Oxford Smith School for Enterprise and the Environment

Policy brief

A clean energy transition powered by modern renewables can turbocharge the UK economy, and net zero transition

Summary

- **Research shows that moving to a clean energy system by around 2050 in line with global climate commitments is expected to save the world at least £10 trillion** ($12 trillion) in energy costs, compared to continuing our current levels of fossil fuel use. This equates to savings of approximately £1,200 per person, based on a population of 8 billion. Additionally, it is expected to save hundreds of trillions of pounds globally by reducing the severity of climate change and associated impacts such as heatwaves, wildfires, storms, and floods.

- **Analysts have consistently and systematically overestimated the future costs of key green energy technologies.** But solar and wind are now the cheapest new sources of electricity in the UK, and globally, and evidence shows that the faster we decarbonise, the faster the costs of clean energy will continue to fall, the larger the savings will be, and the sooner they will be realised.

- **For the UK, as a country with significant net fossil fuel imports, the savings from a fast transition to a decarbonised and largely domestic energy system could be proportionately higher,** while also improving resilience to supply chain shocks. Realising these savings would require policies to focus on ramping up modern clean energy technologies rather than propping up fossil fuels.

- **As the penetration of renewables in the energy system increases, investments in energy storage and flexibility technologies will be required;** however, progress in these technologies is well underway, and integration costs will likely be more than offset by large savings due to electrification elsewhere in the economy. The same innovation and learning dynamics that drive down solar and wind energy costs also apply to batteries, power grid technologies, and some energy storage technologies, including green hydrogen, underscoring the need for investment in these technologies now.

- **The UK, like every other country racing to decarbonise, faces policy challenges this decade. But if the skills transition for UK workers is managed well,** the evidence suggests that green jobs can add higher economic value, may carry a wage premium, may not be as spatially concentrated as high-carbon (non-green) jobs, and that for some technologies green jobs could be more resilient to automation than non-green jobs.

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A fast global transition to clean energy can save trillions

The clean energy revolution has been picking up pace for some time now. Solar energy has fallen in cost by a factor of 5,000 since photovoltaic cells were first used to power satellites in 1958.[1] Wind energy and battery costs have fallen by over 90% since they were commercialized in the 1980s and 1990s. Solar and wind are now the cheapest sources of new electricity generation in most places on earth,[2] and Electric Vehicles (EVs) are now cheaper to run than petrol or diesel cars.[3] In contrast, fossil fuel prices have not improved in the long run – all fossil fuels now cost around the same as they did a century ago.[4] They are also subject to extreme short run fluctuations due to global events, such as the skyrocketing prices following Russia's invasion of Ukraine, leaving importing countries vulnerable to severe economic disruption. The data shows that modern clean energy technologies experience strong improvement trends due to innovation and technological progress, but fossil fuels, nuclear energy, carbon capture and storage, and blue hydrogen do not.[5]

Standard energy system models have failed to capture these technological progress trends, and have systematically overestimated the future costs of key clean energy technologies. For example, in 2010 the IEA projected that solar energy would cost $260 per megawatt-hour in 2020.[6] In 2020 the actual cost was $50 per megawatt-hour, well below the global average cost of gas- or coal-fired electricity[7]. Most of the models used to inform the Intergovernmental Panel on Climate Change have similarly overestimated key green technology costs, and there is now an urgent need to update policy makers' and the public's beliefs around the low costs of clean energy technologies. By underestimating clean energy cost declines, conventional models have acted as a brake on the pace and efficiency of the net-zero transition. This is because they fail to fully consider 'learning effects', also known as 'experience curves', which describe a well-known pattern in which cost declines are associated with increasing cumulative production, as each element of the production value chain accrues more 'experience'.[8]

Way et al (2022), at the Institute for New Economic Thinking (INET), Oxford University, developed a new, empirically-grounded forecasting method for incorporating this effect into estimates of renewable energy deployment costs and rates, applying it to historical data for solar, wind, batteries, and electrolysers used to produce hydrogen from electricity. This shows that clean energy costs will very likely continue to fall and *the more widely used these technologies become, the faster this will occur.*[9] Analyses from three scenarios for meeting global energy needs until 2070 ('fast' transition transition, 'slow' transition, and 'no transition', all from the current fossil fuel based energy system), show that a 'fast' transition scenario*[10] - generates savings of US$12 trillion (around £10 trillion) compared to 'no' transition, or US$8 trillion more than a slow' transition. A fast transition is cheaper at all reasonable discount rates;**[11] and cheaper energy input costs would also be expected to raise future GDP – cheaper factors of production (such as energy) create greater production possibilities and expand the overall size of the economy. Higher associated green infrastructure costs (which include more jobs) in the short-term are more than offset by fast-forwarding to cheaper renewable energy.[12]

