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AN EXPANDED GLOSSARY OF WIND TERMS

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Rated capacity. A wind turbine design is such that power output increases with wind strength, but only up to a certain point. The reason for a limit is that it would be hard to make use of spikes of wind power that occurred only a few days a year; and then perhaps for just a few hours. Thus at a certain wind speed — around 13 m/sec, the power output from the wind turbine stabilizes (only to be interrupted if exceptionally high winds cause a problem). This stable plateau of power output — the maximum which a wind turbine can feed into the grid — is known as the *rated capacity* (in kW or MW) of that wind turbine.

Peak infeed factor. While a few wind turbines which are in moderate proximity to one another will sometimes feed their full *rated capacity* into the grid, wind turbines spread over a wide area will never produce their collective *rated capacity*, because it is unlikely that the wind will be at optimum levels over the whole area. For instance, in the E.ON Netz area, which spreads 800 km across Germany, the peak infeed from all the wind turbines collectively, during 2004, was 85% of their *rated capacity*. That is to say, in 2004, their *peak infeed factor* was 85%. Incidentally, the ideal would be to spread the wind turbines so widely that the *peak infeed factor* was much lower than this.

Load factor (also called capacity factor and infeed factor). Of course wind does not constantly blow in the optimum speed range. Sometimes, even over a substantial area, it may be calm. In order to assess how much electricity wind turbines are producing as a fraction of their *rated capacity*, we need to know the average amount of power that they feed into the grid over a year (unqualified, *load factor* usually implies a year, although it can also be useful to look at individual months). *Load factor* is calculated from the total energy, in watt-hours, fed in from the wind turbines, divided by the 8760 hours in a year. While there is no widespread agreement about usage, the term *infeed factor* does imply clearly that the measurement is based on the amount of power that is fed into the grid. For example, in Wind Report 2005, E.ON Netz reported the mean power fed into the grid, in 2004, as 1295 MW (i.e. 1295 x 8760 MW hours). The average installed *rated capacity* was 6650 MW. This makes the *infeed factor*, during 2004, 1295 / 6650 = 19%.

With figures given in that way, there is no doubt that what is being counted is the electricity that is fed into the grid, which makes the term *infeed factor* slightly more appropriate. The term *load factor*, although closely similar, is perhaps more appropriate when there is an element of doubt about the statistic. For instance, data given by the DTI for the UK contains this supplementary note: "Actual generation figures are given where available, but otherwise are estimated using a typical *load factor* or the design *load factor*, where known." The term *capacity factor* can generally be taken as synonymous with *load factor* It appears to be a term introduced by the wind industry as an alternative to *load factor*, perhaps in recognition that the *load factor* of wind turbines is entirely different from the *load factor* of fossil fuel plants. The latter is normally below plant capacity mainly because electricity is only produced when wanted. Wind turbines operate below *rated capacity* because wind does not always blow at optimum speed.

Backup. This word requires a dissertation rather than a precise definition. In their first wind report, Wind Report 2004 (referring to the year 2003), E.ON Netz said,

> Only limited wind power is available. In order to cover electricity demands, traditional power station capacities must be maintained as so-called 'shadow power stations' at a total level of more than 80% of the installed wind energy capacity, so that the electricity consumption is also covered during economically difficult periods.

This has often been taken to mean that 80% of the *rated capacity* of the wind turbines must be additionally provided as '*backup*' to wind power. A better way of looking at it is to say that the referenced 80% (i.e. peak infeed) must be there whether there is wind power in the system or not. Introducing electricity from wind into the system will cause 'intrusions' (i.e. encroachment) into fossil fuel plant equivalent to about 80% of the *rated capacity* of the wind turbines, since with wind producing at *peak infeed factor*, all the '*backup*' fossil fuel plant could be closed down. In practice, it does not work that way, since the varying intrusion of wind into the system is not borne by a specific part of the total fossil fuel and hydro capacity, but rather it is shared out over the whole flexible part of the system.

It is apparent now why the term 'shadow power station' might be misleading. In Wind Report 2005, E.ON Netz dropped the term, and conveyed the same idea in these terms:

> Their dependence on the prevailing wind conditions means that wind power has a limited *load factor* even when technically available. It is not possible to guarantee its use for the continual cover of electricity consumption. Consequently, traditional power stations with capacities equal to 90% of the installed wind power capacity must be permanently online in order to guarantee power supply at all times.

That final sentence, containing the word "online," is a mis-translation. A better translation is: "Consequently, in order to guarantee power supply at all times, there must always be sufficient capacity available from traditional power stations to cover at least 90% of the *rated capacity* of the installed wind turbines." The 90% figure for 2004, rather than the 80% of 2003, is due to slightly stronger winds in 2004, giving a higher *peak infeed factor*.

All that may seem clear, but it has been thought to be in conflict with the Germany Energy Agency (DENA) report which stated that, "The wind related regulation and reserve capacities can be covered by the conventional power station park and its operating method as outlined in this study." In fact there is no conflict. For E.ON Netz is not to be understood as asserting that *more* fossil fuel capacity has to be available to deal with the wind, but rather that the *existing* fossil fuel plant and hydro has to act in concert with the additional wind infeed, with fossil fuel output reducing as the infeed from the wind increases. Thus the term *backup*, as it applies to wind, is rather loose, referring both to plant covering the 80% or 90% of *rated capacity* referred to by E.ON Netz, and plant kept available to deal with sudden unforeseen changes, such as failure of a major nuclear plant. In the latter respect, wind may only requires a small additional reserve to what is available already, which is why DENA said that the 'rapid response reserve' — what it called the "regulation capacity" — that is presently available within the system can cope with the wind infeed up to the 13% *wind penetration* (see next) that it was studying.

Wind penetration. In Wind Report 2005, E.ON Netz say, "In total, German wind farms generated 26 billion kWh of electricity [in 2004], which is around 4.7% of Germany's gross demand." In that statement, 4.7% is the *wind penetration*. E.ON Netz refer specifically to "gross demand." Occasionally an alternative figure is given as the *wind penetration*, namely one referring to the fraction of "final consumption" rather than of "gross demand." Final consumption is a figure *net* of the electricity used within the energy industry and *net* of transmission losses; it is about 85% of gross demand.

In summary, for 2004, with a 4.7% *wind penetration*, and 19% *infeed factor*, we know that the *rated capacity* of the wind turbines must be 4.7 / 0.19 = 25% of Germany's mean demand. Because of the 85% *peak infeed factor*, we know the wind turbines 'intruded' on the rest of the system to the extent of 25 x 0.85 = 21% of mean demand. Low demand is about 60% of mean demand, thus the 'intrusion' was about 21 / 0.60 = 35% of low demand. It is thus understandable that 4.7% *wind penetration* was manageable.