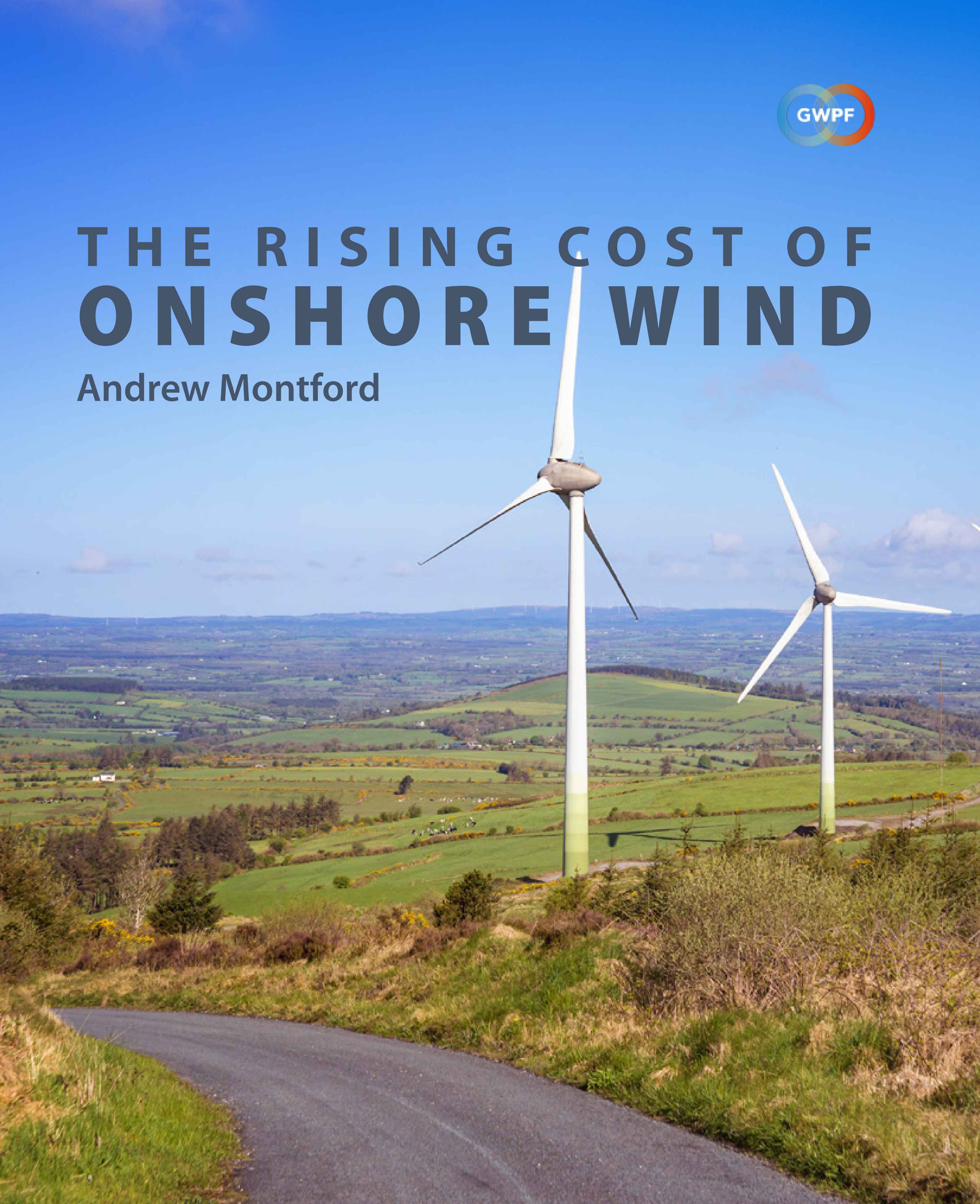

THE RISING COST OF ONSHORE WIND

Andrew Montford

The Global Warming Policy Foundation
Briefing 59

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About the author

Andrew Montford is deputy director of the Global Warming Policy Foundation.

1. Introduction

My recent paper on offshore wind[1] set out the extraordinary discrepancy between the levelised cost of electricity (LCOE) as revealed by accounts data and the claims made by advocates of green energy, including official bodies like BEIS and the Committee on Climate Change. This paper will look at estimates of the LCOE of onshore wind.

As in the earlier paper, I will examine claims made by the Department for Business, Energy and Industrial Strategy (BEIS),[2] Bloomberg New Energy Finance (BNEF),[3] the International Renewable Energy Agency (IRENA),[4] and the merchant bank, Lazard.[5] As in the previous paper, I will refer to these organisations collectively as 'the advocates'.

I will compare the advocates' claims to my own estimates of LCOE, based on Ofgem's generation figures and data published in audited financial accounts, and the recent comprehensive review of UK windfarm financial accounts by Hughes.[6] My sample includes all UK onshore windfarms larger than 25 MW for which accounts are available, approximately 40% of windfarms of that size.[7]

I will look at disaggregated capital and operational expenditure estimates, capacity factors (a measure of what proportion of maximum capacity that is delivered each year), as well as the levelised cost, which brings these parameters (and others) together. For each component, I will look at different views on the history, the current position, and the predictions that are being made about its future evolution.

It is worth repeating my earlier caveats. LCOE has been strongly criticised when applied to intermittent energy generators such as offshore wind, because it presents a misleadingly optimistic view.[8] Nevertheless, renewables advocates and the media continue to use it as a way to make claims about the viability of such technologies. However, this paper will show that the claims of renewables advocate are unfounded, even on an LCOE basis.

2. Capital costs

Figure 1 shows views on the history of onshore windfarm capital costs per megawatt of capacity. The blue dots represent data extracted from the financial accounts of large UK onshore windfarms.[9] The upward trend since the start of the century is clear. It is notable that Hughes' dataset, which covers windfarms of all sizes, finds a very similar pattern. The two lines represent the positions of IRENA and BNEF.[10] Both show a remarkably different pattern. This may partly be due to the length of the two series, going back to the very earliest days of the wind power industry, when small experimental facilities were the norm. Nevertheless, the failure of both organisations to detect the steady increase in the cost of a megawatt of wind turbine capacity that is shown in both the GWPF and Hughes datasets, both of which are based on audited financial statements, is surprising. One possible explanation is that the data for both of the advocates' graphs is for a global average, whereas the GWPF figures are only for the UK. Another possibility is that, while the GWPF figures are only for larger windfarms, the advocates do not mention any restriction on size. Thus the

