Wind Energy

Price 40p

A fast expanding industry

Wind energy has come a long way since interest was renewed in the '70s following the oil price rises. Installed capacity reached over 59,000 Megawatts (MW) worldwide by the end of 2005, up some 24% over 2004. Average turbine size has increased to over 1 MW with some 5 MW turbines being installed and 7 MW ones under consideration. Early small turbines installed in California, Germany and elsewhere are being replaced by larger and more efficient units. Turbines are being installed off shore and in more countries. Germany, which has made astonishing progress since 1990, had 18,428 MW installed capacity at the end of 2005 (the most in any country) providing 6% of its electricity. The EU attained its 2000 target of 8000 MW a year early, with major contributions from Denmark and Spain as well as Germany. A second target of 40,000 MW by 2010 set in 1997 was reached 5 years early and has been successively raised to 60,000 MW and now 75,000 MW. Elsewhere the USA had over 9000 MW and India almost 4500 MW of wind farms by end 2005. The wind market and technology is already 'mature'.

All this heady progress should not obscure 2 facts. First, wind generated electricity is more expensive than 'fossil' fuel and second there is a practical limit to the amount that can be taken.

Limitations of wind power

The first and obvious point to make is that the wind does not always blow, nor blow at the same strength, all the time. The more turbines one has and the more widely spaced they are across the country, the more chance there is of wind occurring *somewhere*, but there can still be little or no wind on dark winter days. A recent study in Germany concluded that wind output was less than 11% of full capacity for over half the year. Second, as the amount of wind energy increases, the more fossil fuel back up will be needed as a 'spinning reserve', though not 100% of the wind capacity. Wind energy saves some fossil fuel (which is good) but not all the *capital or running cost* of standby plant. Third the low 'load factor' and far flung location of many wind farms means the cost of grid connection *per unit of electricity* is higher than fossil or nuclear plants.

Over the 8 years '97-'04 the *average* output from wind turbines in the UK was 27.6% of the installed capacity. Thus a wind farm of 20 MW capacity will produce only 5-6 MW *on average*. About 3000 1 MW turbines are needed to provide the same electricity as one AGR nuclear station.

Integrating wind energy into the grid

Clearly if the wind is blowing one must use the electricity generated. In the UK electricity is fed into a national grid from nuclear, gas, coal, and oil fired power stations and a number of smaller sources such as hydro, CHP and energy from waste plants. Nuclear reactors can not be stopped and started easily and because the most efficient gas stations operate at high temperatures it is undesirable to stop and start these as well. At present coal and the less efficient gas stations are used to even out demand, with the pumped storage hydro plant at Dinorwig providing a rapid response in the event of a large power station failure. It helps that the domestic 230V supply is allowed to fluctuate +/- 3% as this means the generated power can vary by +/- 2000 MW on a minute to minute basis.

1.5 MW wind turbine at Swaffam, Norfolk

At Dinorwig water is pumped from a low reservoir to a high one at times when electricity demand is low so it is available for a sudden increase in demand or failure of a power station. More systems like this would be invaluable because reservoirs can act as electricity 'stores' and so balance out supply. There are unexploited hydro sites in the UK, mostly in Scotland, but development is often opposed.

An ALDES Briefing Note

Last updated January 2007

This briefing note has been prepared for ALDES by Richard Balmer, but the opinions expressed are his own. If you see errors or have comments, please contact Richard Balmer, at 79, Links Drive, Solihull, B91 2DJ or email richard_balmer@blueyonder.co.uk

Forecasting the demand for electricity hour by hour, and hence which generators need to be switched on or off, is a science. Forecasts take into account previous records, the time of year, hour of day, temperature, wind speed, and even what is on the TV. Accuracy gets close to +/- 2% but, as average UK demand is about 40,000 MW, that is still around 1000 MW variation (half of the 3% variation allowed) from a 'perfect' match.

