Malcolm Keay considers the paradoxes of wind power

Introduction

The development of wind power in recent years has been full of paradoxes – and this is in itself something of a paradox, given that the power of the wind is easy enough to understand, indeed to experience directly, on a windy day.

Among the most obvious paradoxes are the following:

- **New but old.** Wind power is normally classified among the so-called 'new renewable' energies along with such sources as wave power and photovoltaics. But of course wind is one of the oldest sources of power, and has been exploited for millennia. What is new, of course, is the use of wind power to generate electricity, a process which first took off in the USA in the early 1980s, driven by the tax credits then on offer. The focus of action then moved to Europe where wind power expanded rapidly in countries such as Denmark, Germany and Spain, encouraged by high support prices.
- **Environmentally friendly but environmentally objectionable.** Wind power is thought by many to be environmentally friendly, given that it is a renewable source with no CO_2 emissions from operation. But one of the biggest problems for wind developers in the UK is the considerable opposition to new wind farms on environmental grounds. Many more wind farms are rejected at planning stage than, for instance, gas turbines.
- **Secure but unreliable.** Again, the proponents and opponents of wind power take diametrically opposed views. On the one hand, wind is an indigenous, renewable source, not dependent on imported fossil fuels. On the other, it is intermittent and unpredictable (or perhaps more precisely uncontrollable).
- **Economic but subsidised.** This is another contentious area. Wind is argued by its proponents to be nearly competitive with fossil sources – and fully competitive once environmental externalities like CO_2 emissions are taken into account in prices. On the other hand, wind power has always been dependent on government support – and that need seems to be increasing. One part of the answer to this paradox is relatively simple – there is no such thing as the cost of wind power in general; there are only the economics of particular projects at particular places at particular times. Two broad generalisations seem safe however: wind is generally not competitive with conventional (non-renewable) sources of generation, but is generally the cheapest of the 'new renewables'. Furthermore, the economics of wind power are affected by two trends which tend to move in opposite directions – on the one hand, as the technology improves, costs tend to fall; on the other, since the costs are site specific, the best sites tend to be used first so leading to a rising cost curve over time. Proponents of wind power tend to emphasise the former, though it seems recently to have levelled out (and even went into reverse as the price of inputs soared earlier this decade). It is the trend in site economics that now seems to be predominating, in the UK at any rate, as the focus of development moves offshore.

However, this article is concerned with a further anomaly:

- **UK – well placed but lagging.** The UK has probably the best wind resource in Europe, but the development of wind power (and indeed of all renewables) has been slow. Despite decades of government support, the UK remains at the bottom of the European league in relation to the penetration of renewables in its energy system, languishing along with such states as Hungary and the Czech Republic, well below Portugal and Ireland, much less Germany or Denmark.

European and Global Background

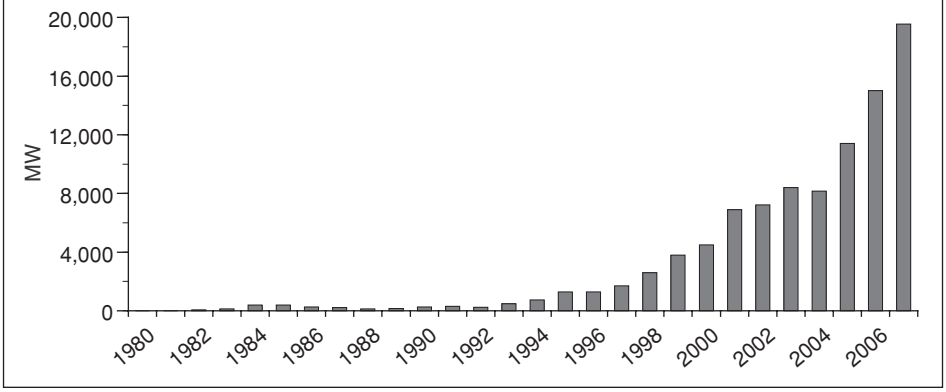
According to the European Wind Energy Association, in 2008, for the first time, wind energy was the largest single form of new power capacity in Europe, as shown in Figure 1.