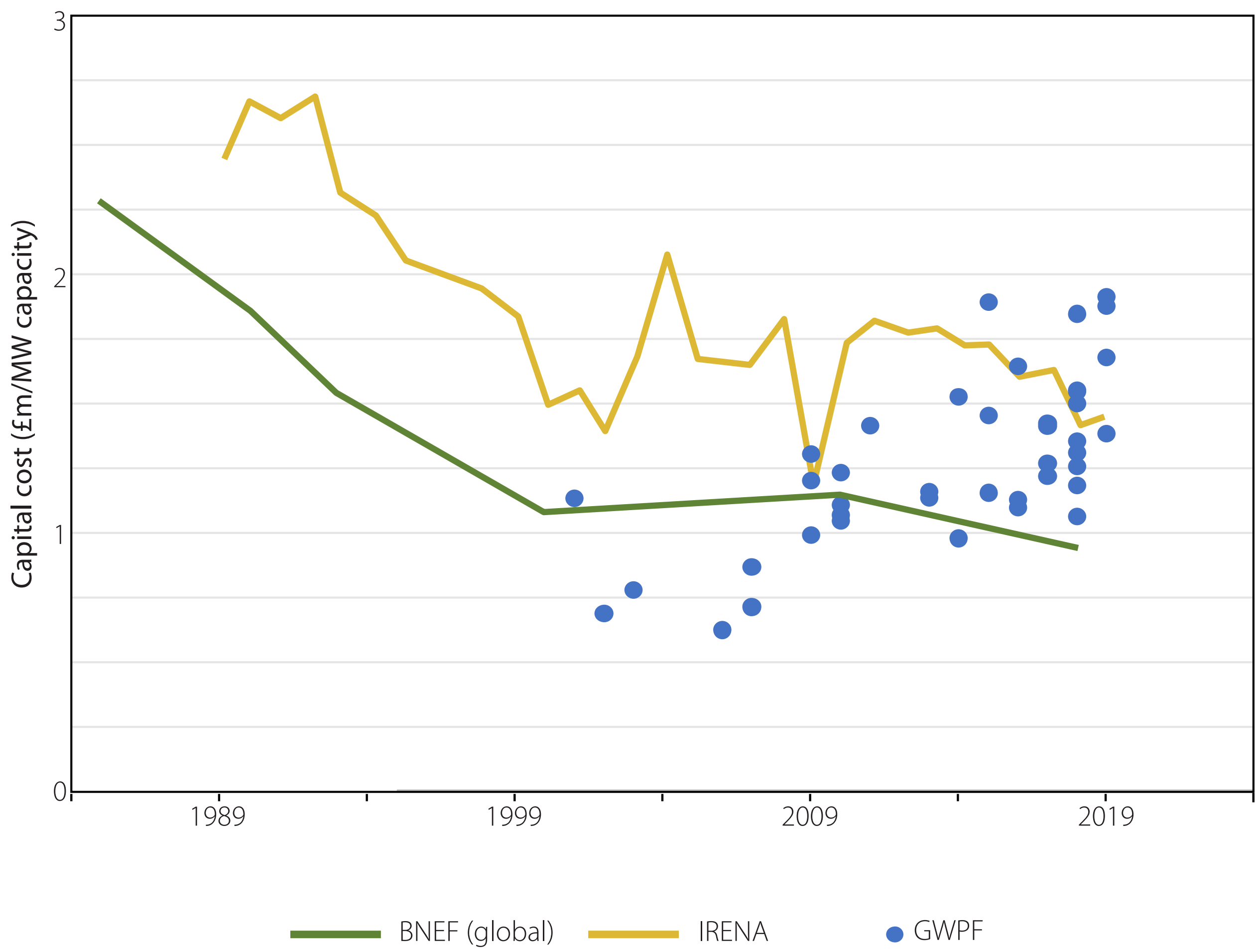

Figure 1: Capital costs: views on the history

apparent decline represented in the advocates' graphs may merely reflect a greater preponderance of large windfarms rather than an underlying fall in costs. Nevertheless, it is noteworthy that both of the advocates find little change in the capital costs of onshore windfarms in the last twenty years.

But what about predictions of future capital costs? Figure 2 shows the GWPF data again for reference, and then adds advocates' views on how they expect those costs to change in future. The predictions include those from BEIS and Lazard. Note that the Lazard data is for the USA, but the others, including BNEF, are for the UK alone. It is clear that all of the advocates believe that the 20-year upward trend in capital costs reversed last year. They are expecting the average cost for windfarms commissioning in the next few years to be more than 40% below the average for the last five years. The disconnect between past and future is striking, and makes their predictions less than convincing.

