Environmentally unfriendly wind power – a personal opinion

By Dr V.C. Mason (February 2004) ©

Wind technology is promoted as a means for countering climate change and for reducing the pollution and greenhouse gas emissions associated with power production. Evidence is accumulating, however, which suggests that for technical, economic, and environmental reasons this technology in its present form is not the panacea that many claim it to be.

The need for conventional backup

The national grid of the UK (i.e. the National Grid plus Scottish Power and Scottish & Southern Power) operates to a large extent as an island system, with load generation tracking demand. The proportion of total load and demand balanced via the 2,000 MW interconnector to France is marginal, representing only about 3.5% of current peak load (Sharman, 2003b).

Traditionally, the operational integrity and stability of the grid has been maintained by the provision of about 23% backup from coal-fired, gas-fired, or other dependable generators (Laughton & Spare, 2001). This figure recently fell to a more critical 16% following the introduction of the New Electricity Trading Arrangements (NETA). Most backup is provided by reserve plant running less efficiently below full load to respond instantaneously to any unexpected loss of the largest generating unit. Some of it is used, however, to ensure stability of start-up and / or connection (Laughton, 2002).

The situation becomes more complex when wind, or other unpredictable power source, enters the scene. Since the energy content of wind is related to the cube of its speed (Baird, 1993; Hayden, 2001), the amount of wind power produced at any particular time can vary rapidly. The output of turbines in Western Denmark, for example, rises more or less linearly as wind speeds increase from about 5 m/s (gentle breeze) to 13 m/s (strong breeze), and then levels off at near maximum production. Many machines stall at about 20 m/s (gale), but modern turbines are designed to operate above this speed with a 20% decrease in output. Most are turned off when the speed exceeds about 25 m/s (storm) (Sharman, 2003ab).

Such unpredictable features are unsuited to the requirements of the UK grid, which, second by second, has to balance the power supplied to the transmission lines (by selected conventional and renewable generators) against actual power demands (including losses). Moreover, since the overwhelming majority of UK wind turbines are connected as ‘embedded generation’ to the lower voltage distribution network, their output is largely outside the direct control of the transmission system operator (TSO), and is monitored only as an unpredicted decrease or increase in power at the transmission - distribution interface.

Small variations in supply, and the present very low level of wind power production in the UK (about 0.3% of supply in 2002) can be accommodated by slack in existing facilities. However, as the number of wind turbines grows, serious difficulties will be met in disposing of wind power surges unless large interconnectors are connected internally and to other European countries. Moreover, a serious challenge to backup provision will occur during periods when high-pressure weather systems cover much or all of the UK, causing wind power output to drop to near zero for hours or even days at a time. Such large-scale intermittency is a regular feature of British weather, and will require the existence of alternative plant capacity far beyond that of normal backup, wind generation having no reserve-capacity credit. As at present, the entire peak load plus reserve margin will have to be covered by conventional plant (Laughton, 2002), the deployment of wind turbines not allowing other sources of power to be taken out of service (Hayden, 2001).

The proportion of installed wind capacity actually achieved by UK land-based machines over a year (i.e. the capacity or load factor) is estimated to range between about 25 and 30%, with an overall average of about 28% (DTI, 2003b). Foreign records suggest, however, that these data may over-estimate the value for longer-established or lattice-block arrangements of wind stations, because annual load factors of around 20% have recently been recorded for Denmark which experiences similar wind-conditions to the UK (Sharman, 2003b). Comparable low estimates can also be calculated from data published for Germany (Reuters, 2003, 2004) and parts of the USA (Hayden, 2001). Part of the explanation may lie in differences in weather conditions, but turbulence from lead turbines in clusters can reduce the wind energy available to those down-wind. Furthermore, wear and tear (Andersen, 2004) and midge and salt accumulations on turbine blades (Merritt, 2004) may also be factors. At the present time, only a small and variable proportion of the electricity fed by the grid to the average UK house typically comes from wind power, more energy coming from other renewable sources and the overwhelming part being provided by conventional generators.

Danish experience

Denmark is a small country with two unconnected grid systems, east and west of the Great Belt, respectively. Its western region has already achieved the renewables goal to which the UK aspires by 2020, so it is instructive to examine its experience of extensive wind power

In 2003, Western Denmark had the highest concentration of wind turbines in the world, its c. 4,700 wind turbines having an installed capacity of 2,374 MW (Bülow, 2004), or about 62% and 85% of peak winter and summer loads, respectively (Sharman, 2003ab). It also possessed about 500 decentralised heat and power (CHP) plants, as well as coal-burning facilities. Of great importance, Western Denmark has interconnectors to Norway, Sweden and Germany Their total capacity (c. 2,400 MW) almost exactly equals the installed wind capacity. This allows the export of surges in windy conditions and the importation of power (including nuclear-generated power) during windless periods.

