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A Clean Electricity Scorecard for the G7

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Executive Summary

The UK has been at the forefront of global efforts to decarbonise energy production. The 2021 Net Zero Strategy aims to eliminate unabated fossil fuels from the electricity mix by 2035, on the road to hitting net-zero by 2050. The UK's electricity system has evolved dramatically over the last decade, but the growing range of production sources and the variety of country-specific metrics used in the electricity sector obscures the assessment of how clean power production really is, and how well the UK is doing relative to other countries.

To cut through the complexity, this report introduces a 'Clean Electricity Scorecard' and uses this to compare progress in decarbonising electricity. Three simple, yet critical, metrics are scored as falling behind / almost on track / on track to benchmark progress in the UK and the G7 group of rich nations by 2030:

- **Share of clean electricity:** share of electricity generation met by biomass, wind, solar, nuclear, and other clean sources (below 80% / 80-90% / over 90%).
- **Gross carbon intensity:** grams of carbon dioxide (CO_2) released to produce a kilowatt hour (kWh) of electricity (above 100 / 100-50 / below 50 g/kWh).
- **Net carbon intensity:** carbon intensity after accounting for carbon removals from bioenergy carbon capture and storage (same scoring as for gross carbon intensity).

The UK's clean electricity ambition for 2030 under the Sixth Carbon Budget is ranked almost on track in all categories: making good progress but has ambition to go further. Current progress places the UK third among the G7 nations, behind France and Canada, both of which are on track because of their existing high shares of nuclear and hydro power. The other G7 nations: Germany, Italy, Japan and the US are all falling behind because of their less ambitious 2030 targets (under 80% clean share, over 100 g/kWh). Germany and the US must take the largest steps to progress from their current electricity mix to meet their 2030 targets, but this level of ambition was matched in the UK by the previous Conservative Government's British Energy Security Strategy (BESS) and bettered by the new Labour Government's Clean Energy Mission (CEM)[1]. Implementing the BESS would move the UK from third to second place in the G7 on share of low carbon electricity, and implementing the CEM would put the UK top of the G7 – up from the bottom of the G7 in 2010.

[1] See 'Accelerated clean electricity: Impact on UK climate ambition' report

The UK Carbon Budgets and the Net Zero Strategy

The United Kingdom (UK) was the first country in the world to set a legally binding target for reducing domestic greenhouse gas (GHG) emissions. The Climate Change Act (2008) mandated an 80% reduction relative to a 1990 baseline by 2050. In 2019, the Climate Change Act was strengthened to commit the UK to reducing emissions to net zero by 2050.

In 2021, the UK Government published their Net Zero Strategy which sets out policies and proposals for decarbonising all sectors of the economy by 2050, based on advice provided by the Climate Change Committee (CCC)[1]. Within this, they committed to fully decarbonising its electricity grid by 2035[2] – 15 years earlier than the goal set in the Energy White Paper published in 2020[3]. Achieving this ambition requires that electricity generated from unabated fossil fuels (primarily gas) is rapidly replaced by clean sources like wind, solar, nuclear, hydrogen, and carbon capture and storage (CCS).

Decarbonising electricity supply is fundamental to the UK's Net Zero Strategy, because electricity plays a key role in decarbonising end use-sectors via electrification – the lower the carbon intensity of electricity, the greater the emissions saved. The power sector can play a second role in decarbonising the economy, through the provision of so-called 'negative emissions'. Negative emissions technologies (NETs) remove CO_2 from the atmosphere and can be deployed to offset residual positive emissions that are more difficult to abate (e.g., in aviation and heavy industry). While there are a wide variety of NETs, bioenergy with carbon capture storage (BECCS) – producing electricity or other fuels from bioenergy and capturing the resulting emissions – is the most prominent.

Progress to date

Britain's electricity system has changed considerably over the past 70 years, undergoing three major transitions. In 1950, Britain generated almost all its electricity (97%) from coal. Between 1960 and 1990 the share of oil and nuclear power increased, although coal still dominated. The 1990s saw the so-called 'dash for gas' – by the turn of the century gas had overtaken coal as the Britain's largest source of electricity. The final transition followed the Climate Change Act in 2008, when the share of renewable electricity increased ten-fold from 4% to nearly 40% in 2022. Today, 60% of the Britain's electricity is generated from clean sources (that is, renewables and nuclear) and only a single coal plant remains. Wind has seen particularly rapid growth, recently becoming the largest source of electricity over a single quarter (producing almost one-third of all electricity)[4].