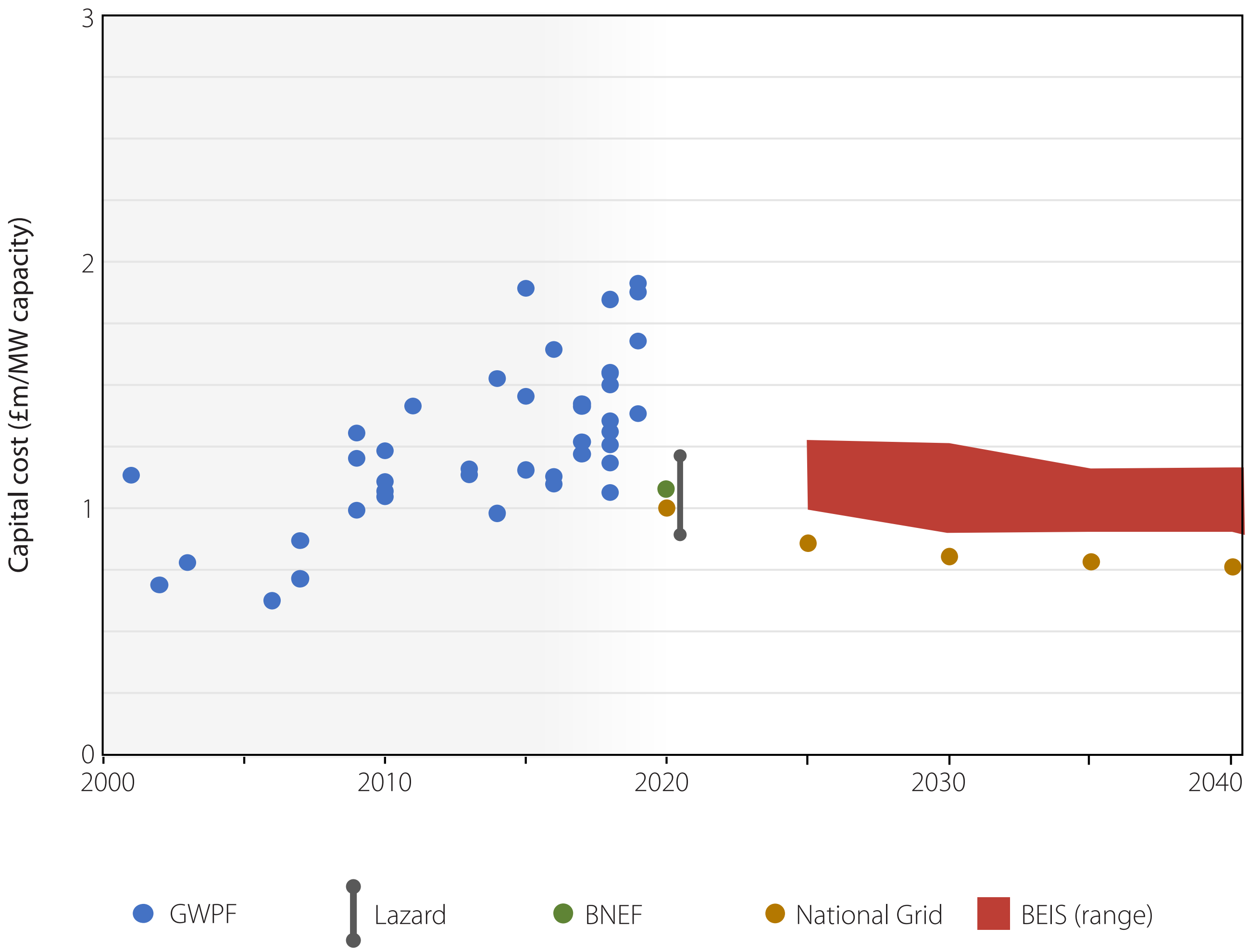

Figure 2: Capital costs: predictions

3. Operational costs

Figure 3 shows the moving average operational costs per megawatt of capacity, for larger windfarms in the UK, by year of operation. More recent windfarms are readily identifiable as the shorter data series. It is clear at a glance that the operational costs for any given windfarm increase year by year as the turbines age. It also seems that the cost per megawatt of capacity is higher for more recent windfarms.

We can extrapolate the trends in these data to estimate an average opex per megawatt hour over the 20-year lifespan of the the windfarm. Figure 4 shows the results, plotted by commission date. There is clearly an upward trend over time. In other words windfarm opex is becoming more expensive, even after correcting for inflation. This observation is consistent with Hughes, who notes that the trend is still upwards – at a remarkable rate of 2.8% per year – even after correcting for turbine size.

However, there is an interesting contrast with IRENA, who say they can detect a steady decline in opex costs in windfarms in a selection of EU countries (excluding the UK) and the USA. The range of these estimates is indicated by the yellow bars in Figure 4.

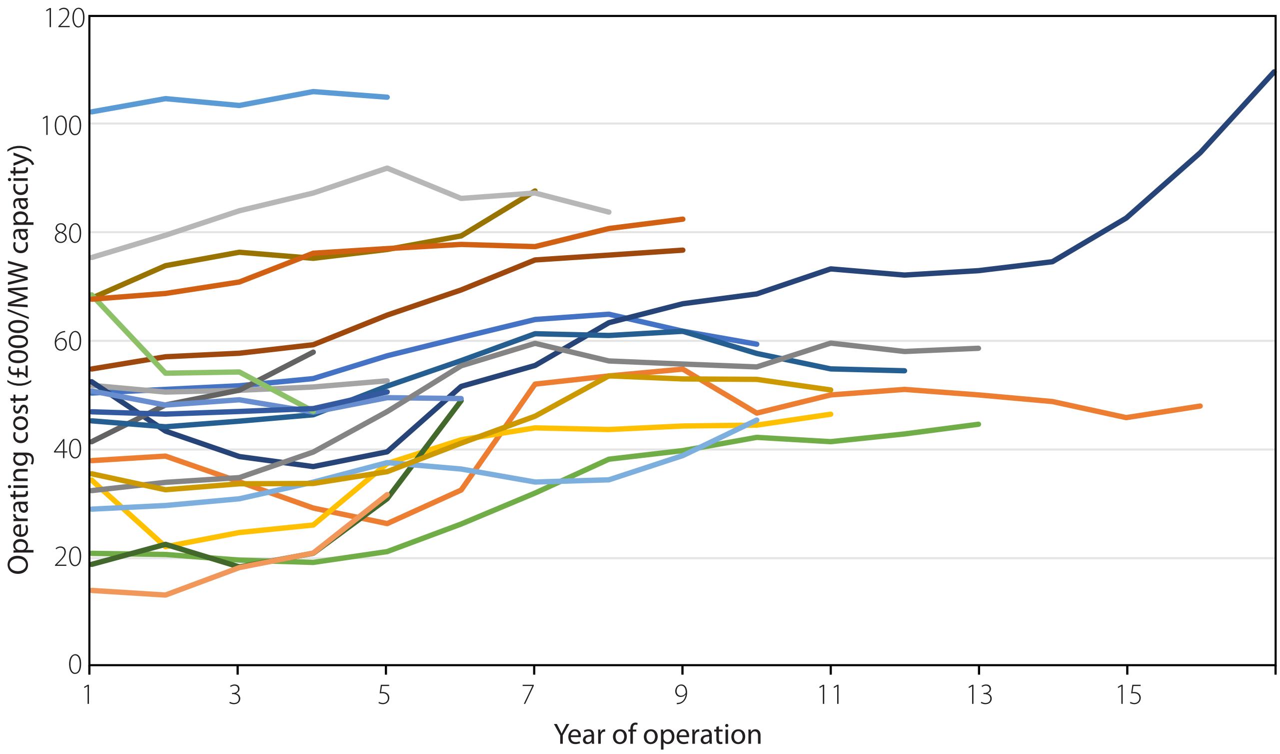

Figure 3: Operating costs: history

Three-year moving averages from accounts data. For clarity, the data shown are a subsample of the full GWPF dataset, covering only windfarms greater than 40 MW capacity.