Regulation of the output of Western Denmark's wind turbines and CHP plants is thus achieved by a combination of paying the region's largest power company to ramp its coal or gas-fired output up or down, by exporting power (often at very low prices) (Sandøe & Thisted, 2003), or by importing electricity at premium prices. The system is very different from that of the UK, and survives by virtue of Denmark's ability to transfer large amounts of power to and from the much bigger grids of its neighbours (Sharman, 2003b), who possess large hydro facilities (that can be switched off or on at short notice) and/or big markets.

Even with its geographical advantages, however, Western Denmark's principal TSO has reported that managing the unregulated production of electricity from its wind turbines and CHP plants can be akin to manoeuvring a rapidly moving articulated lorry train without a steering wheel, accelerator, clutch or brakes (Andersen, 2003). Although its annual production of renewable (mostly wind) power is currently about 21% of local consumption, wind supply can exceed regional demand on occasion. Conversely stranded wind power production has been a frequent event, and even negative output has occurred when the steering requirements for the system exceeded wind output (Sharman, 2003ab). An acute challenge was experienced in Western Denmark on New Year's Day 2002, when twelve wind farms were shut down for a 12-hour period for fear of over-capacity on the grid (Rostgaard, 2002). This problem arose because the export option was not available (industrial shut-down in a holiday period) and windy conditions prevailed at a time when the demand for electricity was low but cold weather dictated a high demand for heat from the CHP plants (Andersen, 2002). An inaccurate weather forecast caused another serious event on 27th October 2002, described under the heading ["More wind turbines cause chaos"] (Sandøe & Thisted, 2003). It is also becoming increasingly difficult for Western Denmark to export over-runs to Germany because of the large concentrations of wind turbines on both sides of their shared border. These countries often compete to export superfluous wind power for whatever low price the market can bear (Sandøe & Thisted, 2003).

To reduce its dependency on neighbours, Denmark is now investigating the use of wind power to part-heat the water for the district heating system at its CHP plants (Bülow, 2003; Sandøe, 2003). This is a traditional taboo to those interested in the efficient use of power; and will require a change in legislation, because high energy taxes make it more economic to give away excess power than to heat the district heating water with it.

Wind turbine economy

Large subsidies are needed to make wind power economic. The cost of installing 1 MW of off-shore power is said to be c. £1 million (two-thirds of this cost on-shore), depending on the size and location of the turbine. The cost of backup plant must also be considered. Even assuming a load factor as high as the 40% optimistically predicted by some in the UK for off-shore turbines, 1MW of installed capacity would earn only £56,000 per year at current wholesale prices of fossil-fuel electricity (Etherington, 2003b). Under these conditions it would take most of the operational life of a turbine to pay off the investment and the cost of servicing the capital expenditure. To encourage UK wind power production, a massive hidden subsidy is therefore paid by the consumer via the Renewables Obligation and the Climate Change Levy Exemption. Wind energy producers receive a c. £50 / MWh 'premium' (NAW, 2003) on top of the wholesale price of around £20 / MWh paid for fossil fuelled and nuclear electricity. Clearly, these large subsidies, the overall load factor and the life expectancy of a turbine are all critical to its economy.

Development of wind power in Denmark has been exceedingly expensive. A recent question to the Danish Economy and Industry Minister revealed that during 2003 alone electricity consumers were subsidising so-called 'environmentally friendly electricity production' (via their electricity bills) to the tune of DKK 3.4 billion (Bendtsen, 2003). This is a massive annual sum for a population of only 5.4 million.

Carbon emissions

Wind technology is promoted with claims that it reduces carbon emissions from power stations by displacing fossil-fuelled sources such as coal. Indeed, because the blades of wind turbines do not themselves produce emissions during operation, it is a widespread perception that their power output must be 'environmentally friendly'.

Contrary to this view, much evidence suggests that the supply of wind power to the National Grid may promote little if any saving in carbon emissions. Annual electricity demands have recently been increasing by about 1.0 to 2.0%, yet in 2002 the combined output of no less than 1,000 UK onshore wind turbines amounted to only 0.3% of the country's production. (Simple mathematics illustrate how many thousand turbines need to be deployed each year just to keep abreast of the annual increase in demand for electricity!) Carbon emissions savings (uncorrected for backup and embedded emission costs, etc.) were a miserly 0.08%, although UK emissions have recently been increasing by about 2% a year.