Clean energy can similarly accelerate the UK's net zero transition

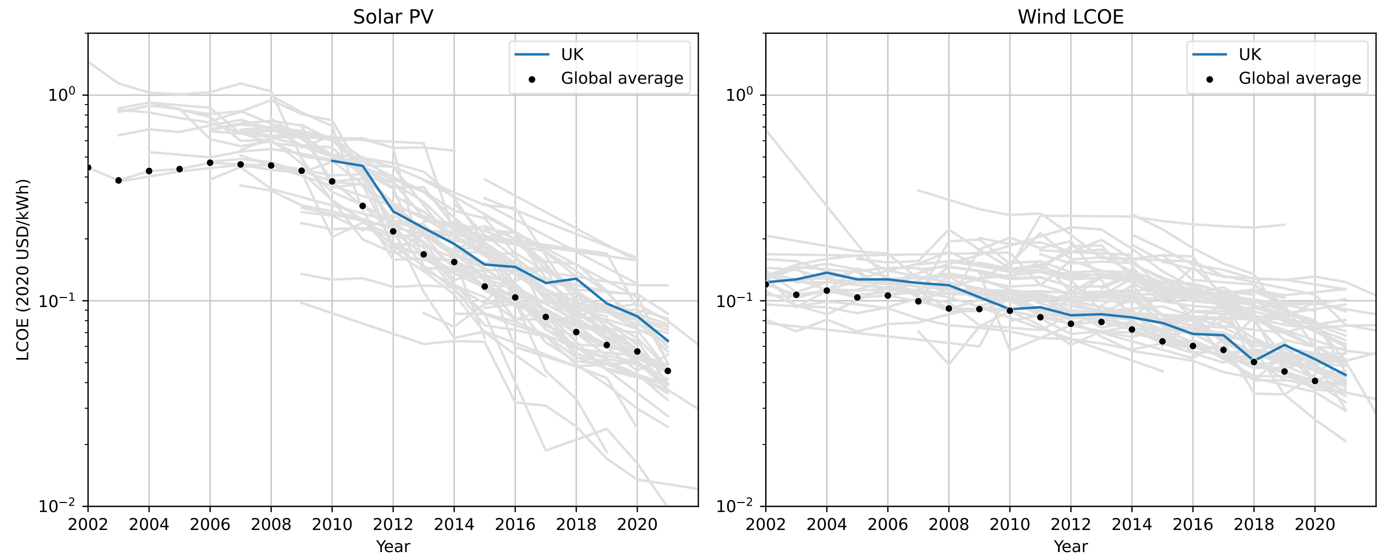
What does this imply for the UK? With the country now well into the critical decade that could make or break its legally binding goal of reaching net zero by 2050, legislated by the Climate Change Act fifteen years ago, and also facing a cost-of-living crisis, policymakers should look to the science to guide policy direction. New analysis shows that out of over 60 countries, cost declines for solar PV and onshore wind in the UK have closely tracked global average costs (and cost declines) (see Figure 1).

For example, between 2010 and 2020, solar PV costs in the UK dropped 87%, exceeding the global average cost decline of 85%. Similarly, the cost decline for onshore wind in the UK (despite a *de facto* ban) between 2010 and 2020 (52%) closely aligns with the global average (54%). This suggests that the global forecasts of savings from a fast transition from Way et al. (2022) could inform outcomes for the UK, in terms of its own savings potential from a fast transition to net zero. In a fast global transition, we expect an additional cost reduction of ~50% for solar PV and ~20% for onshore wind by 2030, with respect to today's costs.

* In which 90% of the world's electricity is generated from zero carbon sources and 81% of final energy is provided by zero carbon sources (based on the above technologies) by 2040 (Way et al, 2022a; 2022b).

** The discount rate is the rate at which we value the future costs and benefits of climate action compared to costs and benefits today. When policy makers apply high discount rates to climate initiatives, it tends to undervalue their future benefits. See Way at al. (2022a; 2022b) for details.

Figure 1: Declines in the Levelised Cost of Electricity (US$/kWh) – UK and Global Average.