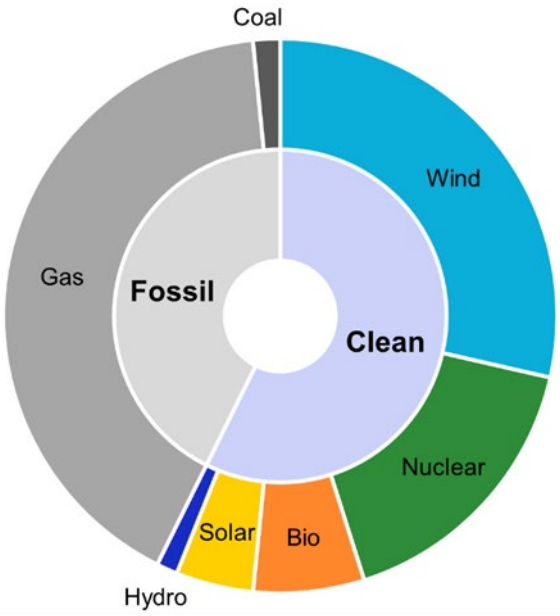

Figure 1 – Clean energy sources contributed three-fifths of Great Britain's electricity mix in 2022[4].

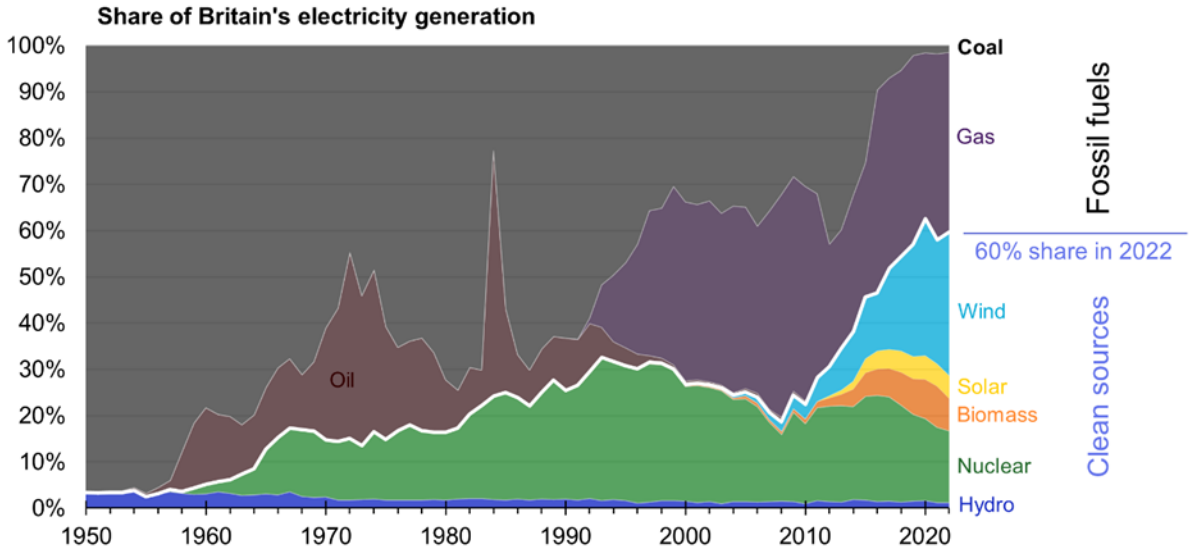

Figure 2 – The radical change in Great Britain's electricity generation mix.

Despite recent successes, there are problems. Development of new nuclear projects has slowed, due to delays and cost overruns. Likewise, growth in onshore wind has been hampered by new policies that place limits on subsidies and planning licences. Nonetheless, offshore wind has been the main catalyst for decarbonising Britain's electricity system in recent years, and the rapid expansion of capacity over the last decade has managed to make up for slowing progress in the deployment of other low-carbon generation.

The carbon intensity of electricity (the amount of CO_2 emitted per kWh of electricity) has followed a consistent downward trend since 1950. Over the 20th century, this decline was driven primarily by improvements in power plant efficiencies and switching to lower-carbon fuels (from coal to oil, nuclear and gas). The decline haltered between the late-1990s and early-2010s, as emissions saved by switching from coal to gas were offset by falling nuclear output. However, from 2012 onwards widespread deployment of renewable energy and coal-to-gas fuel switching drove a rapid decline in the carbon intensity of electricity[5], achieving a record low of 172 g/kWh in 2020.