Even this low value for carbon savings is an over-estimate. As explained earlier, current wind technology cannot provide much power to the grid without seriously affecting the smooth operation of other generators. Allowance must therefore be made for a fair share of the requirements of backup, and, in the future, the less efficient operation of fast-access conventional backup systems struggling to balance unpredicted changes in the supply of wind power. Under NETA, much UK coal plant is only part loaded so that the loss of a generating unit (such as a wind station) can swiftly be replaced by bringing other units to full load. It appears that the entire benefit of reduced emissions from the renewables programme can currently be lost by increased emissions from part loaded plant (Orgill, 2002; Tolley, 2003).

Consideration must also be given to the embedded pollution costs of mining/quarrying, transporting and refining the basic components of thousands of wind turbines, massive concrete foundations, access roads, pylons, cables and associated electrical plant, as well as the processes employed in their manufacture, deployment, operation, maintenance and replacement. The size of these costs depends on the operational life of such plant. The life of wind turbines is often stated to be 20-25 years, but even in Denmark few have survived this long, many on-shore machines being replaced by larger ones for technical and economic reasons after only 10 to 16 years of operation (Bülow, 2002). A similar 10-15 year life-span has been predicted for the latest Danish off-shore turbines because of the harshness of their marine environment (Gatzwiller, 2002). Transformers are already being replaced in the newly installed Horns Rev turbines because of unpredicted flashovers (Andersen, 2004).

Reports often suggest that 1 MWh of wind power prevents the emission of about 0.84 tonnes of CO_2 (i.e. 0.23 tonnes carbon). This over-optimistic claim wrongly assumes that wind power production is a CO_2 – free process which supplants power exclusively obtained by the burning of ‘dirty coal’. In fact the mixture of sources selected by TSOs to supply power is determined by economic and practical considerations. The benefit will thus depend on the mixture of sources actually replaced, coal and gas, combined cycle gas and nuclear sources producing in the region of 0.60, 0.37 and 0 tonnes of CO_2 / MWh, respectively (excluding backup and embedded carbon costs) (DTI, 2003a; Etherington, 2003a). Economic pressures on TSOs naturally encourage them to exclude the more expensive sources from their portfolio.

Despite Denmark’s enormous efforts, it has been suggested that its notional CO_2 reduction benefit from wind is currently dissipated to up to 50% of the theoretical saving, depending on where the power is being channelled (IchemE, 2002). Furthermore, after achieving a continuous fall in these emissions between 1995 and 2000, Western Denmark has experienced an increase in CO_2 production over the last two years (Sharman, 2003a).

Several ‘catch-as-catch can’ options are being considered to reduce the need for conventional backup, to optimise carbon savings, and to avoid the export or import of power:

a) Power storage in fuel cells has been envisaged, and prototype plants installed in the USA, England, and Denmark (Bülow, 2001). Recently, however, the company concerned was taken over, and at least the Danish project has been terminated. Large numbers of such cells would be needed to support widespread wind installations, the holistic environmental and carbon costs of their manufacture and operation being unknown.

b) Industrial companies are also considering the sequestration of CO_2, - as well as the use of wind-power to re-cycle water within pumped storage systems (similar to the Dinorwic, Ffestiniog and Cruachan stations) or produce hydrogen by the electrolysis of water. Despite their advantages, most of these approaches are very expensive and have potentially serious environmental draw-backs.

Environmental impact

Expansive nature of wind technology

A major weakness of current wind technology is its requirement for large areas of land and sea over which to harvest the energy contained in moving air. Air turbulence can be registered at considerable distances from revolving blades, so wind turbines need space in which to operate efficiently. A 27-year-old Danish rule of thumb is that turbines should be separated by at least seven times their rotor diameter, to prevent them taking wind from each other and reducing efficiency. The 80 new 2MW off-shore turbines at Horns Rev were thus arranged in lattice pattern, such that the distance between individual turbines and rows is 560 metres (Bonefeld, 2001). This corresponds to an area of about 78 acres per turbine. Land-based wind projects are typically rated at 25 to 100 MW, a 25 MW installation comprising 60 to 70 turbines covering 1500 acres (Hayden, 2001) corresponding to 21 – 25 acres per turbine. It is evident that as the size and number of turbines and pylons grows, their deployment will inevitably mean that many of the windiest, exposed, and often most precious, attractive, and spectacular regions of the country will be carpeted by these machines and their pylons.