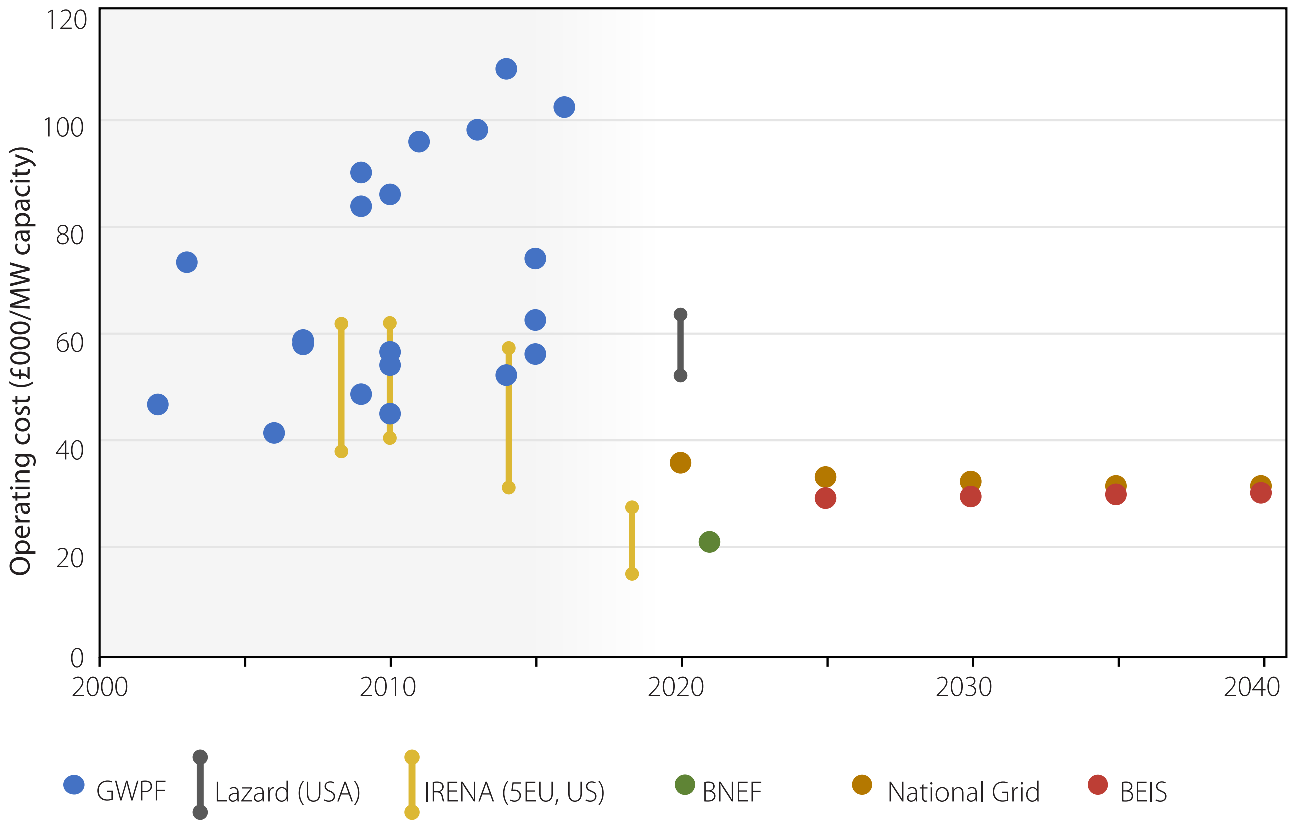

Figure 4: Operating costs: history and predictions

GWPF figures are estimated average annual opex per megawatt over a 20-year liftime. The IRENA figures and the predictions are assumed to be on the same basis.

Figure 4 also shows the opex predictions made by the advocates. The disconnect between the historical data and the claims about the future is again extraordinary, with none of them appearing plausible given the history. It is possible that some of the advocates' figures actually represent first-year figures. If so, a 5% annual growth rate might lead to a lifetime average that was 60% higher. This would make the figures more plausible, but still very low.

4. Financing costs

It is generally agreed that financing costs have fallen, as investors have decided (rightly or wrongly) that the risks associated with windfarms have fallen.

5. Capacity factors

No electricity generator produces 100% of its capacity over the course of a year. Even gas-fired power stations have to shut down for maintenance, although they can still deliver over 90% of that theoretical maximum over a year, if given the chance. The percentage of the maximum that a generator delivers is known as the capacity factor or load factor. In the UK, the data in this area is excellent: it is possible to calculate capacity factors for all grid-connected windfarms from data in a publically accessible database.[11]

Renewables deliver much lower capacity factors than fossil fuels. As they age, their output deteriorates, as can be seen in Figure 5, although for some windfarms there is a period in the early years in which operators seem to optimise the performance of their turbines, and capacity factors increase. Most large onshore windfarms never achieve a capacity factor above 30%, and those that that do, only do so for a few years.

The two advocates that do portray the history of onshore wind capacity factors are IRENA and BNEF. Their data are shown in Figure 6, although note that BNEF's figures are global, not just for the UK. Both organisations discern a steady improvement, with figures of 35–40% achieved in recent years. This rise suggests that the graphs represent first-year (or early-years) performance rather than a fleet average, in which the poorer performance of older windfarms would tend to reduce the average.[12] The figure also shows recent performance of the whole UK onshore windfleet. The dark blue line is the average achieved by new large windfarms each year, where 'new' is defined as windfarms commissioned two years earlier (so as to allow time for teething problems to be resolved). The other two lines represent the capacity factors