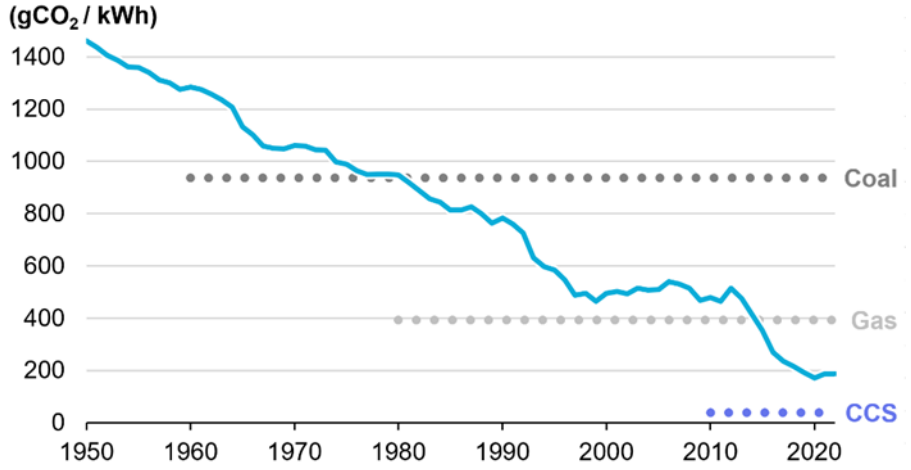

Figure 3 – Carbon emissions per unit of electricity in Great Britain since 1950.
The carbon intensity of modern power stations is shown as dotted lines for reference.

A Clean Electricity Scorecard

There are many ways to measure progress towards decarbonising the power sector, but these are often complex and scenario dependent, impeding the ease of comparing progress between countries. The Conservative Government has committed to fully decarbonise the power sector by 2035, but pledges and details on how this is achieved use a wide variety of metrics (e.g., 50 GW of wind capacity and up to 95% 'low-carbon' generation by 2030)[6]. Capacity metrics say little about how clean an electricity system is, as deploying 1 GW of solar power will have much lower impact than 1 GW of nuclear power (due to intermittency), and definitions of what is 'low-carbon' or 'clean' electricity vary. This makes it difficult to say how clean any one electricity system is compared to another (e.g., today versus 2030 or the UK versus Germany).

To provide a simple measure of decarbonisation progress that can be applied to any electricity system, this work has developed a 'Clean Electricity Scorecard' which uses three key (technology-agnostic) metrics (see Box 1). These three metrics quantify how decarbonised the electricity system is without prescribing any particular route or technology for decarbonisation, differentiating only between gross and net emissions intensities to account for the negative emissions that BECCS may provide for the electricity system in the future.

Box 1 – The three key metrics for the Clean Electricity Scorecard

1. **Share of clean electricity generation**: share of electricity generation met by biomass, wind, solar, nuclear, hydrogen plants, gas with CCS, and BECCS.
2. **Gross emissions intensity**: grams of carbon dioxide (CO_2) released to produce a kilowatt hour (kWh) of electricity.
3. **Net emissions intensity**: emissions intensity of electricity after accounting for Greenhouse Gas Removals such as BECCS, which removes carbon from the atmosphere providing negative emissions credits.

To benchmark progress made in decarbonising the electricity system, we must first consider what is required to be 'on-track' to decarbonising the power sector by 2035. The UK is unique in having an independent advisory body, the CCC, which advises on its economy-wide decarbonisation plans by producing feasible sector decarbonisation pathways to net zero. We use the level of ambition set out by the CCC to benchmark progress to 2030:

- Green (on track) for targets of above 90% clean energy share, and emissions of below 50 g/kWh, as these are broadly compatible with reaching net zero by 2050.
- Amber (almost on track) for targets of above 80% clean energy share, and emissions of below 100 g/kWh, half the levels of green.
- Red (falling behind) for targets below these levels.