Turbine incidents

The implications of siting large numbers of these 100-176 metre-high structures on hill-tops, near to woods, private dwellings, public roads, footpaths and bridleways, or close to wildlife migration routes and feeding, breeding or resting areas, are potentially serious. Many incidents of turbine fires and the ejection of ice or debris have been recorded throughout Europe. An amateur parachutist was killed by gliding into rotating blades, a Vet, out walking, was struck on the shoulder by a large piece of falling turbine ice, a fitter was killed by falling parts while servicing a wind turbine, passing cars have been damaged by flying ice, turbines have blown over, a turbine blade penetrated the wall of a neighbouring house, a European record of about 460 metres has been recorded for ejected turbine material, and horses have bolted at the sight of flailing blades (Krämer, 2000).

The deployment of these machines, with their massive concrete foundations, access roads and pylons, is already destroying wildlife habitats. Throughout Europe and America, large numbers of birds and bats (many of protected species) have been killed by turbine blades, the tips of which can rotate at up to about 160 mph. It has been estimated that every year, wind stations kill over 100 Golden Eagles, 500 to 1000 Hawks and Falcons, more than 500 Griffon Vultures, a variable number of Sea Eagles, Booted Eagles, Short Toed Eagles, Harriers, Kites, Egrets, Red Grouse and other large birds, and hundreds or thousands of smaller birds. At German wind stations 26 dead Red Kites have been recovered so far, and it is reported that these birds have disappeared from certain Italian valleys following the installation of wind turbines (see Duchamp, 2003abc). Recently, the death of one of these relatively rare birds (c. 500 breeding pairs in Britain) was reported very close to a wind station in Wales (Welsh Kite Trust, 2003: Townsend, 2004). Migration flight paths, and breeding, feeding and resting areas are particularly threatened.

In Sweden and Germany, individual bats of 10 species have become victims of wind turbines (Ekert, 2003). Concerned about the well-being of endangered Large mouse-eared and Noctule bats, a Dresden Administrative Court (2003) recently turned down an application for the construction of 2 wind turbines in Bautzen County, Germany. The wind industry is itself seriously discussing the danger presented by wind turbines to birds and bats (Windpower Monthly, 2003). In this context one must remember that for every dead bird or bat recovered at the site of a wind station, many more corpses are usually lost in surrounding scrub, or removed from the site by scavengers, such as foxes, cats, and other creatures, which do not take long to set up home near to these potential food dispensers. This makes an accurate assessment of mortality very difficult. The influence of low-frequency noise emissions on the breeding and nesting habits of wildlife is poorly understood, but it would be surprising if it did not have a negative affect on the activities of at least some species.

Recognising the dangers to wildlife, especially to birds, bats and their habitats, the US Fish and Wildlife Service has expressed serious concern about the potential impact of the current rapid expansion of wind power developments, and has produced interim voluntary guidelines to avoid or minimize wildlife impacts from on-shore wind turbines (Hogan, 2003). Professor David Bellamy, an ardent UK campaigner for biodiversity and sustainable living, has stated that wind turbines ruin the beauty and tranquillity of unspoilt landscapes and biodiverse habitats, their concrete bases and service roads adversely affecting catchment and wildlife management (Bellamy, 2003). Dr James Lovelock, the leading environmentalist and scientist who proposed the widely respected view of the earth as a self-regulating, living system (Gaia theory), has recently expressed regret that he once endorsed wind stations in the Westcountry. He now advocates nuclear power (Kuhn, 2004). Even Norges Naturvernforbund (Friends of the Earth, Norway) appears to have broken ranks and recognised the damage that wind stations could do to bird life at Sleneset in the northern municipality of Nordland (Ingdahl, 2003). Recently the European Commission stalled plans for the construction of Germany’s first off-shore wind station to investigate the proposed project’s possible infringement of

European environmental laws, including a threat to a potentially endangered species of bird, the red-throated diver (Young, 2003).

Health problems in humans living close to wind turbines have recently been documented, the symptoms ranging over headaches, migraines, nausea, dizziness, palpitations, tinnitus, sleep disturbance, stress, anxiety and depression. These symptoms were attributed to the effects of low-frequency sound emissions (Milner, 2004). Olympic and world champion equestrians have demanded a 2.5-3.0 kilometre separation distance between horses and wind stations because of the disturbance caused (Balkenhol & Balkenhol, 2002). Property prices have also seen dramatic falls close to these sites (Jordal-Jørgensen, 1996), a recent court judgement suggesting a 20% decrease in market value in a particular UK case (Hawkins, 2004). It is therefore not surprising that there now exists a growing number of individuals and groups who for aesthetic, environmental, technical, spiritual, religious, financial or leisure reasons are strongly opposed to what they perceive as the philistine desecration of ever-dwindling areas of wild countryside, wildlife habitats, and marine environments.

