OFFSHORE WIND STRIKE PRICES
Behind the headlines

Gordon Hughes, Capell Aris and John Constable

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About the authors

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1 Summary

Because the successful bid prices (£57.50/MWh and £74.75/MWh, in 2012 prices) for offshore wind in the second round of competition for UK renewable electricity Feed-in Tariffs with Contracts for Difference (FiTs CfDs) are very significantly lower than those awarded in 2015 (£114–£150/MWh in 2012 prices) it has been widely assumed that the underlying costs of offshore wind are falling, and that the CfD prices indicate a sudden paradigm shift for the technology. However, statistical analysis of the data available, covering 86 offshore wind farms, suggests that the capital cost of offshore wind (£/MW installed) is not in fact falling, since the extra costs of necessarily moving into deeper water are offsetting a real but modest rate of technological progress. The successful projects in the second round are almost certainly not viable at the low CfD prices offered, and these bids therefore must have other explanations. We infer that developers see the CfD as a low-cost, no-penalty option for future development, and that, because the contract is easily broken once the windfarm has been built, they regard the price as a minimum not a ceiling. Should the market price rise above the contracted price, because of rising fossil fuel costs or a carbon tax, they would cancel the CfD contract and take the higher price that would become available. On the other hand, if there is no significant probability of that elevated market price, these sites are very unlikely to be built. Contrary to media exaggerations, the low CfD prices are commercial speculation, not the dawn of a new age for offshore wind and renewables.

2 Introduction

In recent days the naïve press coverage of the results of the Contracts for Difference (CfD) auction for offshore wind has highlighted the unsuspicious nature of both civil servants and journalists when considering apparently good news about renewable energy. We are asked to believe that bidders have committed to deliver power from offshore wind farms at fixed prices that vary from a third to a half of those to be paid to bidders at the previous auction in 2015. This has been widely hailed as indicating a new paradigm in renewable energy costs, and a death blow to its low-carbon competitor, nuclear power. In real life – outside the renewables sector – regulators and journalists earnestly advise us that deals that appear too good to be true are almost certainly not what they seem. When offered a guaranteed annual investment return of 10%, we should take note of Bernie Madoff and steer clear. Cheap handbags or scarves that purport to be made by Gucci or Hermes are usually fakes. But in the renewables sector the situation is different, and we are expected, even encouraged, to believe that all that glistens really – truly – is gold.

For those of a more cautious or inquiring disposition there are some awkward facts that should be borne in mind. Despite the publicity, the bidders are not in fact

committed to deliver wind power at the prices promised: *there are no serious penalties for failure to build the generating capacity promised at the auction.* Examination of the relevant sections of these contracts, buried in 540 pages of legalese, reveals that a developer who has built the promised capacity can easily abrogate the contract. If the market price of electricity seems likely to consistently exceed the price set in the CfD then contract holders will be strongly motivated to cancel and pay the relatively small penalty for default. In other words, from the developer's perspective the CfD price is not a fixed price, but a *minimum* price. If the market circumstances change and wholesale prices rise, for example because of rising fossil fuel costs or the imposition of a high carbon tax, then they can break the CfD and take advantage of the market rate.

In essence, CfD contracts are no more than rather cumbersome and lengthy option contracts. Wind farms from the earlier round of the CfD auction process have guaranteed prices far above current or expected future market levels, and are consequently likely to be built: a guaranteed price of £140 or £150/MWh (especially adjusted by inflation since 2012) is a very good deal, even for a relatively high-risk project such as an offshore wind farm. However, for guaranteed prices of £74.75 and £57.50/MWh, such as in those contracts just announced, the calculation is entirely different. These are highly speculative proposals that are very unlikely to be built unless a higher price can eventually be obtained. To understand what is at stake we have to look at the facts rather than the hype.

The key to these agreements is the capital cost of constructing a new offshore wind farm. Strikingly, no reference has been made to this in any of the statements released by the Department of Business, Energy and Industrial Strategy (BEIS) and others. The implication in the media coverage is that capital costs have fallen, but surprisingly this implication is not substantiated, and no details of the technological progress that has made it possible are given. However, there is now enough publicly available data to make a reliable assessment of the factors that determine these capital costs in the UK, and to identify the real trends in capital cost. With that in hand we can draw our own conclusions about what has motivated the companies behind these offshore windfarms to make such remarkable price offers.