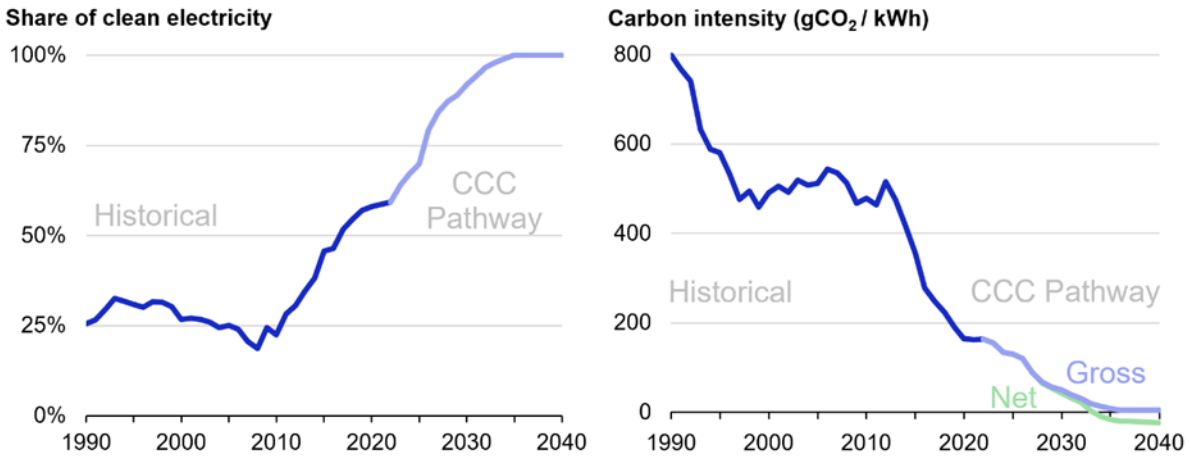

Figure 4 – Evolution of the Scorecard's three metrics over the last three decades, and over the next three decades under the CCC Balanced Pathway.

As the UK's electricity system decarbonisation has outpaced the ambition set out in the Third, Fourth and Fifth Carbon Budgets, targets for deploying clean electricity have been bolstered with each successive budget. In response to the energy crisis following the Russian invasion of Ukraine, the Conservative Government's British Energy Security Strategy (BESS) further increased the UK's clean electricity ambition, notably boosting the commitment from 40 to 50 GW of offshore wind by 2030. As part of their election campaign, the new Labour Government set out even stronger commitments for boosting deployment of low-carbon technologies under its Clean Energy Mission (CEM)[7]. The impact of these commitments has not been accounted for in the UK's Fifth and Sixth Carbon Budgets, and consequently the UK's Nationally Determined Contribution (NDC) for 2030. We explore the impact of this increased ambition briefly here and in more detail in a second report: *Accelerated clean electricity: Impact on UK climate ambition*[8].

International Comparison

The UK has repeatedly been championed as a "clean energy superpower"[9], but does this claim really stand up to the test? In this section, the metrics in this Clean Electricity Scorecard are used to put the UK's progress and scale of ambition into a global perspective.

Just 12 years ago, the UK had the lowest share of clean electricity of any G7 nation; however, between 2010 and 2022 the UK also saw the greatest increase, driven by widespread deployment of wind power. By 2015, the UK had the third highest clean electricity share in the G7 – a position it still holds today – behind only France and Canada (where nuclear and hydroelectric power have long supplied the vast majority of electricity).

The story is similar for the carbon intensity of electricity. Since 2010, the UK's carbon intensity fell by 6.5% per year – faster than any other G7 nation (almost twice the rate seen in the US and three times that seen in Germany and Italy). Today, only two G7 countries have cleaner electricity than the UK: Canada and France. Japan is the anomaly, where the share of clean electricity has decreased and the carbon intensity of electricity has increased since 2010, following the decommissioning of nuclear reactors in 2012 after the Fukushima disaster.