This follows years of rapid global expansion – a growth rate of over 30 percent per year in wind capacity over the past ten years as shown in Figure 2.

This growth has taken place in many of the countries you might expect to be prominent in this area – Denmark, Germany and Spain and (after a period of low interest) the USA. But it should be stressed that it is not solely an OECD phenomenon. China and India are both active in the manufacture of wind turbines and in the development of domestic wind generation. Indeed, China is currently the most dynamic wind market in the world, having doubled its wind capacity in each of the past three years.

Such developments, along with the renewed interest in the USA, led the World Wind Energy Association to conclude, in its report for 2008, that: 'North America and Asia catch up in terms of new installations with Europe, which shows stagnation.' That is, it describes as stagnation a year when in Europe, wind led the league table on new power plant installation!

Figure 2: World Wind Annual Additions (MW)



Wind in the UK

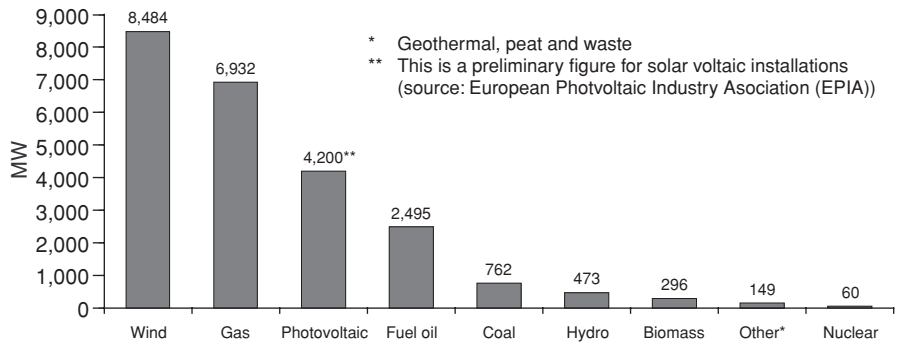
While the UK has seen significant wind development, against this background its efforts seem feeble. Wind currently accounts for less than 2 percent of electricity generation – under 1 percent of the energy supplied in the UK.

Why the slow rate of development? One thing is clear – it is not for lack of government policies and targets. Wind has been given significant policy support for the best part of two decades. This came first through the so-called Non Fossil Fuel Obligation (NFFO), which operated during the 1990s. It had some successes; although only relatively small quantities of wind generation were built, the technical cost of wind power fell significantly. In the second NFFO round in 1991, the average cost of wind was around 11p/kWh; by the time of the fourth NFFO round in 1997, the cost had fallen to between 3 and 4p, leading some to conclude that wind would soon need no subsidy. In practice, of course, wind has needed continued and increasing support, now given primarily through the Renewables Obligation (RO) scheme described below. Onshore wind power, being generally the cheapest renewable source, tends to be the favoured option under the RO.

The UK had a target of 5 percent of electricity to come from renewables by 2000 and 10 percent by 2010. The first has already been missed; the second will no doubt also be missed – it was only in 2008 that the proportion of renewables finally reached the 2000 target. It currently stands at a little over 5 percent; wind is about one-third of this total. For 2020 the UK initially had a target of 20 percent of power from renewables. This was widely regarded as unrealistic, but has actually been increased in line with the EU's target of 20 percent of energy from renewables by 2020. The UK share of this target is for 15 percent of energy from renewables by 2020. This may not sound overly onerous but it applies to total energy supply, not just electricity; given the current low rate of renewables penetration (only 2¼ percent of UK energy) the increase required of the UK is in fact the most ambitious in Europe. Furthermore, since most of the renewable energy will in practice be in power generation, the new goal translates into a target of over 30 percent of power generation from renewables, most of which will have to be wind power. The government recently published a new Renewable Energy Strategy setting out how it proposed to meet this target.

Is the UK likely to stop being the laggard in Europe? This seems unclear.