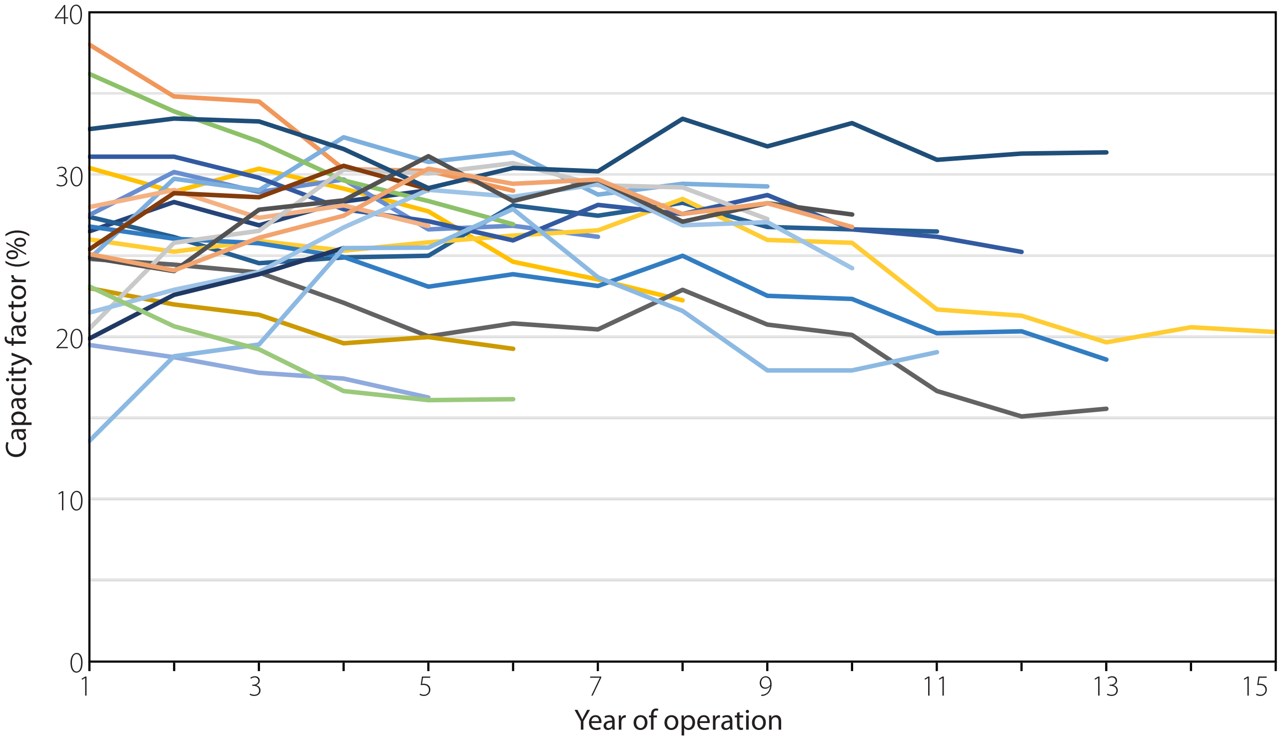

Figure 5: Capacity factors: deterioration over time

The graph shows all windfarms with three or more years of data available, presented as a three-year moving average. Source: Ofgem REGO data.

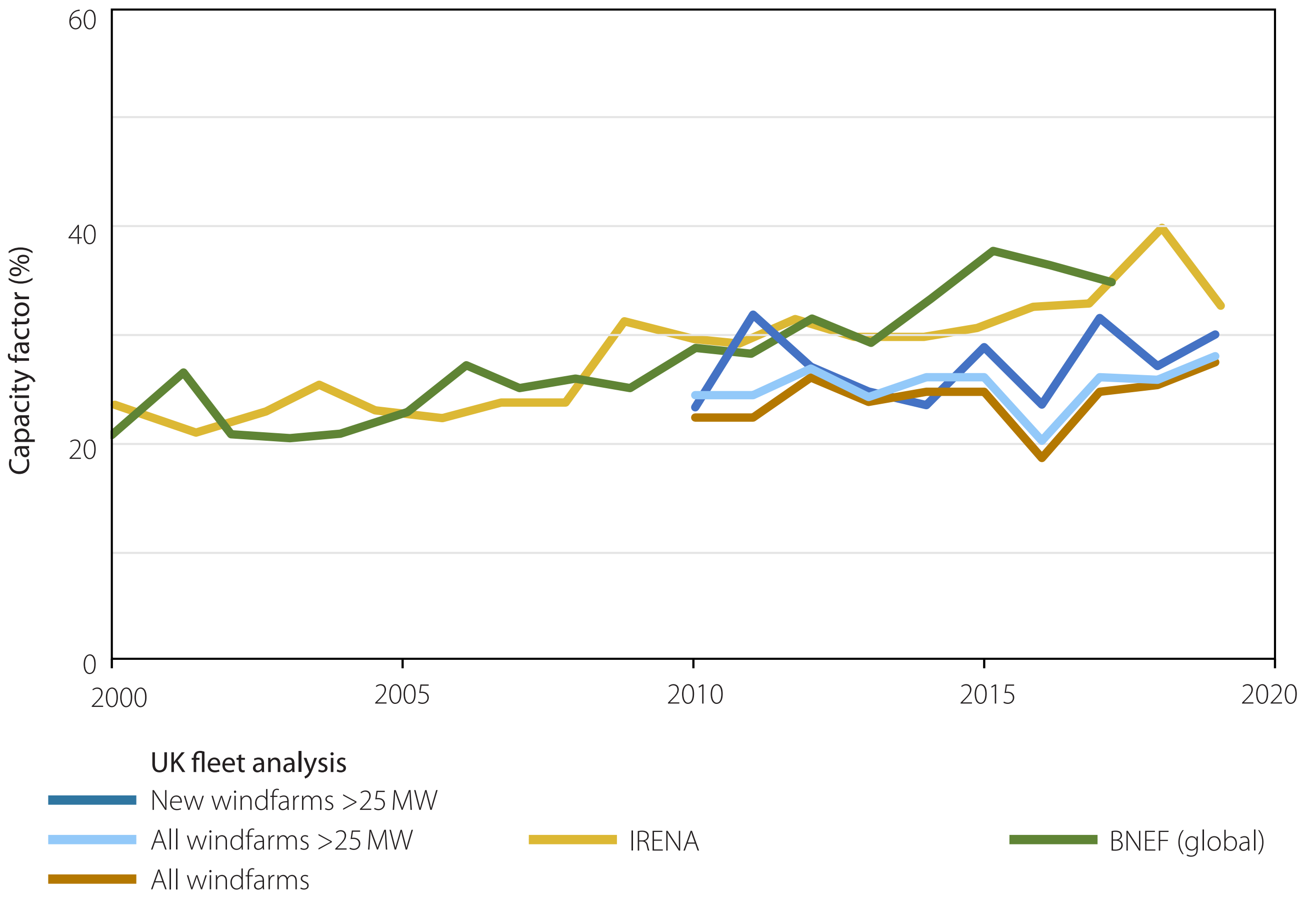

Figure 6: Capacity factors: history

UK fleet analysis data from Ofgem REGO/RO database. New windfarms are those commissioned two years before the year for which data is reported.

for all large windfarms and for the whole fleet. All three suggest that any improvement in output has been small at best, and possibly even non-existent.

It is possible that the gap that has opened up between the new large windfarms and the fleet average represents a step change in performance. To test this assumption it is possible to treat each year's newly commissioned windfarms as a cohort and follow their capacity factors in each year that follows.[13] We would expect, by year 3, any teething problems to have been resolved and that the capacity factor would be well above the fleet average, and this is indeed what we see: on average, the cohort will 16% higher than the large-windfarm average. But by year 6, this advantage has fallen to zero.