Practical limits for wind energy

Denmark has gone furthest in exploiting wind energy. Around 20% of its electricity comes from wind but only because it can balance its supply by taking and dumping to the Scandinavian and German grids which have large hydro electric back up. Even so a problem arose in January 2005 when a hurricane hit Scandinavia. The grid tripped under the surge of power and left large areas without electricity for 3 days. Poor 'quality' (ie variable and unreliable) electricity is a concern to Danish consumers, as well as the price paid. At the end of 2003 doubts surfaced in Ireland too when the actual and planned connections to the grid exceeded 10% of total capacity. Most countries believe they could take 20% of electricity from wind at *peak* without problems (5-6% on *average*) but UK politicians are contemplating 15% of electricity *on average* from 22,000 MW installed capacity! One recent study[1] suggests anything over 10,000 MW (6-7% of total electricity, 8 times the present amount of wind) is impractical. Another[2] implies up to 10% might be possible.

This second study analysed wind speed data from around the UK and postulated an 'ideal case' where wind farms were sited so that whatever wind was present over and around the UK could be used. The conclusions were useful and interesting. First about twice as much wind occurred on average in the 3 winter months, when electricity demand is high, than summer. Second there was more wind between the hours of 8 am to 8 pm than 8 pm to 8 am which, again, is when it is most needed. On the other hand the study found considerable variation from hour to hour.

Wind turbines are designed to optimise performance at particular sites and so figures differ. The turbine quoted in the study produced no electricity in winds of less than 4 metres/sec (9 mph) and shut down at 25 m/s (though speeds in excess of this are rare). From 4 to 14 m/s output increased by the *cube* of the wind speed. (from 14 to 25 m/s output was constant). The variation between 4 and 14 m/s poses problems. A relatively modest change in wind speed from 8 to 10 m/s *doubles* output. A drop from 10 to 8 m/s *halves* it. The study found that even with the 'ideal case' a change of 10% in output in an hour would occur on average once a day, and sometimes the change was greater. An hour is too short a time to start or stop conventional stations so the more the grid relies on wind the more the voltage will bounce around and the more difficult it will be to achieve stability.

For those interested in all the factors in siting and designing wind turbines there is an excellent article by John Twidell in the May-June 2003 edition of Renewable Energy World

Storage and managing demand

The crux of the problem is the need to find new ways to 'store' electricity besides hydro. This would assist the introduction of solar energy as well. A possible route is to use surplus electricity to produce hydrogen. The hydrogen could be re-converted back into electricity using fuel cells when the wind drops or, alternatively, be used for transport fuel, opening up a huge new market. Currently a company is proposing to trial this technology in 2 farms, one in the Baltic off Poland and another in California. Alternatively huge batteries might be used, though progress to date has not been encouraging. Lastly one might try to 'manage' demand. Industry can already choose 'interruptible contracts' and 'Economy 7' tariffs for example are used to feed domestic storage heaters at night and sometimes switch on dishwashers and washing machines. Economy 7 however is a predictable system whereas a wind related supply is not. It is easy to see domestic consumers becoming very frustrated.

Costs of wind energy

It is not easy to estimate the real cost of generating wind energy. There are good and less good sites. Much of the UK's best wind energy is in the north and west while most demand is in the south east, so allowances for the extra cost of overhead power lines should be made. In Germany guaranteed prices vary from about 4.5 to 5.8 p/kWh. The best sites in the UK will struggle to get much below 3.5p/kWh and perhaps 1p/kWh should be added for the capital cost of standby plant and extra cost of grid connection. This total of 4.5p/kWh compares to a recent UK cost of power supplied to the grid of about 3 p/kWh which has risen with increased with rising gas prices. (Distribution costs add about 4p/kWh to generating costs).

Surveys have shown that the majority of people would pay more for 'green' energy, but when asked 'how much' interest tails off rapidly at 10%. Government has therefore *imposed* a requirement on electricity suppliers to use a minimum amount of wind or other renewable energy under the 'Renewables Obligation'. Electricity companies have to supply 6.7% from renewables in the 2006/07 year and this figure will rise to 15.4% in 2015/16. Every renewable unit not supplied costs 3.3p so wind generators currently receive over twice as much as fossil fuel ones.

