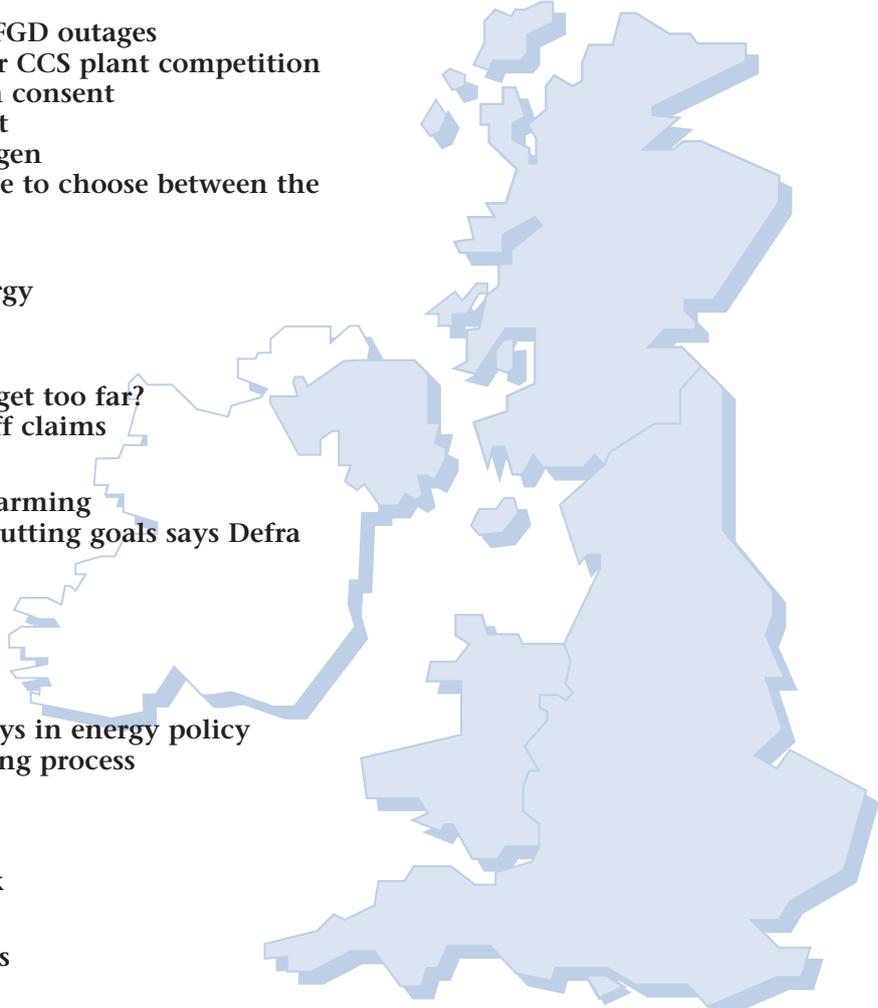


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Electricity generation costs: little to choose between the options?

Over the last 12 months there have been steep rises in construction costs for gas and coal-fired plant largely due to increased commodity prices. These same pressures have pushed up prices of wind turbines and nuclear plant construction costs. As the prices of all fuels – coal, gas, oil and uranium – are also on an upward trajectory, the net result of all these changes is that the electricity generating cost estimates quoted in the UK government's 2006 Energy Review and the 2007 White Paper have changed out of all recognition. In the current climate, comparing the prices of the various energy sources is somewhat hazardous and comes with health warnings. In the following article, **David Milborrow*** attempts to set out the main issues.

There were various sets of generation cost data published with the UK government's recent White Paper and its latest Energy Review. A fairly pivotal figure was the estimated generation cost of nuclear, based on a 40 year life and 10% discount rate, and that was estimated at £38/MWh.

Combined cycle gas turbine (CCGT) costs (without a carbon cost) were a little lower, but broadly similar with a carbon cost of €25/tCO₂. Coal with FGD and the same carbon price was around £40/MWh, and onshore wind around £55/MWh, although later estimates were about 13% higher.

The figure for onshore wind has turned out to be reasonably accurate. Hydro-Quebec has recently accepted 15 bids, for a total of 2000 MW, with an average price of about £54/MWh, with installed costs that are fairly similar to those in the UK. That is a current figure and illustrates one of the difficulties in making comparisons between technologies in the present climate. Costs for wind generation projects, which have short construction times, are virtually fixed once the plant is being built, as the technology is capital intensive.

The same does not apply to coal or gas, where fuel prices are now very uncertain, or even to nuclear. The latter, like wind, is capital intensive but will the costs currently being quoted still hold 10 or more years from now when the plant is actually built, given that the prices of steel, copper and other commodities are rising rapidly? There is now no easy way of comparing costs on a completely level playing field.

Nuclear costs – now less of a mystery?

Perhaps the most interesting data to surface in recent months comes from American studies for new nuclear plant and these are summarised in table 1.