3 The second round of FiTs CfDs

Putting aside the contracts to six small 'advanced conversion technologies' (with a total capacity of just over 60 MW), and two biomass combined heat and power plants (total capacity 86 MW), which may all be regarded as research projects, the most significant announcement in the UK government's decision on successful bids in the second round of allocations of FiTs CfDs, is for contracts to three large offshore wind farms:[1]

- Triton Knoll Offshore Wind Farm (860 MW)
- Hornsea Project 2 (1,386 MW)
- Moray Offshore Windfarm (East) (950 MW).

These are large wind farms by any standards, with a total capacity equivalent to 60% of the UK's current 5.4 GW of offshore wind. They would generate, according to the government's own estimates, about 10 TWh per year, which is approximately 3% of the UK's annual electricity consumption.

The contracted prices are as follows:

- £74.75/MWh for Triton Knoll
- £57.50/MWh for Hornsea 2 and Moray East

These figures are all in 2012 prices, and are to be adjusted for inflation since that year, an important point quite neglected in most media reports, which also reported the prices of the previous allocations as £151–162/MWh without appreciating that these figures are in 2017 prices. In this context it should also be noted that the recently announced contracts are for delivery starting in 2020–2021 (Triton Knoll) and in 2022–2023 (Hornsea 2 and Moray East).

The first set of CfD strike prices was administratively set, with a higher price for an earlier date of completion. Dudgeon, Burbo, and Walney received prices of £150/MWh (at 2012 prices), while Hornsea 1 and Beatrice (close to the site of Moray East) will receive £140/MWh (again at 2012 prices). The Round 1 auction yielded a price of £114.39/MWh for Neart na Gaoithe and £119.89/MWh for East Anglia 1 – all at 2012 prices and for delivery from 2018 onwards. While East Anglia 1 is now under construction, recent announcements suggest Neart na Gaoithe is unlikely to be built before 2021–22. The delay is only partly due to challenges in obtaining planning consent.

It is also important, in spite of the media excitement, to recall that these prices are still subsidies. In other words, they are state grants of fifteen-year-long legal entitlements to a price that is likely to be above the market price, entitlements where there is almost no penalty for non-delivery, but where the liability to the consumer is substantial unless conventional electricity prices rise on average well above current levels for long periods. It is of course difficult to know what the subsidy component of these non-market prices will amount to in the early 2020s when the projects are projected to be phased in, since we cannot be sure of the wholesale price at that time. However, we know what the subsidy would be today, and on that assumption, and using the implied generation in the BEIS announcement, the subsidy can be estimated at about £300 million per year, which over the fifteen-year contracts for these wind farms would amount to over £4 *billion* in total.

In other words, this is a guaranteed price with an implied subsidy that will probably amount to several hundred million a year, and several billion over the life of the

projects. Offshore wind is still not as cheap as conventional energy, and when system integration costs are taken into account it will be even more expensive for consumers.

That said, it is quite true that these prices compare favourably with the very much higher rewards offered in the first round in February 2015. For example, the Beatrice wind farm, currently under construction and near to the site of the prospective Moray East windfarm, received a contract for £140/MWh, as did the first phase of the Hornsea wind farm, which owner DONG is proposing to extend with a CfD price of £57.50/MWh. This simple contrast forms the basis for the extremely positive media coverage. The fact that this is still a subsidy, and an expensive one, has been quite lost in the excitement of reporting what appears to be a new dawn in renewables costs. The headlines tell their own story:[2]

- *Financial Times*, 'UK subsidy price to offshore wind falls 50%'
- *The Times*, 'Power industry harnesses winds of change'
- *Daily Telegraph*, 'Offshore wind to power £17.5bn investment boom as costs halve'
- BBC, 'Offshore wind power cheaper than new nuclear'
- *The Times*, 'Record-breaking Hornsea Two wind farm will cut cost of green energy'
- *The Times*, 'Winds of Change: The price of renewable energy is falling faster than anyone dared hope'
- *Daily Telegraph*, 'Wind could make Britain an energy superpower to rival Arabia'

Even some specialists, such as Cornwall Energy, have been prepared to join the cry: 'Paradigm Shift: Offshore wind blows hole in opposition to renewables'.[3] But these reactions are obviously premature. *The grounds offered are simply insufficient to warrant the conclusion, and no one should accept it without question*. To put it simply: the second round prices are so much lower than those in the first round that suspicions should have been automatic. Journalists should have asked themselves whether it is remotely plausible for costs to have fallen so dramatically as to produce a difference of £80–90/MWh in so short a time? Indeed, there is little or nothing in power sector experience to support the assumption that offshore capital costs could have fallen by 55% in less than five years, especially bearing in mind that the wind turbines themselves are only one part of total capital expenditure. The wind industry claim is obviously too good to be true.