Opposition to wind energy

For many years progress in the UK was dogged by the difficulty of obtaining planning permission. Only 60 wind farms had been built by 2000 with a miserly total of 409 MW capacity even though subsidies had been promised for over 2000 MW. Wind farms need 1 km^2 for every 10 MW capacity and, though many find turbines elegant, they are prominent with the tip of the blades often 100 m above ground. Environmentalists are unhappy about these large structures especially in scenic countryside and there are concerns about hazards to birds and low flying aircraft, noise, and interference to radio, TV and radar. A judge has recently decided that a wind turbine 500 metres away reduced a property's value by 20% and a campaign group is already fighting a proposal for a 220 km long overhead power line to bring wind generated electricity across the Scottish Highlands. Nor is it easy to give financial incentives to communities prepared to accept a wind turbine 'in their back yard'. Wind energy costs more and the cost of the standby grid connection, when the wind doesn't blow, remains.

UK companies almost gave up but the log jam began to clear in 2002. Many farms have now gone ahead and recently permission has been granted for a very large farm near Glasgow (322 MW). Plans for 500 turbines on the Isle of Lewis however have hit opposition. Perhaps a more important decision occurred in July 2003 when the Government announced it would support the installation of 6000 MW of capacity offshore by 2010.

Offshore wind farms

The decision to go 'offshore' ducks the tricky problem of finding sites on land but it has 2 advantages. First there are more sites near centres of demand such as London. Second the wind, though weaker, is steadier. Offshore farms with turbines out at sea, even over the horizon in up to 40 metres of water, could comprise a major part of the UK's wind energy program. Big farms at Hoyle (Rhyl Flats) and Scroby Sands off Yarmouth started to feed electricity into the grid at end 2003 and end 2004 respectively. Electricity from a third offshore farm, Kentish Flats, (30, 3 MW turbines) is also coming ashore. In December 2006 Government approved a massive farm (the London Array) comprising 341 turbines, with installed capacity of 1000 MW and costing £1.5 bn, spread over 90 sq miles in the Thames Estuary 12 miles off the coast between Margate and Clacton. The first electricity should come ashore in late 2010 and all by 2014. Another farm of 100 turbines, costing £0.5 bn, is to be built 7 miles off the coast opposite Margate. More have been proposed, including the Triton Knoll farm in the Wash (which would be larger even than the London Array), though many are held up in planning enquiries or worries over cost.

Offshore turbines do not attract the onshore aesthetic objections but the sea is a much more hostile place. Foundation costs will be higher, maintenance more difficult, shipping lanes and fishing grounds must be avoided. Generation will probably cost at least 2p/kWh more than on land.

Local generation

A further development has been to encourage local (so called micro or embedded) generation of power. Small turbines, which can be sited above roof level on simple poles, are on the market and can be plugged straight into a house electric circuit. Any surplus can attract ROCs and, with various grants, are economically attractive. They do not remove the need for a grid back up however and as they do not increase the total amount that can be taken from wind they may not represent a particularly good 'buy'.

Conclusions

At the end of 2006 the UK had around 1570 MW of wind capacity, still way short of the 10,000 MW that could probably be safely accommodated without large scale storage. Clearly the wind programme should proceed at pace but it is perhaps even more important that research on storage of electricity be accelerated now.

Assuming the true *extra* cost of wind generated electricity over fossil stations averages 3p/kWh and ultimately 10% of UK electricity comes from wind, consumers will be paying about £1bn/year more for their electricity.

References

1: Sharman Hugh "Why UK wind power should not exceed 10 GW" Civil Engineering 158 Nov 2005 pages 161-169

2: Environmental Change Institute, University of Oxford "Windpower and the UK wind resource" 2005