The data from Florida Power and Light are the clearest and the range of cost depends on which type of reactor is chosen. The lower figure for Progress Energy is the cost of a second reactor – adding the recommended “one third” for financing charges brings the range to £2250-2760/kW. The South Carolina figure may not include all the costs of the ancillary plant – it appears that the proposed new units would use at least some of the facilities at an existing power station site, which probably accounts for the estimate being the lowest of the three. There are other estimates – up to £5,000/kW – but with less detail.

Comparable data for European nuclear construction are hard to come by and it is assumed that these American costs will travel safely across the Atlantic. It may be noted that, historically, British power plant costs tend to be higher than those in America.

Assembling all the cost components

Assembling all the data needed to provide present-day generation cost comparisons is relatively straightforward – except for the price of fuel. The prices of all fuels are on an upward trajectory and although they may fall in the future, few analysts expect them to do so.

To give some indication of how rapidly prices are rising, Central Appalachian coal futures averaged around

Table 1. Recent estimates of capital costs for nuclear plant (£/kW)

Source	Nuclear Plant	Whole site	Including financing charges
Florida Power and Light	1222-1791	1554-2720	2890-4035
Progress Energy		1688-2072	“Add about one-third”
South Carolina Electric			2193 (see text)
Keystone Center		1500	2000

Source: Utility data and World Nuclear Association

Table 2. Input data for generation cost calculations

Technology	Item value or range	Source	Comments
Gas			
Installed capital cost	£700/kW	Power UK	
Fuel price	£24-36/MWh	Various	See text
O&M cost	£25/kW	Poyry	"Compliance costs for meeting the 20% renewable energy target in 2020"
Coal			
Installed cost	£1550/kW	Power UK	
Fuel price	£7-14/MWh		See text
O&M cost	£24/kW+£1.6/MWh	Redpoint Energy	"Dynamics of GB electricity generation investment"
Nuclear			
Installed cost	£1554-2720/kW	See text	Excludes interest during construction
Fuel cost	£4.4/MWh	UK Energy White Paper	"Busbar" cost, not delivered fuel cost (as for gas and coal)
O&M cost	£9/MWh	UK Energy White Paper	Includes waste disposal and decommissionin
Onshore Wind			
Installed cost (2010 figure)	£950-1330/kW Various, plus ref in next col.		Ernst and Young, 2007, "Impact of banding the Renewables Obligation"
O&M costs	£40/kW		As above
Source: David Milborrow			

\$40/ton in 2007; by January 2008 they had reached \$57/ton and by the beginning of July had reached \$140/ton. European coal hit \$200/ton early in July, fell back slightly but then most of the other international markets moved up to near that figure. It may be noted that, in 2007, the average price paid by UK electricity generators for coal was £41/ton. As the electricity generators may have forward contracts, a near-term price of £50/ton possibly represents a cautious "low" estimate, and £100 a "high" estimate.

Similar uncertainties surround the price of gas, which has increased by around 50% since the beginning of the year. It is now trading at about 70p/therm – roughly double the price UK electricity generators paid last year, while year ahead prices are at least 20% higher – prices have reached 100p/therm, although that is a "winter" price, not a year-round average.

Given that the price of gas is now less than the price of oil, a "low" estimate of 65p/therm and a "high" estimate of 100p/therm can be used. As these are "beach" prices, around 8% needs to be added to turn them into "electricity generator" prices. The main assumptions are summarised in Table 2. Another factor that influences generation cost comparisons is the "price of carbon". This is also somewhat uncertain, and depends on political as well as economic factors. It is currently about €28/ton, but is expected to rise – a value of €30/ton has been used for the analysis.

Discount rates and project lifetimes

The Energy Review and the White Paper used "whole life" amortisation periods (20 years for wind, 30-50 years for coal plant, 35 years for gas and 40 years for nuclear).

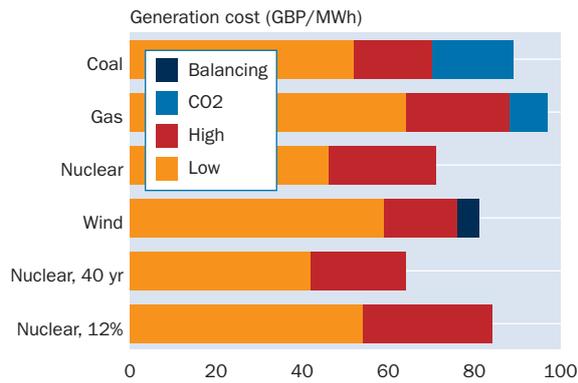
A common economic lifetime of 20 years is used here, since this is considered to be more relevant. The White Paper used a single project test discount rate of 10%, whereas the International Energy Agency generally uses a lower discount rate as well in its economic assessments. While this can be as low as 6%, 8% has been used as an alternative in this instance; it was the "hurdle" rate used by the regulator in the days of being Non-Fossil Fuel Obligation. The lower rate improved the competitive position of wind and nuclear, but did not radically alter the comparisons.