Figure 1: New Power Capacity Installed in 2008



Source: EWEA and Platts Power Vision

There have been three main factors underlying the slow progress in this country:

- **Environmental objections.** These have been much stronger in the UK than in other European countries and the planning process has taken longer and proved more risky – about half of proposed onshore wind projects are rejected, though offshore projects have fewer problems. Private wind developers often describe this as the main drawback of operating in the UK.
- **Form of support.** Under the RO scheme in the UK electricity suppliers have to source a certain proportion of their power from renewables, a proportion that rises year by year. Renewables generators receive income both from the direct sale of their power and from the sale of certificates (called ROCs). Suppliers must have enough certificates to cover their quota, or pay a buy-out price (which is in turn fed back into the renewables support system). The current price for a ROC is around 5p/kWh; at recent power prices of around 4p, onshore wind operators therefore receive over double the income of conventional generators, while offshore projects get even more help. The system is fairly market friendly but entails considerable uncertainty as to the future value of the ROCs, which constitute most of a wind generator's income. Most countries have gone for rather simpler systems involving Feed In Tariffs (FITs) or premia – a fixed price or premium for renewable electricity. Such systems are used in the fastest growing wind markets like Germany and Spain, and China has a comparable approach, based on tenders for new wind power projects; the US has a variety of support systems in different states. Nearly all studies show that FIT systems are much more effective at encouraging new renewables capacity, because of the greater certainty they provide. Recently the IEA concluded that well-designed FIT systems have 'proven to be both effective and cost-efficient' while quota systems 'showed higher transactions costs and turned out to be much less effective and more costly than expected'.
- **Difficulties of operating offshore.** Given the environmental difficulties onshore, the UK has to look offshore for most of its future wind capacity. But the offshore environment is very challenging, risky and expensive and it is by no means clear whether it will prove feasible to deliver the results the government is aiming at. A 2004 Report by the House of Lords Committee on Science and Technology commented that 'the potential obstacles to large-scale wind development remain formidable' and that 'it remains to be seen whether offshore wind power can fulfil the vital role assigned to it.' The NAO has also pointed out that risks and costs are likely to be high for offshore wind and that the potential is very uncertain. Support for offshore wind has increased but these practical questions remain.

Prospects for 2020

The government recognises the problems but has so far tended to address them piecemeal. First, as to the measures taken to address the three issues mentioned above:

- **Environmental objections.** A new Planning Act is designed to speed up the planning process for so-called Nationally Significant Infrastructure Projects – to include offshore wind farms over 100MW and onshore farms over 50MW. The aim is to provide planning decisions within nine months of the start of the process. The process will be supported by a renewables National Policy Statement setting out why development is in the national interest. However, the new system remains to be tested.
- **Form of support.** The government appears to have no very strong argument for continuing with the ROC system – it says only that changing to a FIT system would cause delay and uncertainty and might be incompatible with the liberalised power market in the UK. Nonetheless, the government recognises that it will need to change and extend the support – for instance, by using FITs for small generators, developing the RO system to give extra certificates for more expensive technologies such as offshore wind, perhaps adding floor prices and 'headroom' (to maintain ROC price levels), reducing exposure to electricity price fluctuations and so on. But these measures would add significant extra complications, reduce the importance of market signals and get rather close to picking winners. Furthermore, in many cases, extra capital grants of various sorts are needed to promote offshore technologies.
- Meanwhile the development of **offshore wind** remains very difficult. The UK regards itself as a world leader in offshore wind, but the quantities are still very small – less than 1GW of capacity. It remains a very expensive and high-risk technology, requiring significant injections of government support. Although it was announced with much fanfare, the decision earlier this year to go ahead with the London Array offshore project only demonstrates the scale of the problem. The Prime Minister played up the announcement, claiming that: 'The London Array is a flagship project in our drive to cut emissions by 80 percent by 2050 and meet future energy needs.' But the first phase announced in May amounts to only 630MW. The government's target for offshore wind is 25GW. If this is to be built by 2020 to meet the EU target, we would need three or four projects of the scale of the London Array every year, which would need tens of billions of pounds of high risk capital (some £46 billion according to the government's consultants SKM), at a time when credit availability is a major problem. Recently, there seems to have been a shift in emphasis back to onshore wind, perhaps judging that forcing communities to accept wind turbines onshore will be easier than

meeting the physical and financial challenges offshore. Nonetheless, offshore wind remains central to government strategy.

