	1.2	~	1.1	–0.1 (–7%)	44%	98%
Wind	27.6	+2.3 (+9%)	24.0	+0.8 (+3%)	41%	79%
– of which Onshore	13.7	~	9.6	–1.2 (–11%)	33%	66%
– of which Offshore	13.9	+2.3 (+20%)	14.4	+1.9 (+15%)	48%	97%
Solar	14.0	+0.5 (+4%)	1.7	–0.3 (–15%)	6%	50%
Gas	27.7	~	23.4	–1.2 (–5%)	39%	88%
Coal	1.8	–2.0 (–52%)	0.9	–0.9 (–51%)	12%	53%
Imports	8.4	+1.0 (+14%)	9.2	+2.5 (+36%)	53%	98%
Exports			2.0	+0.4 (+29%)	11%	69%
Storage discharge	3.1	~	0.6	–0.0 (–5%)	9%	80%
Storage recharge			0.6	+0.1 (+11%)	10%	54%

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

Wind power had a record-breaking quarter, producing more than 20 GW sustained over a whole day on 11 January, and hitting its highest ever peak output the day before. The daily average output from all renewable sources rose above 22.8 GW on 31 January, beating the previous record by more than 1 GW. Conversely, output from all fossil fuels fell to a new minimum of less than 4 GW for the first time on 24 March. Britain also saw its lowest ever carbon intensity of electricity, falling to just 15 g/kWh. Nuclear hit several new minima, having both its worst day and month in February.

The tables below look over the past decade (2009 to 2023) 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 2023. Each number links to the date it occurred on the Electric Insights website, so these records can be explored visually.

Wind – Maximum	Output (MW)	Share (%)
Instantaneous	21,929	68.6%
Daily average	20,002	60.1%
Month average	14,525	40.4%
Year average	8,825	26.8%

Solar – Maximum	Output (MW)	Share (%)
Instantaneous	9,680	33.1%
Daily average	3,386	13.6%
Month average	2,651	10.0%
Year average	1,397	4.4%

Biomass – Maximum	Output (MW)	Share (%)
Instantaneous	3,831	16.8%
Daily average	3,316	12.9%
Month average	2,849	8.8%
Year average	2,216	7.1%

All Renewables – Maximum	Output (MW)	Share (%)
Instantaneous	27,915	72.9%
Daily average	22,875	66.3%
Month average	18,334	51.0%
Year average	12,603	38.3%

Gross demand

	Maximum (MW)	Minimum (MW)
Instantaneous	60,070	16,934
Daily average	49,203	23,297
Month average	45,003	26,081
Year average	37,736	30,709

Demand (net of wind and solar)

	Maximum (MW)	Minimum (MW)
Instantaneous	59,563	3,566
Daily average	48,823	8,385
Month average	43,767	16,663
Year average	36,579	20,572

Day ahead wholesale price

	Maximum (£/MWh)	Minimum (£/MWh)
Instantaneous	1,983.66	–72.84
Daily average	666.90	–11.35
Month average	353.36	22.03
Year average	198.16	33.88

Carbon intensity

	Maximum (g/kWh)	Minimum (g/kWh)
Instantaneous	704	15
Daily average	633	49
Month average	591	135
Year average	508	172

All low carbon – Maximum

	Output (MW)	Share (%)
Instantaneous	35,172	92.1%
Daily average	29,618	85.0%
Month average	23,754	66.1%
Year average	18,287	58.3%

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	1,495	4.1%
Daily average	2,740	8.7%
Month average	7,382	24.3%
Year average	11,336	36.1%

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	2,065	5.6%
Daily average	2,238	6.9%
Month average	3,563	10.5%
Year average	4,956	15.4%

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	0	0.0%
Year average	488	1.5%

Gas – Maximum

	Output (MW)	Share (%)
Instantaneous	27,131	72.6%
Daily average	24,210	62.2%
Month average	20,828	54.8%
Year average	17,930	46.0%

Gas – Minimum

	Output (MW)	Share (%)
Instantaneous	1,403	4.1%
Daily average	2,444	7.7%
Month average	6,775	19.9%
Year average	9,159	24.6%

Imports – Maximum

	Output (MW)	Share (%)
Instantaneous	8,055	28.7%
Daily average	6,810	21.6%
Month average	4,705	15.3%
Year average	3,333	10.3%

Exports – Maximum

	Output (MW)	Share (%)
Instantaneous	–5,662	–20.9%
Daily average	–4,763	–14.1%
Month average	–3,098	–9.8%
Year average	–731	–5.8%

Pumped storage – Maximum[1]

	Output (MW)	Share (%)
Instantaneous	2,660	7.9%
Daily average	409	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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