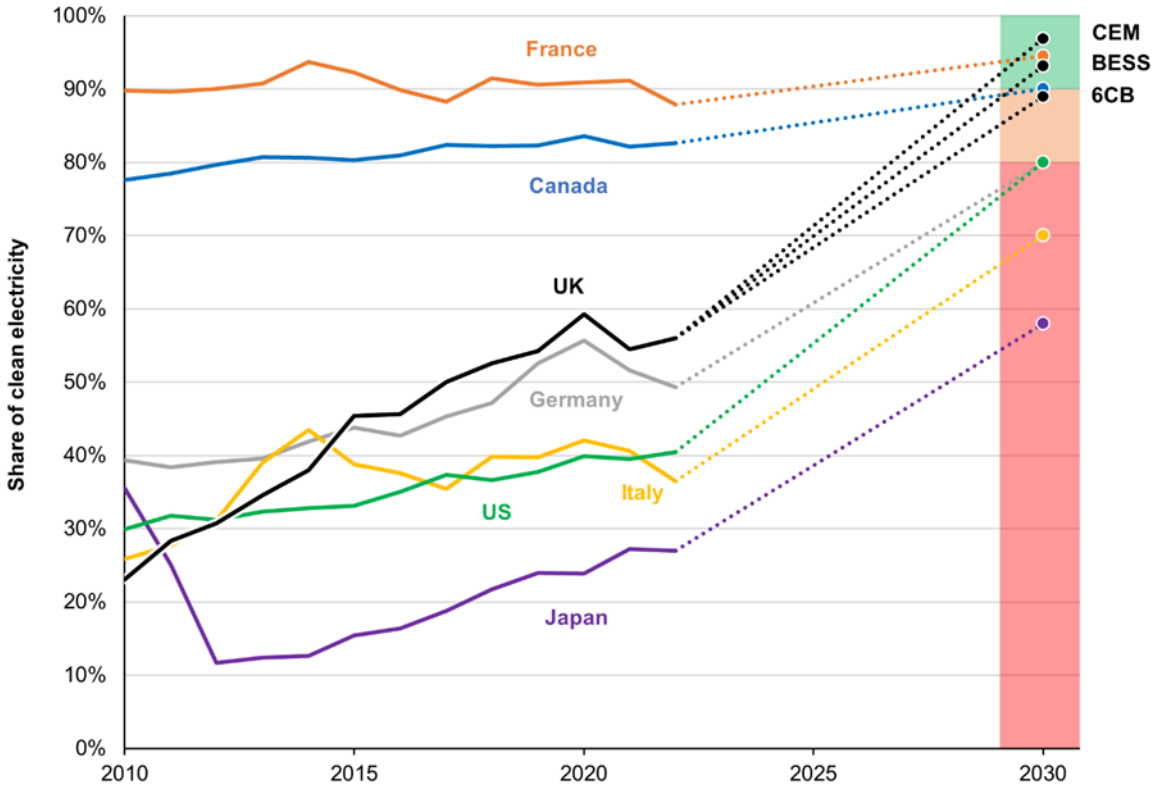

Figure 5 – The Race for Clean Energy: The UK has increased from the lowest to the 3rd highest share of clean sources in national electricity generation since 2010.
Chart shows the change in the share of national electricity supply met by low-carbon sources in G7 Nations between 2010 and 2022, and national targets for 2030.

Yet historical progress is only one part of the story. In June 2021, under the UK's presidency, G7 leaders committed to reaching "an overwhelmingly decarbonised" power system in the 2030s [10]. Following this announcement, the G7 commissioned the IEA to produce a "Roadmap to Achieving Net Zero Electricity Sectors in G7 Members" by 2035 [11]. All G7 nations have set targets for increasing the share of clean electricity in their generation mix by 2030. Given their head start, unsurprisingly the most ambitious targets are in France, who aim for 95% clean electricity in 2030, and Canada. The UK's target of 89%, as of the Sixth Carbon Budget, is not far behind – higher than those for the US and Germany, and well above Italy and Japan. In the terms of our RAG rating, only Canada and France score green, the UK is close behind but only scores amber, and all other G7 countries score red. Note that if the previous Government's commitments in the BESS are included, the UK could reach 93% clean electricity by 2030 moving it to second place and the new Labour Government's CEM commitments would bring this to 97% putting the UK in top position among the G7 [8]. But how difficult are each of these targets going to be to achieve?

Both France and Canada require only a small increase in the share of clean electricity to achieve their 2030 targets – although significantly tackling the last 10% of emission will rely on low carbon thermal stations, such as CCS and/or hydrogen power generation. The UK requires a much faster increase in the share of clean electricity but has also increased its share much faster in the recent past, and is progressing low carbon thermal options. To achieve its 2030 target, the UK must increase its share of clean electricity 50% faster than it

has since 2010 and make progress on deployment of CCUS and hydrogen infrastructure. While no doubt challenging, compared with Italy, Germany, and the US, who must accelerate their deployment of clean electricity by 5-6 times, the UK appears relatively well-positioned with ambitious plans for offshore wind and the transmission grid to connect it. Japan has a less ambitious 2030 target but a much lower share of clean electricity today, hence it must still increase its share of clean electricity 2.5 times faster than it did over the last decade, but with technology cost reductions and energy security challenges could overachieve their ambition. The story on clean electricity shares is much the same for carbon intensity targets, with differences driven by the use of coal or gas.