4 Are offshore wind capital costs really falling?

With the carefully worded encouragement of government and the renewables industry itself,[4] many reporters naïvely assumed that a lower bid price must indicate a lower

capital cost for the building of the wind farms. But that need not be the case. Indeed, it is striking that in all the positive talk published so far, there is no clear data supporting the implicit claim that the capital cost is actually falling. That is in itself quite surprising. If this achievement were real the companies responsible would want to publicise it so as to take commercial advantage of their breakthroughs. But in fact the only evidence provided of falling capital cost is the CfD price itself, which is very equivocal evidence.

Unfortunately, there is a serious shortage of reliable information on capital costs. Many initial estimates are subsequently revised upwards with rather less fanfare. For example, an early announcement for the Borkum Riffgrund 2 wind farm (in the German sector of the North Sea) with a planned capacity of 450 MW, gave a capital cost of €1.35 billion. A later stock market announcement relating to the sale of a 50% interest in the development implied a total development cost of close to double that figure. We infer that the latter is more likely to be right.

Subject to this qualification, we have drawn on three sources of publicly available data to test the hypothesis of large falls in capital costs. The first is an EU-funded study by the FOWIND consortium (Facilitating Offshore Wind in India) covering various European sites, and prepared under the auspices of the Global European Wind Energy Council;[5] the second is a set of UK-specific figures obtained by one of the present authors, Capell Aris, through careful gleaning of press stories and press releases; the third is the online source published by the industry consultancy, 4C Offshore, whose database contains capital costs alongside much other circumstantial information.[6] Our sample contains 86 offshore wind farms with a capacity of at least 10 MW, either completed or due for completion between 2000 and 2022, half of them in UK waters and most of the remainder from Germany, Denmark, the Netherlands, Belgium and Sweden. All costs were standardised to 2012 prices (the same as FiTs CfD strike prices) and converted to Sterling using 2012 exchange rates. The dataset is public.[7]

Figure 1 is a scatter plot of this data. It is intuitively clear that costs have not fallen dramatically over the history of offshore wind development; indeed they appear to have risen. This first-order impression is in itself surprising, a fact that the authors of the 2014 FOWIND study noted when they reviewed cost changes in a smaller data set and over a shorter period. FOWIND's authors wrote that:

> The broad trend in the development of Capex since the early days of offshore wind technology in the early 1990s is contrary to any expectation of conventional industrial maturation. Learning or experience curve theory would predict reducing costs with time, through the combined impact of innovation, learning effects and economies of scale. The historical reality has been dramatically different …with Capex increasing ….[8]

Statistical analysis of the larger data set considered in this paper can shed light on the reasons and the subtleties behind this contravention of normal expectations.