It is evident that unless the interests of country dwellers, visitors and wildlife are protected more actively by politicians, health and safety authorities, wildlife organisations and the general public, the actual and perceived dangers associated with the inappropriate location of wind stations (many of which are fenced off to exclude the public) may render many outstandingly beautiful, productive and interesting regions of the country virtual 'no-go' areas for many species of wildlife and horse-riders, and make them less inviting to wildlife enthusiasts, walkers, and tourists. Unfortunately, ignoring the cumulative effects of the widespread dispersion of wind stations, some wildlife and self-styled 'green' organisations appear for economic reasons to promote all sources of renewable energy irrespective of merit.

Alternative options

Energy conservation measures could reduce UK carbon emissions by over one fifth, so serious efforts should be made to promote this approach. If carbon emissions are judged to be so very dangerous to climate that it warrants the industrialisation of large areas of precious landscapes and wildlife habitats, one must ask why the UK Government promotes the widening of motorways and the extension of airport runways, - major structures that encourage two of our principal sources of pollution. Maximum speed limits of 50 – 60 mph on motorways could make a big difference to fuel consumption, as would an efficient, well-used public transport system. Why has fuel-rationing not been introduced and why is the aviation fuel used by international aircraft not taxed? Why isn't local production of essential commodities promoted more aggressively? The absurdity of some world trade practices is striking – for example, New Zealand lamb and Chinese shoes compete side by side with their British counterparts in UK shops. How much energy is wasted in refrigerating and/or transporting these commodities half way round the world? How many UK buildings are properly designed and insulated to conserve energy? Why is the UK Government offering more than £1.5 billion in loans, grants etc. to build fossil-fuelled power stations in several developing countries while almost ignoring this option at home? The questions go on and on!

Critical of the economic and technical weakness of current UK wind policy (DTI, 2003c), the Institution of Chemical Engineers has argued that although the efficiency of current combustion-based power generating capacity is only about 30%, modern technologies are available (such as those based on combined cycle systems) which use fuels that can achieve a net doubling of efficiency while reducing CO_2 emissions by 65%. Fuel cells could open the way to the development of small-scale combined heat and power plant of 95% thermal efficiency, a key stage in the development of a hydrogen economy. It also emphasises the importance of CO_2 capture and electricity storage technologies (IchemE, 2003). The Chair of the Government's power generation forum has suggested at a recent DTI conference that efficiency improvements in existing and future power plants could provide a 30% reduction in carbon emissions, with sequestration providing another 30% (Coppinger, 2003).

In the long term novel sources of power will be needed to replace dwindling sources of some conventional fuels. New technologies must therefore be developed which can be shown to be predictable, controllable, technically efficient, environmentally friendly, aesthetically acceptable, and economically competitive. In its present form wind technology does not appear to satisfy many of these needs, and will become less environmentally friendly as turbine and pylon numbers grow. Before more damage is inflicted on human and wildlife habitats by massive wind station developments, the attributes of this and other renewable options should be thoroughly compared under controlled, impartial scientific conditions.

Conclusions

When allowance is made for the pollution costs of the less efficient operation of conventional backup systems, and the holistic embedded costs of manufacturing, deploying, operating, maintaining and replacing wind turbines and associated plant, the supply of wind power to the National Grid currently promotes little if any saving in UK carbon emissions. Furthermore, the mixture of power sources actually selected by TSOs, for economic and technical reasons, promotes less carbon emission than is often claimed.

In their present form wind stations are expansive in nature and environmentally unfriendly. Their spread across many of the last surviving regions of outstanding natural beauty in the UK adversely affects the quality of both human and wildlife habitats, degrades local residential and leisure amenities, and kills large numbers of protected birds, bats, and possibly other creatures. This situation will probably worsen as turbine and pylon numbers increase.

The use of modern technology to upgrade existing and new generating plant, and a more aggressive energy conservation policy, would be more effective ways of reducing man-made pollution and the emission of greenhouse gases. New technologies must also be developed which can be shown to be predictable, controllable, technically efficient, environmentally friendly, aesthetically acceptable, and economically competitive.

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