The high values claimed by IRENA and BNEF are something of a mystery. While there are undoubtedly windfarms with capacity factors over 35%, they are the exception rather than the rule. BNEF's figures are global, and will thus take in countries such as the USA, where larger turbines and less undulating terrain give better performance. However, there are few places in the world with such good wind resources as the UK. IRENA, meanwhile, does not maintain comprehensive records of renewable assets, since they cover all technologies in all countries, so it is possible that they have hit on some of the outliers on the high side in the UK. Either way, neither of these two graphs should be considered representative of the true performance of UK onshore windfarms.

Few of the advocates make predictions made about future performance of onshore wind turbines, and only one is UK-specific. However, there is again an extraordinary disconnect between the history and the claims made (Figure 7).

The blue line is the record of capacity factors for new large windfarms in the UK, taken from Figure 6. The grey line represents Lazard, whose position – capacity factors of 38–55% – is again for US windfarms only.[14] However, the US Energy Information Administration, the body officially charged with monitoring such figures, takes a position very similar to BNEF and IRENA, with capacity factors rising from 29% in 2010 to nearly 34% in 2019.[15] The Lazard figures are clearly absurd.

The red line is the prediction of BEIS, who are suggesting an equally implausible figure of 34%, although they see no improvement in that figure in coming decades. That value might represent the performance of the best windfarms in their early years, but as such it is an outlier, and not the basis for policy decisions.

Finally, the green line and shaded range is BNEF's longer term prediction and upper and lower bounds for onshore wind turbine performance.[16] However, they say these figures are for China, which might be compared to the USA, with lower wind speeds than the UK,[17] but with less turbulent wind. Note also that a small adjustment has been made to the figures to make them comparable to the others.[18] The steady rise in capacity factors that BNEF are predicting for China seems implausible given the history for the UK.

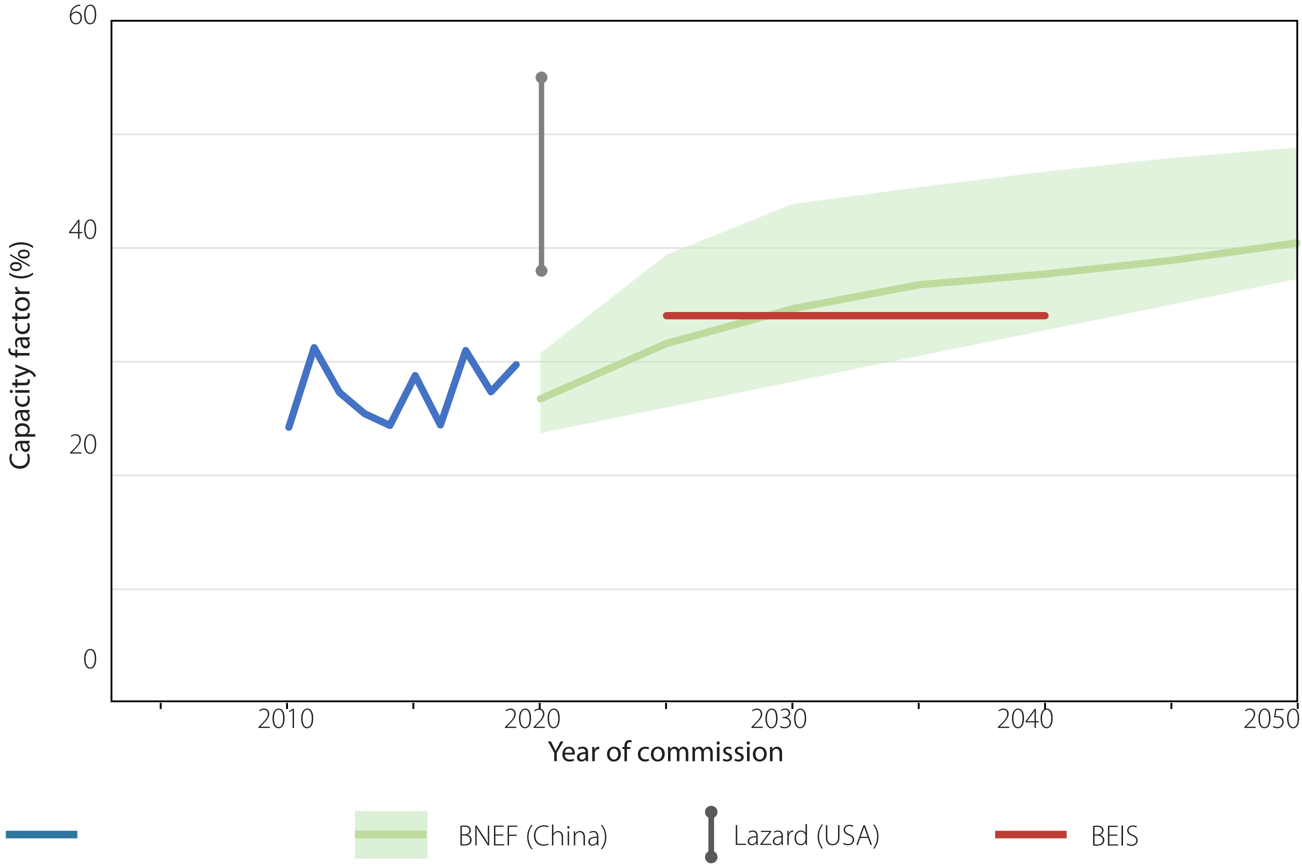

Figure 7: Capacity factors: the disconnect between history and predictions
The GWPF estimate is fleet average for large UK windfarms based on audited accounts as per Figure 6.

6. Levelised cost

Figure 8 shows the views on the history of levelised cost as reported by IRENA and the current value according to BNEF.

IRENA's take is surprising; the graph in the original report extends back to 1989, thus preceding the commissioning of the UK's first commercial onshore windfarm by two years.

IRENA detects a strong decline in the overall cost of onshore wind in the UK, which matches a similar decline found by BNEF for the globe and by Lazard for the US (not shown). The scale of the claimed cost reduction for all three since 2000 is remarkable – over 50% in each case.

The contrast with the GWPF sample is again remarkable, and it is worth taking a moment to consider the impact of the cost drivers considered in earlier sections on levelised cost. For example, both BNEF and IRENA believe that there has been only a slight fall in capital costs in the last two decades (Figure 1), but rise in capacity factors of perhaps 15% or more (Figure 6), although BNEF's figures are global rather than UK-only. These increases cannot, on their own, explain the fall in LCOE that the advocates claim has taken place.