To reach net-zero power sector emissions by 2035, G7 countries also face different challenges. Most countries must maintain approximately the same annual reductions in carbon intensity required between today and 2030 out to 2035. France, Canada and the UK must maintain reductions of 5, 8 and 16 gCO_2/kWh per year respectively, while the US, Germany and Italy must maintain higher reductions of between 25-30 gCO_2/kWh per year. Again, the exception is Japan, where carbon intensity reductions must more than double from 2030 onwards (from 23 to 51 gCO_2/kWh per year) to achieve net zero emissions in 2035.

Meeting these targets will require enormous investment and there are positive signals. In April 2022, the EU published its RePowerEU plan, to increase the share of renewables in the electricity mix to 70% by 2030, which plans to mobilise around 320 billion USD equivalent worth of funding to realise this ambition [12]. Then in August 2022, the US passed the Inflation Reduction Act which in combination with the Bipartisan Infrastructure Law pledges 370 billion USD (one-quarter of global support pledged since 2020) [13,14].

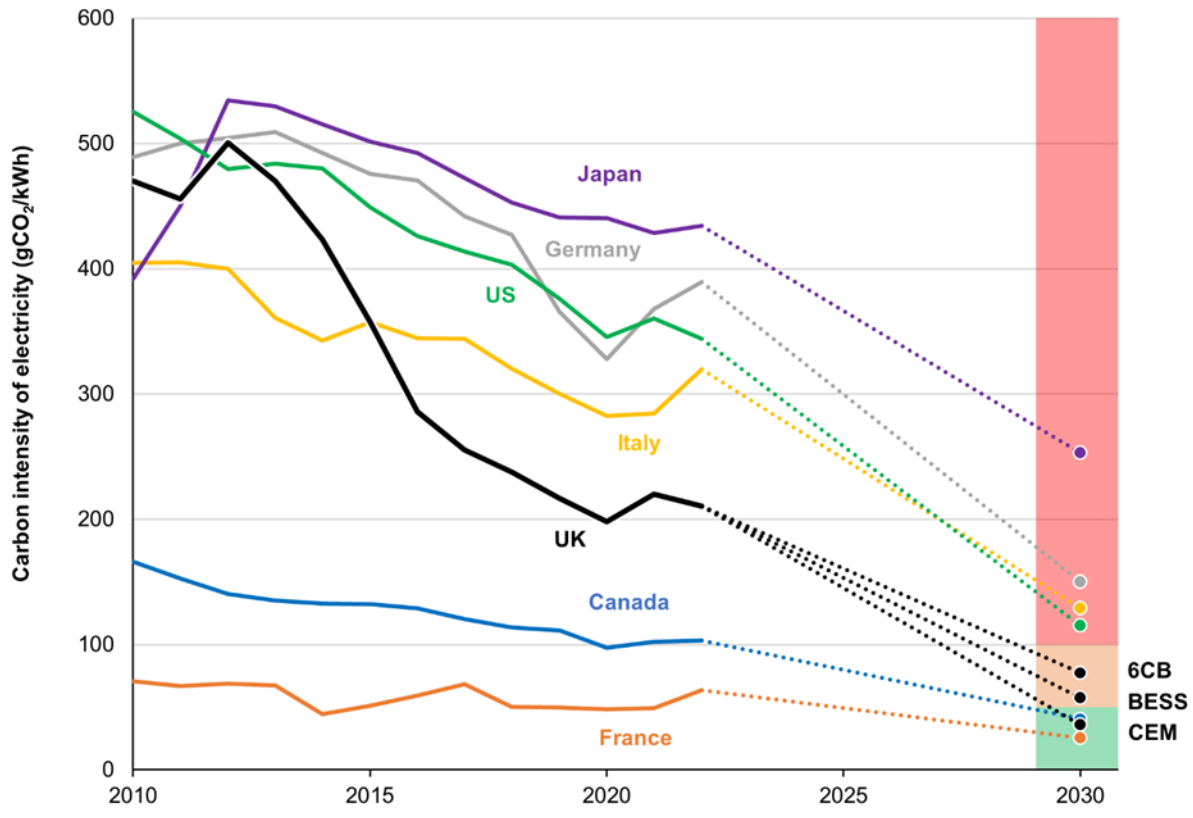

Figure 6 – How Low Can You Go: The UK has more than halved the carbon intensity of its electricity generation since 2010, and plans to more than halve it again by 2030. Chart shows the change in gross/net carbon intensity (in gCO_2/kWh) in G7 Nations between 2010 and 2022, and national targets for 2030.