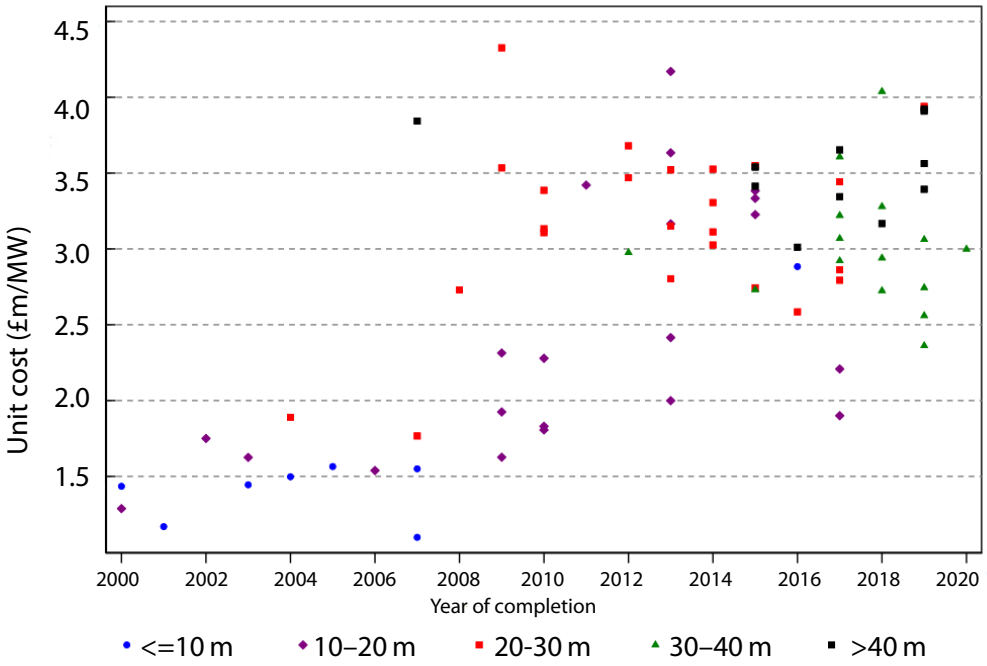

Figure 1: Wind farm capital cost and water depth, 2000–2020.
£/MW, 2012 prices.

The data were analysed using robust regression techniques to minimise the impact of outliers on the results, which are displayed in Figures 2 and 3.

Figure 2 shows the trends in unit costs for a standardised wind farm – capacity 600 MW, built in North Sea waters of depth 40 m – for completion dates between 2005 and 2020. The vertical error bars indicate the range of uncertainty for each of the estimates. Unit costs at 2012 prices increased strongly (6.1% per year) from 2005 to 2013 but have been falling at 4% per year since 2013. That is a real but modest rate of technological improvement, and to be expected. At the peak in 2013, the unit cost of the standard wind farm was £3.90 million per megawatt, and this should have declined to £3.20 million in 2020 – the projected completion date for Hornsea 1.

Perhaps surprisingly, wind farm capacity and distance from shore seem to have little or no effect on unit costs. We find no indication that increasing the size of turbines actually reduces the capital cost of new installations. Indeed, it is possible that one reason behind the rise in offshore capex costs observed up to 2013 resulted from:

- the extra costs of upgrading the 2–3 MW onshore turbines for use offshore, at least in deeper waters
- the shift to bigger turbines, which was almost entirely an offshore change as onshore turbine sizes did not increase much.

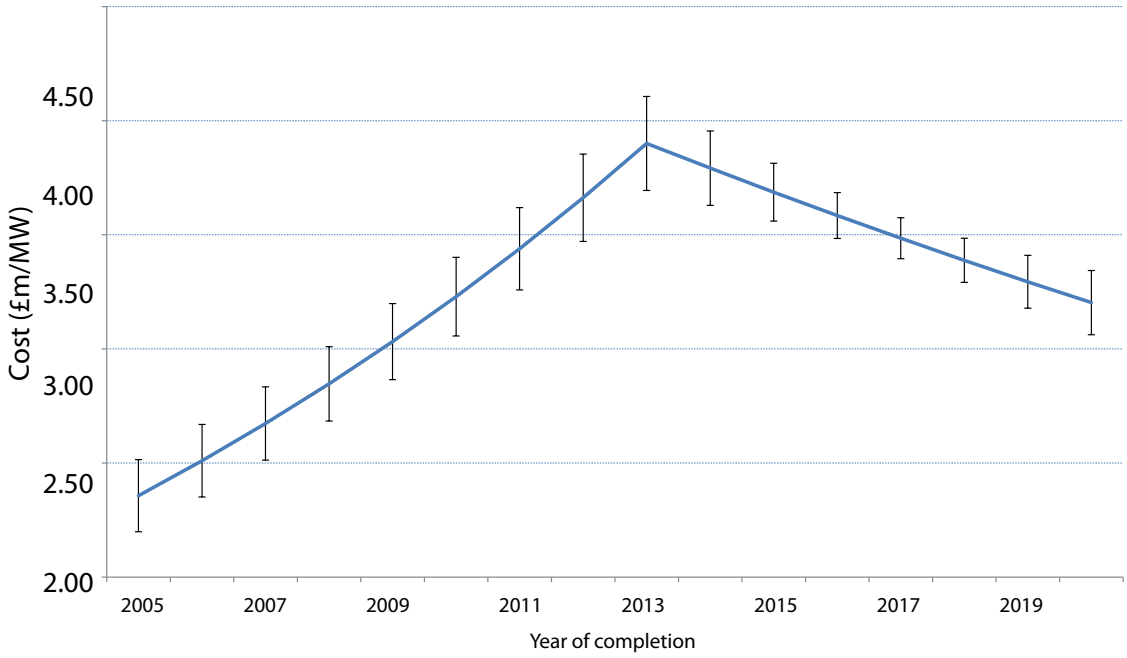

Figure 2: Evolution of standardised unit costs for wind farms over time.
Authors' dataset.[7] Calculations by the authors.