How the technologies compare

The cost comparisons, shown in figure 1, suggest that the "mainstream" generation technologies now have delivery costs that lie in a similar range. If nuclear can be built for £1554/kW, it delivers the cheapest electricity, at around £46/MWh. If coal prices do not rise above \$100/tonne, it comes next, at about £52/MWh – excluding the cost of carbon. At £950/kW, wind comes next – at about £58/MWh – followed by gas (£63/MWh). If coal and gas prices rise, however, and the cost of carbon is added in, then wind and nuclear, even at their respective "high" costs of £1330/kW and £2720/kW become the cheapest technologies. Amortising nuclear costs over 40 years unsurprisingly makes it more competitive and, conversely, raising the test discount rate to 12% (over 20 years) takes the range to £54-84/MWh. At the high end it is still competitive with gas and coal but "high cost" wind comes in slightly cheaper at £81/MWh. The wind costs include an allowance of £5/MWh for balancing costs, in line with the latest estimates from National Grid.

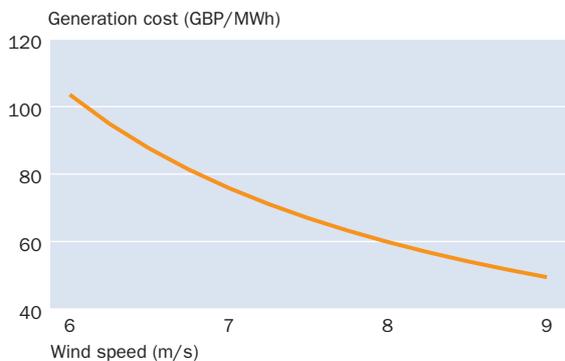
It should be noted that there is a difference between the

Figure 1. Estimates of generation costs for coal, gas, nuclear and wind.



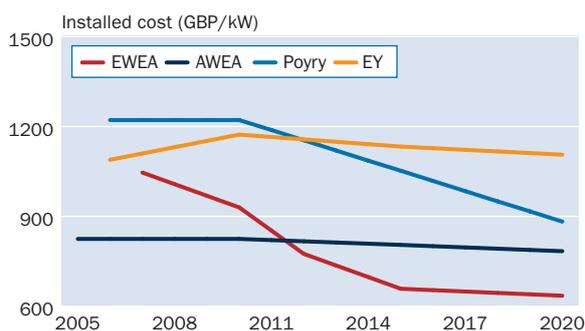
Source: David Milborrow

Figure 2. Variation of wind energy generation costs with wind speed.



Source: David Milborrow

Figure 3. Forecasts of future installed costs for onshore wind energy



Source: Ernst & Young (EY), American Wind Energy Association, Poyry, European Wind Energy Association

wind costs and those of the other technologies used in this comparison. The range of installed costs for wind reflect actual experience, whereas the range of installed costs for nuclear, and of fuel costs for coal and gas, reflect uncertainty. The issue of uncertainty has been explored by other analysts, notably the late Shimon Awerbuch, and this has enabled the benefits of greater certainty to be quantified numerically – but that is beyond the scope of this analysis.

The generation costs of wind energy are, of course, critically dependent on wind speeds. A 30% capacity factor has been used for this analysis as it represents an approximate UK-wide average but variations of generation cost with wind speed, for a mid-range installed cost, are shown in figure 2. These range from £104/MWh at sites with a mean wind speed of 6 m/s to £49/MWh at 9 m/s sites. Most UK sites have wind speeds around the middle of the range.

Extra costs of renewables

In the light of the European Union’s commitment to delivering 20% of EU primary energy consumption from renewables by 2020, attention is now focused on how much it will cost. This analysis shows that building wind, instead of coal or gas, need not necessarily be more expensive. Other, broader, analyses also concluded that the additional costs of renewables may be modest. The recent report by consultant Poyry (Table 1) suggested that the annual cost of meeting the target across the EU would be about €18.8 billion, which is an additional 1.25% on the projected 2020 energy spend. The report also suggested that changes in the fuel price assumptions were crucial and quantified the sensitivity to alternative price projections for gas. A simple extrapolation of that data suggests that the extra costs to the consumer would be very small if the price of gas reached about 100p/therm.

Where next?

Generation costs comparisons in the present climate of rapidly changing fuel and commodity prices are, as noted earlier, difficult. The generation costs for wind are “current”, whereas those for coal, gas and nuclear implicitly assume that the commodity prices currently prevailing will still apply three to 10 years ahead when the plant is actually built. Projecting commodity prices that far ahead is almost as hazardous as projecting fuel prices but the comparisons made here would only be seriously undermined if commodity prices rose so rapidly that wind and nuclear costs needed substantial revision. The wind industry has a good record in improving productivity and this has tended to offset the effect of increased commodity prices. Four estimates of future installed costs of wind are shown in figure 3. Three out of the four studies suggest they may fall, but possibly by only a modest amount.

One conclusion that emerges from this analysis is that there is now little to choose between the generating costs of the various mainstream electricity-generating technologies. The (relative) cost certainty associated with technologies such as wind, with a short build time, is likely to become more attractive into the future, but perhaps the principal conclusion to be drawn is that the benefits of diversity remain and are likely to become even stronger in these uncertain times.

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