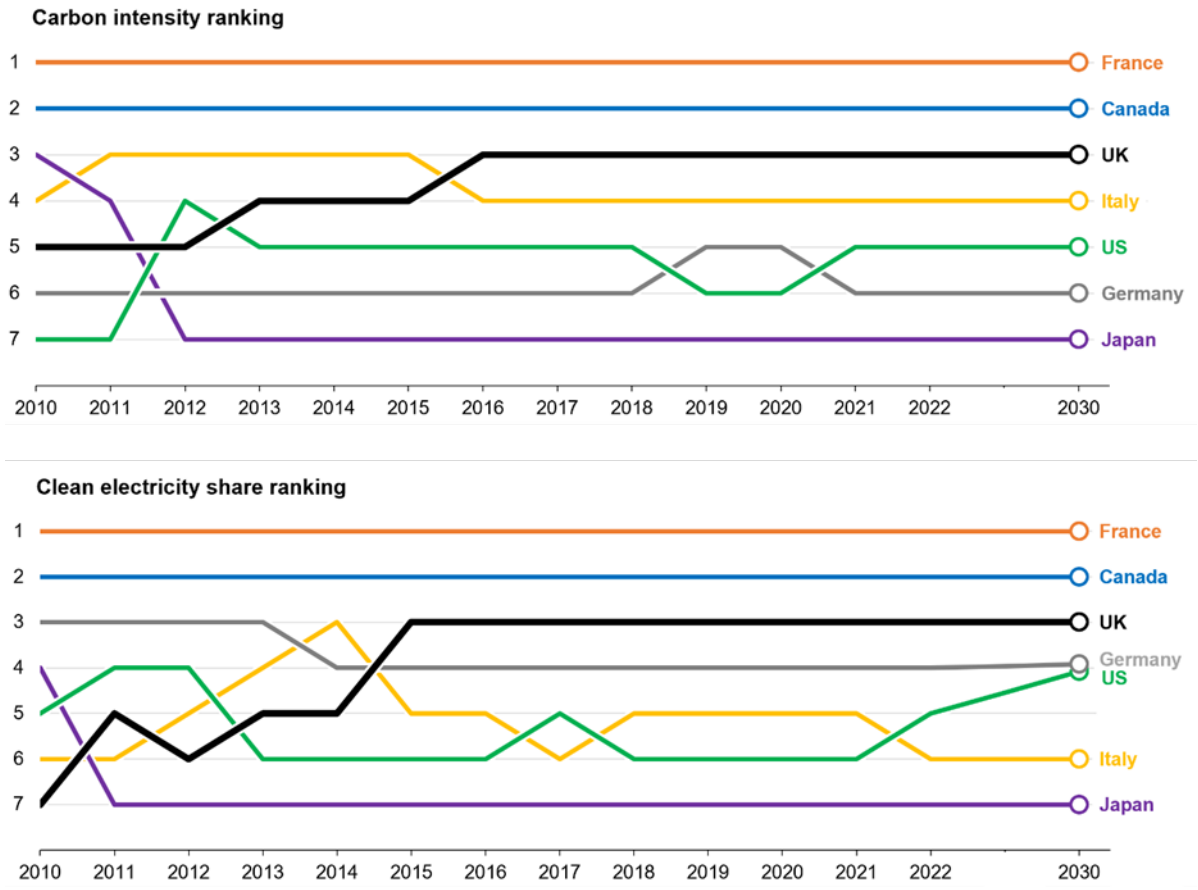

Figure 7 – A Race to the Top: Rank of each country by clean electricity share (highest to lowest) and carbon intensity of electricity (lowest to highest) in G7 Nations between 2010 and 2022, and national targets for 2030.