Previous experience in the electricity industry – the notoriously difficult generation shifts in gas turbines spring to mind – suggests that doubling wind turbine size from the current 6–8 MW models up to 15 MW may be a recipe for great difficulty and expense rather than easy and quick reductions in capital cost.

Marine site conditions, on the other hand, have a critical influence on capital costs. For example, it is significantly more expensive to build wind farms in the North and Irish Seas than in the Baltic. But overall, according to this dataset, the most important factor determining unit cost of an offshore windfarm is the depth of the water in which it is built. The depth will often vary by 5–10 m over the area covered by a wind farm but we have used the greatest depth reported for each wind farm. Figure 3 shows the relationship between depth and unit cost for a standard wind farm completed in 2016. Building at a depth of 55 m (Beatrice) increases the unit cost by £1.13 million per megawatt relative to building at a depth of 15 m (Gunfleet Sands).

Thus, we can conclude that even though the standardised unit costs for wind farms have been falling gradually since 2013 this has been offset by the move to deeper waters for new and larger wind farms. UK offshore wind farms completed between 2000 and 2009 had an average depth of 15 m. This increased to 21 m for 2009–2014 and will double to 42 m for wind farms due for completion in or after 2020. The unavoidable shift to deeper waters is a strong counterbalance to cost reductions

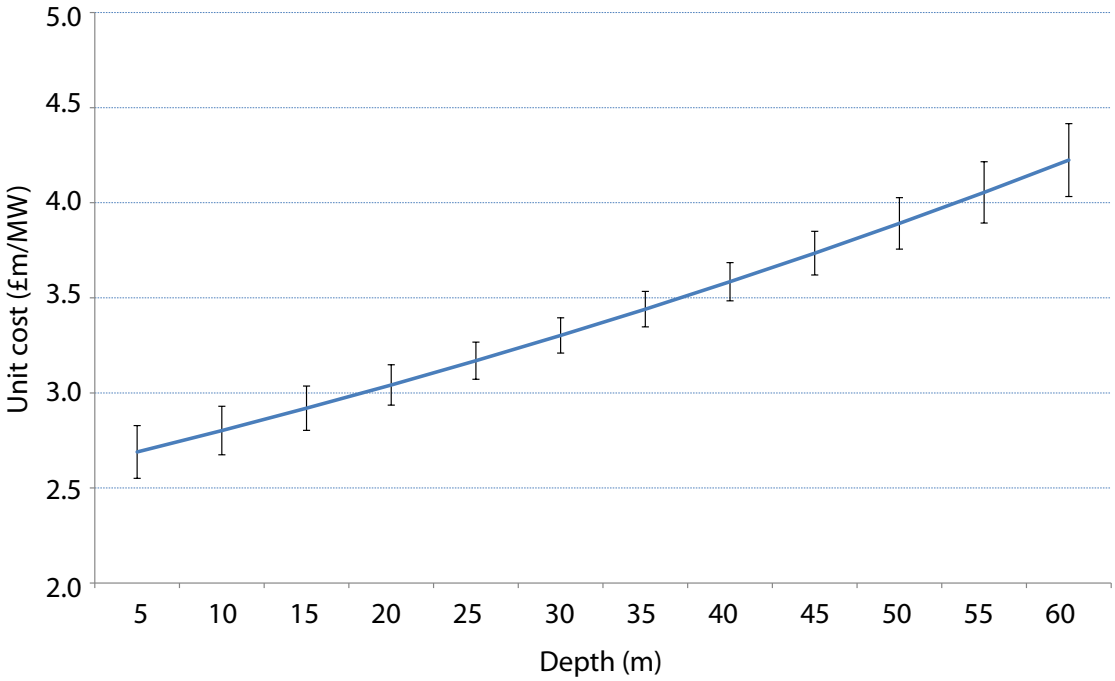

Figure 3: Standardised unit costs vs depth for wind farms in 2016.
Source: Authors' dataset.[7] Calculations by the authors.

from improvements in technology and the supply chain. Allowing for these factors we estimate that the unit capital costs (at 2012 prices) for the three wind farms are follows:

- Triton Knoll: £2.77 (±0.14) million per MW
- Hornsea 2: £2.91 (±0.16) million per MW
- Moray East: £3.12 (±0.17) million per MW.