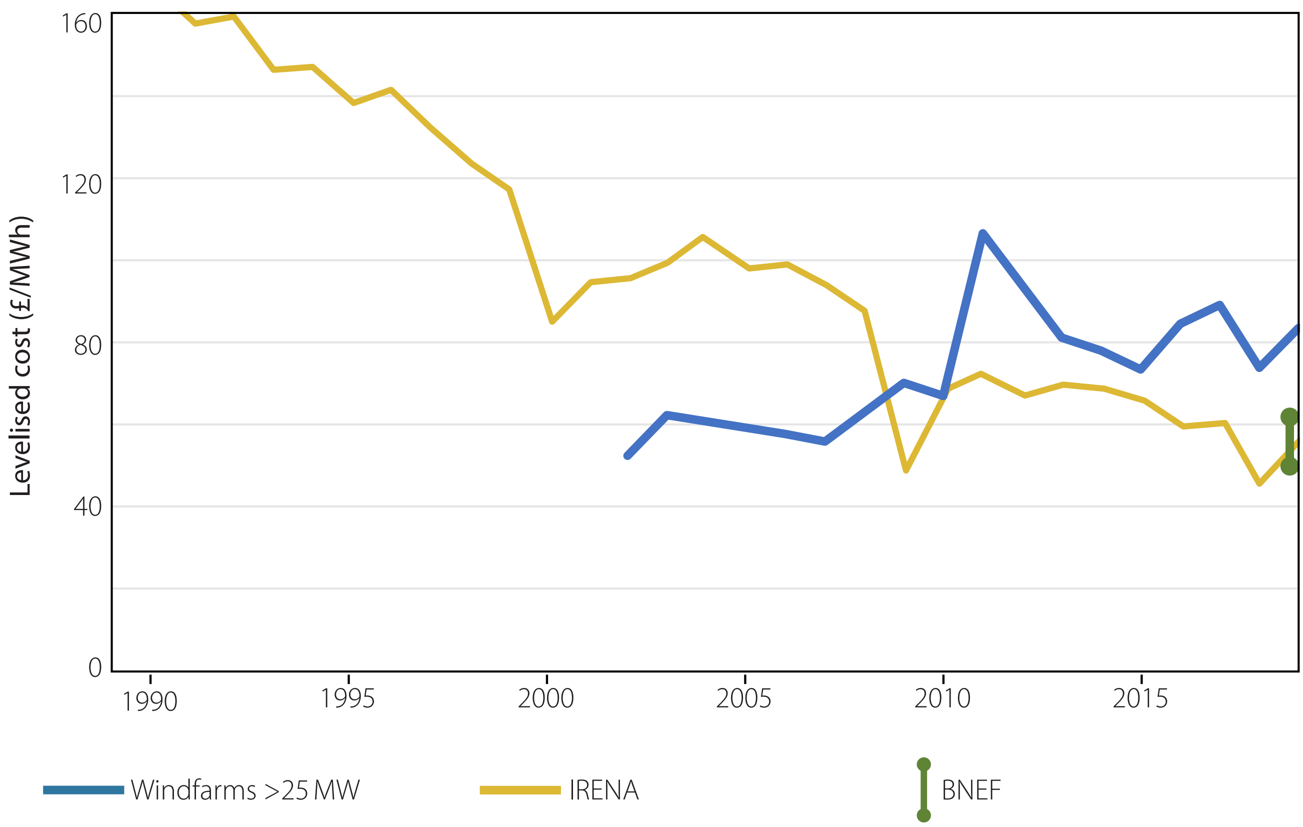

Figure 8: Levelised cost: views on the history

The high value for the GWPF sample in 2011 is because there is only one data point behind the value for that year, and it was an outlier.

IRENA believes there has been a fall in operating costs in the US and in a selection of EU countries, although this is clearly not the case for large windfarms in the UK (Figure 4). In fact, in the GWPF sample, capex represents a relatively stable 60% of the LCOE over the years, as might be expected from rising capex, rising opex, and stable capacity factor. The advocates' position of falling costs seems to rely on a fall in opex which does not show up in the GWPF sample, and a strong rise in capacity factors which appears to be spurious, or at least not applicable to the UK.

There are also few predictions of levelised cost, with only BEIS and BNEF doing so for the UK. These are shown in Figure 9. There is a curious disconnect between the values given by BNEF for current windfarms and the start point of its predictions, but it is obvious that the prediction of both organisations are entirely divorced from the history, as recorded in the GWPF record.