The UK has not announced such ambitious spending but has been able continues to attract private investment for clean electricity, owing in part to the success of the policy and regulatory framework, most notably the Contracts for Different (CfD) scheme. The UK has almost 100 GW of offshore wind in the pipeline, the second largest globally behind only China [15]; however, the latest round of CfD auctions in 2023 (Allocation Round 5) failed to attract a single offshore wind bid for the first time [16]. In response, the Government increased the maximum strike for offshore wind CfDs by two-thirds to keep the UK's industry competitive with those elsewhere [17]. The UK's Autumn Statement also removed a key barrier to more renewables projects with reforms to expedite grid connections and allocated an additional £960m towards expanding low-carbon supply chains in its Green Industries Growth Accelerator (GIGA). However, it lacked further measures for reducing electricity demand and CO_2 emissions, falling short in comparison to broader green initiatives in the US and EU. It remains to be seen whether the UK can mirror its past success on decarbonisation in the longer-term and retain its position as a global leader on clean electricity.

Conclusions

Decarbonised electricity is a fundamental pillar of wider energy system decarbonisation. The UK has made significant progress in decarbonising its power system, reducing its carbon intensity of electricity by nearly 60% between 2000 and 2022.

This work identifies three key metrics that are used in a Red-Amber-Green (RAG) Scorecard to measure progress and ambition in electricity system decarbonisation: the share of low-carbon generation (%), the gross carbon intensity of electricity generated (gCO_2/kWh) and the net carbon intensity of electricity generated (gCO_2/kWh). These measures cut through interim ambitions and grid-specific contexts to provide a simple assessment of progress that can be compared geographically and temporally, allowing the progress made by the UK to be benchmarked to similar countries.

Although in 2010 the UK had the lowest share of low-carbon generation across the G7, it has also seen the fastest increase and now sits behind only France and Canada (whose electricity systems are dominated by nuclear and hydropower respectively). In terms of our RAG rating, the UK scores amber in low-carbon generation, gross and net carbon intensity of electricity. France and Canada score green and all other G7 nations score red. If the previous Government's most recent commitments are included, the UK moves to green for low-carbon generation, while the new Labour Government's Clean Energy Mission (CEM) ambitions also move the UK to green for carbon intensity. Assessing power systems using these three key metrics provides an effective way to measure the progress of decarbonisation over time, illustrating the different paces at which countries have decarbonised historically and how fast they must decarbonise in the future.

Appendix – Data tables

Table 1 – Carbon intensity of electricity (gCO_2/kWh) in G7 nations from 2010-2022, and national targets for 2030.

	Canada	France	Germany	Italy	Japan	US	UK
2010	166	71	489	405	392	525	470
2011	153	67	500	405	450	504	456
2012	141	69	504	400	534	479	500
2013	135	67	509	361	530	484	470
2014	133	45	493	343	515	480	423
2015	132	51	476	357	501	449	358
2016	129	59	471	344	492	426	286
2017	120	68	442	344	472	414	255
2018	114	50	427	320	453	403	238
2019	111	50	366	300	441	376	217
2020	98	48	328	282	441	346	198
2021	102	49	368	285	428	360	220
2022	103	63	390	320	434	344	210
…							
2030	41	25	150	129	253	115	77
	Under the previous Conservative Government's British Energy Security Strategy (BESS):						*57*
	Under Labour Government's Clean Energy Mission (CEM):						*36*

Table 2 – Share of low-carbon electricity generation in G7 nations from 2010-2022, and national targets for 2030.

	Canada	France	Germany	Italy	Japan	US	UK
2010	78%	90%	39%	26%	36%	30%	23%
2011	78%	90%	38%	28%	25%	32%	28%
2012	80%	90%	39%	31%	12%	31%	31%
2013	81%	91%	40%	39%	12%	32%	35%
2014	81%	94%	42%	43%	13%	33%	38%
2015	80%	92%	44%	39%	15%	33%	45%
2016	81%	90%	43%	38%	16%	35%	46%
2017	82%	88%	45%	35%	19%	37%	50%
2018	82%	91%	47%	40%	22%	37%	53%
2019	82%	91%	53%	40%	24%	38%	54%
2020	84%	91%	56%	42%	24%	40%	59%
2021	82%	91%	52%	41%	27%	40%	54%
2022	83%	88%	49%	36%	27%	40%	56%
…							
2030	90%	95%	80%	70%	58%	80%	89%
	Under the previous Conservative Government's British Energy Security Strategy (BESS):						*93%*
	Under the Labour Government's Clean Energy Mission (CEM):						*97%*

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