The question then arises as to whether the prices awarded to these wind farms are sufficient to motivate construction. To address this matter we must make assumptions about cost of capital, timescale for capital recovery, and load factor. The FiTs CfD strike prices are indexed to the CPI so a real cost of capital of 6% is a relatively conservative estimate of the cost of bearing the risks of constructing and operating wind farms in relatively deep waters. The contracts offer guaranteed prices for 15 years, so any risk-averse operator would seek to recover its capital costs over this period. Once one allows for maintenance and other factors a discounted lifetime average of 35% is at the top end of any plausible range for the load factor for offshore wind farms. On the basis of these assumptions, the projected capital costs per megawatt hour (at 2012 prices) for the eight offshore wind farms due for completion in UK waters between 2018 and 2022 fall in a range from £93 for Triton Knoll to £123 for Beatrice.

Even lowering the real cost of capital to 4% (a very low figure given the risks involved) only reduces the range to £81–107/MWh. Extending the period for recovering capital costs to 20 years reduces the range to £79–104/MWh.

In setting its Administrative Strike Prices – a cap on the FiTs CfD auction strike prices – BEIS assumed operating and variable costs of £26/MWh (at 2012 prices). Its calculations use a discount rate of 8.9%, although it is not clear whether this is nominal or real, and a lifetime of 22 years. Applying these parameters to projected capital costs for the eight UK offshore wind farms, the range of capital costs is £95–125/MWh, requiring lifetime revenues of £121–151/MWh. Since revenues after the first 15 years are heavily discounted, these estimates are broadly consistent with the successful bids in previous rounds of FiTs CfDs:

- Beatrice and Hornsea 1: £140/MWh
- East Anglia 1: £120/MWh
- Neart na Gaoithe: £114/MWh (all in 2012 prices).

Suspicions that the most recent bid prices revealed the prices awarded in earlier rounds as too high are probably misplaced. The capital cost data suggests that a price of about £120/MWh and upwards is required.

The prices awarded in the second round are, of course, nowhere close to these figures, and would not appear to be sufficient to motivate investment.

5 Why are companies content with low CfDs?

If the capital costs have not in fact fallen, and the auction prices are thus insufficient to make these projects economic, why have the companies bid at these levels? One possible explanation is the one-off benefit of geographical proximity of the new sites and sites already under development. Clearly this is not technological progress, but it is certainly possible that the strike prices have been held down by shared infrastructure, for example cabling and connections. While that might be the case for Hornsea 2, which is in essence an extension, the proposed Moray East wind farm is not an extension of nearby Beatrice, and has, at present, different owners, so the case is less clear.

Putting aside such special factors, there are three possible explanations for a large drop in the auction prices. These are:

- Bidders believe that investors will accept much lower real rates of return on the equity or debt required to fund the capital investment. For this to add up, the real cost of capital would have to be less than 2%, but even in current conditions this is exceptionally low and there is no evidence that investors are willing to accept such rates of return on investments that are still of relatively high risk.
- Bidders believe that the cost of building new offshore wind farms after 2020 will be less than 40% of the projected figures in our analysis discussed above.

There is no public evidence of any kind to support this belief, and in fact our analysis is based on public statements made by developers themselves, which tend in any case to be optimistic.

- The companies bid low and uneconomic prices in order to make sure of obtaining the CfDs, which they see as low-cost, no-penalty options, gambling on future market circumstances and policies that will generate income over and above the CfD.

In our view this last possibility is the most probable explanation. The media excitement around the auction has generated very useful pro-wind and anti-nuclear PR, which is doubtless welcome. However, it is not the main motivation, which is a commercial speculation on future policy and wholesale prices. The holder of the option, the CfD, has an established position in the market that inhibits competition, but is in fact not restricted by the contract.

If future wholesale prices seem very likely to rise above the strike price and remain there, then the wind farm may be built, and the contract quickly abrogated, which is neither difficult nor costly, leaving the wind farm able to take the higher prices that it actually needs. At present, of course, it does not appear that conventional energy prices are likely to rise sufficiently by the early 2020s to produce the high wholesale prices required, but the wind farm developers may entertain hopes of policy support, such as a carbon price.