Source: Consolidated industry reports; [13] data are shown in logarithmic scale

Given an optimal mix of policies and incentives, the UK could aim to get to net-zero before 2050, for three key reasons:

First, the UK is already advanced in renewables deployment, with electricity production that is cleaner than average, globally. UK electricity had an average carbon intensity of 268 grams per kilowatt-hour (gCO_{2e}/kWh) in 2021 versus the global average of 484 gCO_{2e}/kWh, making it nearly 50% 'cleaner' on average than it was when the 2008 Climate Change Act was passed, compared with a global average reduction of 8%.[14]*** Developers of renewable energy continue to build on previous plans and to innovate, driven by early and evolving incentives for renewable technology deployment such as Contracts-for-Difference.[15] The UK has a pipeline of (operational and forthcoming) wind energy, including nearly 100 Gigawatts (GW) of offshore wind[16] and 37 GW onshore wind.[17] It also has a large and reliable wind resource potential with a broad match between existing patterns of electricity demand and wind power availability: demand is higher in winter and during the day and early evening, a pattern that broadly coincides with the seasonal and diurnal availability of wind power.**** Crucially, the evidence shows that the same economic dynamics that drive the costs of solar panels down work for batteries and technologies to store energy including hydrogen, which are required to deal with intermittency.[18]

Despite heated debates over the future forms of electricity market design and energy system operation,[19] regulators and grid operators are advancing their plans for accommodating variable renewables – for e.g., through plans for a Future System Operator[20] - prompted by increasing public scrutiny and policy guidance from organisations including the Climate Change Committee.[21] An Expert Group on net zero electricity market design convened by the Committee last year has stated that the biggest challenge in the 2020s will be mobilising the huge investment***** needed in low carbon generation, storage and networks; whereas in the 2030s the biggest challenges will be the efficient operation of the low/zero carbon electricity system (with a much more dynamic demand side).[22] The enabling infrastructure, particularly networks, is critical to deployment.

Second, key end-use sectors, such as transport and buildings, are ready for rapid decarbonisation technologically and economically, but a clear policy push is lagging, and there are significant gains that could be made. The EV fleet has grown rapidly, with affordability and acceptability rising. For example, just 0.4% of all new vehicles registered were electric in 2016; by 2022, this had risen to 16.6%, with EV sales growing by a record 60% year-on-year in April 2023.[23] There is scope for significant efficiency improvements through simple upgrades (for e.g. through home insulation) to a poorly insulated buildings stock – for instance, around 59% of homes in England alone were rated D' or below on their Energy Performance Certificates in 2022, with these households estimated to be incurring an inefficiency penalty' of £900 per annum on average, as a result.[24] Similarly, the uptake of heat pumps is gradually rising in the UK despite being among the lowest rates in Europe;[25] but it needs a combination of government support and policy incentives******, and continued

*** The CCC's Balanced Net Zero scenario (Sixth Carbon Budget) requires it to drop to 2 gCO_{2e}/kWh by 2050.

**** Although climate change could alter these patterns (for e.g., through longer periods of wind drought).

***** The CCC estimates that low carbon investment must scale up to £50 bn each year.

****** For example, shifting the collection of 'green' levies from electricity bills to gas bills.

learning and innovating by manufacturers, to drive down costs.[26] **And third**, the UK does not have a lot of hard-to-decarbonise industry (e.g. cement; steel), relative to many other countries, and therefore less worry around a loss of competitiveness, or stranded' skills.[27]

Common arguments made against an earlier UK net zero transition date include: (i) the risk of carbon leakage (where emissions continue but simply move offshore), and (ii) an earlier net zero UK transition will do nothing to speed up the global net zero transition, given the UK's relatively small size.

There are three important counter-arguments here: **first**, there are early mover advantages from acting fast – capturing international competitive advantage in green products and services, and benefitting from spill-overs from technology developed and patented in the UK. Policy tools developed at Oxford that measure which countries have the capability to export the most 'green' complex products in the future green economy, rank the UK among the top ten.[28] Other, related research, shows that UK export potential for low-carbon goods (e.g., energy storage; low emission vehicles; energy efficiency technologies), is estimated to range between £59 bn - £154 bn by 2030, and £186 bn - £494 bn by 2050.[29] Even if the UK is not a leading innovator in these sectors, they are likely to expand with such significant global potential that, it is argued, securing even a small share of them could boost UK export values.[30]

Second, while it is of course correct that the UK is a small percentage of global emissions, its action at home provides credibility to successful diplomatic efforts to support other countries to move faster, which is in its interests.[31] **And third,** economically-advanced countries should move faster given their greater capability, resources and historical role in causing the problem.[32]

A fast clean energy transition managed well will make the UK more, not less resilient to future price shocks