Overall, the programme looks both expensive and unlikely to be realised. Even on the government's optimistic assumptions, renewables appear to be one of the least cost-effective forms of carbon reduction and would be likely to show a significant negative net present value (NPV), even after taking account of the value of carbon emissions reductions.

Furthermore, while the measures discussed above may have some effect in facilitating renewables investment, they do not address another fundamental problem: that if it is to meet the EU target, the UK will need a complete makeover of the country's electricity system. Meeting the renewables target will involve:

- A change in the industry's **cost structure,** which would almost certainly have to be reflected in a change in its market structure. For instance, the scenarios examined by the government's engineering consultants during the consultation process showed that on a business as usual (BAU) basis, marginal costs (mainly fuel) would account for some three-quarters of the cost of each kWh. On the central renewables scenario, marginal costs would be only around one-third of the total; most of the rest would be fixed capital costs, but there would also be a large component for grid management and balancing to cope with the intermittency of wind. It is doubtful if present pricing structures, based on a price per kWh, would be effective. Among other consequences, they would produce significant periods of zero or negative prices at times when wind generation exceeded demand, along with extremely high prices at times of high demand and low wind generation. Since the total cost of the system would be significantly higher than on a BAU basis (at least one-third higher, and probably significantly more), this would produce an extremely odd price structure. The prospect of such volatility would create significant risks for investors.

- Changes in **regulation.** Most of the cost in the present system comes from market-led decisions on power generation investment and operation. In the renewables scenario, network investment (a regulated monopoly function) would soar – over ten times as much would be needed, and it would need to be coordinated with the generation investment. Grid and balancing costs (an administered market) would also be nearly ten times as great as on the BAU scenario. Furthermore, the main element of system cost would be the capital investment in renewables projects – some £60 billion – nearly all of which would be dependent on the government support offered. In other words, most of the cost of the new electricity system would not arise from the free operation of market forces, and economic regulation would need to adapt to this new situation.

- Changes in **operation** would also be required, particularly if the government is successful in encouraging the construction of new nuclear plant and improving energy efficiency. If this happened and the renewables targets were met, there would be considerable periods of time when generation from what are normally regarded as inflexible plant (wind and nuclear) would exceed demand. It is not clear whether price signals would be enough to discourage the surplus generation. Even the negative power prices quoted above might not do the trick – wind generators would still get an income from their ROCs, so might prefer to go on generating, while nuclear generators face significant costs in ramping production up and down and would also be reluctant to do so. UK wind and nuclear plants have not in the past been designed to operate flexibly in response to market signals and may not be able to do so. It is likely that, in practice, much plant would simply have to be stopped from generating at certain times (that is, be 'constrained off' the system). Meanwhile, fossil stations would essentially have to act as back-up for the intermittent wind plants and operate at an unattractively low load factor (30–40 percent for new plants; much lower for older plants kept on the system). Until the new operating regimes were clearly understood, this would create major risks for investors. Generating plants have lifetimes measured in decades so anyone investing in generation now will have an interest in the post-2020 regime and will want some idea of what it might involve.

Sooner or later, the government will have to design a completely new electricity market and regulatory system around its environmental policy goals. It has already acknowledged this trend in part, recognising that 'there has been an increasing shift recently towards a more active role for government'. However, it has not so far been prepared to define its new role in energy markets with any clarity.

This leads to a final paradox – while the government is clear about its goals for renewables, almost everything else is still unclear. Are the targets any more credible than their predecessors? They appear to be both unrealistic in practical terms and highly costly; however, unlike their predecessors, they are now legally binding – will that make a difference? What further support might be forthcoming for wind power when it becomes apparent that the UK is not on track to meet its targets? What changes will be needed to electricity markets and when might they take place? What role will the government and regulators play? It is likely to be some time – especially given the prospect of a general election – before these questions receive substantive answers. This uncertainty can only act as a disincentive for potential investors in power generation.