Without the likelihood of such higher prices, these options will be allowed to lapse. All this is a perfectly reasonable gamble for a large company.

However, the tactic has risks. In a revealing story published by Bloomberg on 20 September 2017, Irene Rummelhoff, executive vice president Statoil ASA's New Energy Solutions unit, is reported as remarking:

> The offshore wind industry needs to be careful…They're taking on these options, and when you get to the delivery date, if they're not able to build the projects, it will ruin the reputation of the industry.[9]

6 Conclusion

The announced FiTs CfDs for Triton Knoll, Hornsea 2 and Moray East tell us next to nothing about the actual cost of offshore wind, and the press coverage asserting a new paradigm in renewables is a gullible overreaction. The fact that so many journalists have accepted it without question is a serious indictment of their judgement.

Our analysis of capital cost data in the public domain shows that the benefits of cost reductions since 2013 have been largely offset by the effects of sites moving to deeper waters. As a consequence, the average cost per megawatt for wind farms completed in 2019–2023 will be close to the average for wind farms completed in 2011–2014.

Judging from the estimates of capital costs that we have examined here, it is very unlikely that the wind farms covered by the recent FiTs CfDs can be built and operated at the prices announced. The reductions in capital costs required to make them viable in the early 2020s are very large and lie outside the range of experience in the energy sector.

There is clearly something about these CfDs that doesn't quite add up, suggesting that there is more to this whole matter than meets the eye. In our view, overwhelmingly the most likely probability is that the companies understand the CfDs awarded to be options, enabling them to gamble on future market circumstances and policies that will generate income over and above the CfD apparently offered. If they can obtain extra income, almost certainly from government policy such as a carbon tax, then and only then will they build; and if the extra funds do not materialise, then they will not proceed to the 'Final Investment Decision' and construction. In the meantime they have secured a market presence and, as the unfavourable comparisons with nuclear generation in the press coverage show, inhibited competitors.

Readers with long memories will already be thinking that this sounds like a rerun of the unsatisfactory performance of the five rounds of the United Kingdom's Non-Fossil Fuel Obligation (NFFO). This subsidy scheme, which began in 1990, required developers to compete in a tender process, with government selecting the cheapest proposals and awarding them premium prices.

The NFFO was a failure. As the government itself documented in its report on NFFO support for wind power, of the 247 wind farms (with a total capacity of 972 MW) given contracts, only 57 (totalling 120 MW) were actually constructed.[10] In spite of the government's claims that planning problems were a leading cause of non-delivery, it is obvious from the data that the early NFFO rounds, which had very high guaranteed prices – £100/MWh, more than five times the contemporary wholesale price – produced much higher levels of delivery (7 out of 9 awarded) than did the later rounds (0 out of 33), when prices had fallen to £29/MWh for large projects.

In effect, the NFFO, again like FiTs CfDs, offered companies options for future development, and the history of that scheme confirms the commonsense view that options with high prices are more likely to be exercised than those with low prices.

Judging from the capital cost data available and analysed in this study, the prices announced in the second round of the auctions for CfDs are very unlikely to be taken up. These sites will most probably not be built, and indeed will only be built with the intention of abrogating the contract to take advantage of much higher market prices, perhaps from a carbon price.

Contrary to media exaggerations, the low CfD prices are commercial speculation, not the dawn of a new age for offshore wind and renewables.

Notes

1. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/643560/CFD_allocation_round_2_outcome_FINAL.pdf.
2. https://www.ft.com/content/7401f5e0-96c0-11e7-a652-cde3f882dd7b; https://www.thetimes.co.uk/article/power-industry-harnesses-the-wind-of-change-xfpdj07cp; http://www.telegraph.co.uk/business/2017/09/11/offshore-wind-power-175bn-investment-boom-costs-halve/; http://www.bbc.co.uk/news/business-41220948;https://www.thetimes.co.uk/edition/news/record-breaking-wind-farm-will-cut-cost-of-green-energy-dong-energy-renewable-uk-hinkley-point-xfs0j893k; https://www.thetimes.co.uk/edition/comment/winds-of-change-hsjn9sj7p; http://www.telegraph.co.uk/business/2017/09/13/wind-could-make-britain-energy-superpower-rival-arabia/.
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