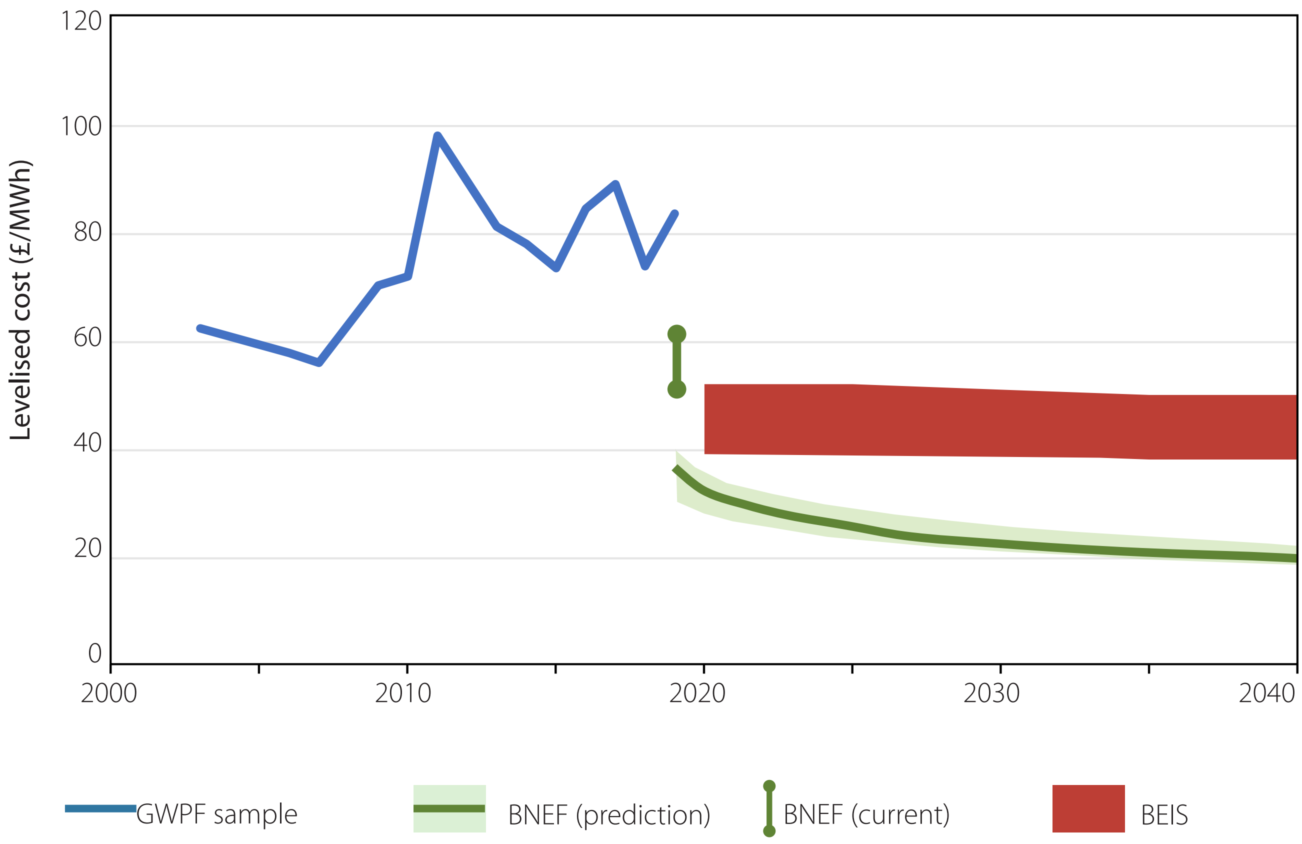

Figure 9: Levelised cost: predictions

The high value for the GWPF sample in 2011 is because there is only one data point behind the value for that year, and it was an outlier.

7. Conclusions

As this analysis makes clear, real-world data – from audited accounts and official power generation figures – show that the levelised cost of major onshore windfarms in the UK is rising rather than falling. At over £80/MWh, it is perhaps twice the cost of electricity from gas turbines running flat out,[19] even before considering the considerable extra burden of dealing with intermittency. In the midst of a economic crisis of historic magnitude, it is surprising that anyone would seek to expand its use. Yet that is what politicians of all stripes seek to do.

In the companion paper to this one, on offshore windfarms, I concluded that the levelised cost claims of renewables advocates bore little resemblance to the recent history of the different cost drivers involved. As this paper shows, their claims about onshore wind are, if anything, even less plausible. That steady increases in costs should, over a year or two, suddenly change into precipitous falls would be extraordinary if it came to pass.

But extraordinary claims demand extraordinary evidencel as yet we only have lines on graphs. In order for the advocates' claims to hold water, they need to explain which windfarms they believe are operating at the low cost levels they say are now the norm. My plea to the advocates is to make public the data to support their claims.

Notes

1. Montford A. *Offshore wind: Cost predictions and cost outcomes*. Briefing 52, The Global Warming Policy Foundation, 2021.

2. *Electricity Generation Costs 2020*. Technical report, Department for Business, Energy and Industrial Strategy, 2020.

3. Brandily T. *2H 2019 LCOE Update: Solar, wind and power prices at the crossroads*. Bloomberg New Energy Finance, 2019.

4. IRENA. *Renewable Power Generation Costs in 2019*. Technical report, International Renewable Energy Agency, 2020.

5. Lazard. *Levelized Cost of Energy and Levelized Cost of Storage 2020*. https://www.lazard.com/perspective/lcoe2020.

6. Hughes G. Wind Power Economics: Rhetoric and & Reality. Volume I, Wind Power Costs in the United Kingdom. Technical report, Renewable Energy Foundation, 2020.

7. Financial records for windfarms operated by the large operators are sometimes subsumed into a larger corporate entity.

8. See, for example, Joskow PL Comparing the costs of intermittent and dispatchable electricity generating technologies. Discussion paper. https://economics.mit.edu/files/6317.

9. The dataset covers all windfarms greater than 25 MW, where there is a special purpose vehicle – in other words a set of financial records covering that one windfarm. In addition, one or two windfarms that have added extra turbines part-way through the windfarm's life have been excluded.

10. The figures are derived from p. 97 of the BNEF paper, with dollar figures converted to Sterling at an average rate for the year in question.

11. https://renewablesandchp.ofgem.gov.uk. The database lists the capacity of each windfarm, the number of certificates issued in any given period, and the number of certificates per megawatt hour to which the windfarm is eligible. It is thus trivial to calculate the number of megawatt hours generated and the capacity factor.

12. The sample of windfarms in Figure 6 is larger than what is shown in Figure 5, the latter being restricted to windfarms with at least three years of records.

13. This was tested by following the performance of the 2011, 2012, 2013, 2014 and 2015 cohorts through to 2019–20. The cohort covered only windfarms in the GWPF sample, i.e. with capacity > 25 MW.

14. This can easily be determined by looking at the Global Wind Atlas at https://globalwindatlas.info/, and comparing the US to somewhere like the Southern Uplands of the UK. On hilltops in the region, for example where the Clyde windfarm is situated, wind power may be as high as 1530 W/m2. It is hard to find anywhere with that sort of power in the USA.

15. EIA. Electric Power Monthly, Table 6.07.B. Capacity Factors for Utility Scale Generators Primarily Using Non-Fossil Fuels. See https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_6_07_b.

16. See p. 97.

17. Global Wind Atlas, *op. cit*.

18. The graph notes that the figures are gross capacity factors; in other words, reducing the theoretical capacity only to take account of wind availability. However, other factors, such as transmission losses, repair time, turbulence, icing of the blades, and so on, reduce the actual yield of electricity still further. A conversion factor of 86% has been used to estimate net capacity factors for the purposes of Figure 6. This figure is derived from http://www.windaction.org/posts/3528-clipper-windpower-the-economics-of-wind-energy.

19. The current spike in gas prices is mostly irrelevant to estimates of LCOE, which must be based on an estimate of *lifetime* average fuel costs.

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People are naturally concerned about the environment, and want to see policies that enhance human wellbeing and protect the environment; policies that don't hurt, but help.

The Global Warming Policy Foundation (GWPF) is committed to providing a platform for educational research and informed debates on these important issues.

In order to make progress and advance effective policy assessments, it is essential to cultivate a culture of open debate, tolerance and learning.

Our aim is to raise standards in learning and understanding through rigorous research and analysis, to help inform a balanced debate amongst the interested public and decision-makers.

We aim to create an educational platform on which common ground can be established, helping to overcome polarisation and partisanship. We aim to promote a culture of debate, respect, and a hunger for knowledge.

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