The UK undoubtedly faces challenges in rapidly deploying clean energy, such as ensuring that the buildout of clean energy infrastructure takes place at a level pace with the operationalisation of new renewable power production, and building in systemic resilience to future potential impacts of climate change on the clean energy system (e.g., wind patterns).[33] As an example, long waiting times for grid connections (up to 15 years) have added to planning delays, but are beginning to be addressed by the energy regulator (Ofgem) which has a legal mandate to prioritise *net zero*.[34]

Arguments against a fast net zero transition also deploy reasons of energy security. These state that to ensure supplies of affordable energy, storable forms should be easily available or in reserve (e.g., stockpiles of coal, gas, and oil). Therefore, moving away from investments in new domestic production of fossil fuels could require the country to import greater amounts of energy in response to future energy price shocks, and hence domestic fossil fuel extraction should continue. However, these arguments perpetuate fossil fuel dependence, and increase the vulnerability of the UK economy, which is a net-importer of energy, to future price volatility.

Gas prices are set on international markets through indexation to price hubs such as the National Balancing Point' in the UK.[35] For domestic or imported gas, UK consumers would pay hub (or market-determined) prices with the differential being the costs to transport gas from an exporting country. International fossil fuel markets are fairly deep and liquid, and hence the UK should be able to easily access them whether it extracts its own fossil fuels or not. Domestically extracted fossil fuels may simply add (positively) to the UK's balance of payments position, rather than improving its energy security.

Wind and solar are domestic, and once installed, they increase energy security in the sense that they are local; however, they do create the need for significant energy storage. This is solvable, but requires an immediate policy push. In 2022, the UK met around 26% of its electricity demand from windfarms******* [36] and had electricity prices not been set at the margin by the high price of fossil gas, this may have been passed on through lower consumer bills.

Delay in transitioning to clean energy has also cost UK taxpayers – for instance, between September 2021 and January 2023, an estimated £89bn (Euro 103 bn) of funding (around 3% of GDP) had been allocated by the UK government to shield households and firms from rising energy prices and their consequences on the cost of living.[37]Analysis shows that had climate policies – such as support to improving energy efficiency – not been scrapped in 2013, the UK's *net* gas imports would have been 13% lower than they were when the war in Ukraine began.[38] Continuing investments into fossil fuel infrastructure rather than in building clean energy systems also makes less financial sense; for instance, Oxford research shows that globally, renewable electric utilities with a higher share of solar and wind power capacities have a lower cost of equity and debt than fossil-fuel focused peers, with the effect particularly pronounced for Europe.[39]

Other cautionary voices on accelerating the net zero transition rightly cite the need to ensure a just transition for workers in the UK's matured hydrocarbon industries. Around 214,000 jobs are estimated to be directly and indirectly supported by the offshore oil and gas industry.[40] ******** If the skills transition is

******* Also see "Britain produced record amount of wind power in 2022, National Grid says', *Reuters,* January 6, 2023.

******** The total UK workforce (16+) is estimated at around 30 million. (House of Commons Library (2023) UK Labour Market Statistics, May 2023; ONS (2023) Labour Market Overview – UK, May 2023, Office of National Statistics.

managed well, the evidence thus far suggests that green' jobs tend to pay a wage premium – but this premium appears to be higher during the earlier stages of the 'green' transition, and has declined over time.[41, 42] For some technologies, 'green' jobs could be more resilient to automation than 'non-green' jobs,[43] and evidence from the UK suggests that they also tend to be more geographically dispersed than high-carbon jobs which are regionally concentrated.[44] ******** As governments across countries similarly face the challenge of transitioning their hydrocarbon industries, UK policymakers have the advantage of drawing on detailed lessons from recent history chronicling the impact of the coal industry's demise on coal workers and wider communities that continue to be affected,[45] and to use this opportunity to design a just socioeconomic transition to the clean energy age.

Conclusion

The belief that the green energy transition will be expensive and decrease energy security has been a major driver of the ineffective response to climate change, and delays in the adoption of green economic policy, for the last forty years; the evidence clearly shows that this pessimism is at odds with past technological cost-improvements, and other trends.[46]

Drawing on existing research and new data, this policy brief has argued that the UK can benefit from a well-managed green transition due to its advanced renewables deployment, falling costs in solar PV and onshore wind, export potential for 'green products' and low carbon goods, and potential for green' jobs. A well-managed clean energy transition can make the UK more energy-secure and resilient to future price shocks.

******** It should be noted that definitions of 'green' and 'brown' vary and are not consistent across studies, and that the transition from 'brown' to 'green' may not be linear.

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