House of Lords Science and Technology Committee Enquiry: The practicalities of developing renewable energy

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Introduction

1. This submission covers one of the Committee's topics only, "The logistics of providing stand-by capacity for times when intermittent sources are not available". The author has a detailed knowledge of this issue, having been involved in studies of the integration of wind energy into electricity networks since 1988. This includes participation in three studies funded by the European Commission, two by the DTI, and one by the Cabinet Office, as part of the recent Energy Review.
2. It may be noted that there are numerous studies of the impacts of intermittent renewable energy sources on integrated electricity networks and that all yield very similar conclusions. This note draws primarily on work carried out by the former Central Electricity Generating Board and, more recently, by the National Grid Company. Institutional changes, such as privatisation and introduction of the New Electricity Trading Arrangements have not altered the technical parameters influencing efficient operation of the electricity network.
3. The discussion which follows tends to focus on the impacts of wind energy, simply because it has attracted more attention than the other technologies.

Operation of the UK electricity network

4. The idea, sometimes advanced, that every MW of intermittent plant must be backed up by an equivalent amount of standby thermal plant is incorrect. The central issue is that additional standby plant will need to be provided, but the amount is a function of the additional uncertainty introduced by the intermittent source.
5. The reason why the amounts of additional standby plant for intermittent sources are modest is that there are always uncertainties in balancing supply and demand but an integrated electricity system only needs to be able to respond to the aggregated uncertainty. For example, a typical margin of error in forecasting demand four hours ahead is about 350 MW – about 1% of average demand. There is a similar margin of uncertainty on the generation side, as it is quite possible that a generating set will shut down due to a fault. Reserve scheduling takes both these uncertainties into account.
6. Present-day reserve holdings are also influenced by the need to be able to respond to failure of the largest generating units on the system (usually Sizewell B power station - 1320 MW - or one circuit of cross-channel link -- 1000 MW).
7. Implementation of the New Electricity Trading Arrangements (NETA) has had two important side-effects: firstly the amount of reserve now being scheduled is much higher than it need be for efficient operation of the network; secondly intermittent generators tend to be viewed in isolation, rather than as part of an integrated network. (Ironically, the extra reserve means that the assimilation of intermittent sources becomes easier). The renewables industry is lobbying to eliminate the second anomaly and similar problems have now been resolved in Northern Ireland and the United States. Discussions are ongoing in Great Britain, but the problem is now less severe than at the start of NETA.

Impacts of intermittent renewable sources

8. However much intermittent renewable energy comes onto the system, sudden changes in output - on a similar scale to those discussed in paragraph 6 - will not occur, simply because the plant will be widely dispersed.
9. The needs for extra reserve are estimated by looking at likely changes in wind output on various timescales. For example, the maximum measured change in output from 2400 MW of wind in western Denmark is about 6 MW per minute. Another relevant statistic is the maximum change in average wind power generation over one hour - about 20% of the rated output of the wind plant. Data from Germany shows similar trends. Analysis of output changes over other timescales, taking into account the "normal" fluctuations in consumer demands, enables the additional reserve needs to be quantified.
10. Drawing on recent British and American studies, the additional reserve needs appear to be around 4-8% of wind capacity when wind energy supplies 10% of electricity requirements. In the UK, 10% of electricity requirements would require about 12,000 MW of wind plant and so around 700 MW of extra reserve plant would be needed. The National Grid Company are on record as saying that even if the whole of the 10% target for renewables were met by wind, they see no difficulty in procuring the necessary extra plant[1].
11. It may be noted that not all of this extra reserve, which would be procured through NGT's normal tendering processes, need necessarily be new thermal plant. Some may be provided by rarely used plant and some might not be physical plant at all. "Demand-side management" -- whereby consumers allow their demands to be interrupted, in return for a lower tariff - might fulfil some of the requirements. In other words, demand may be reduced, rather than generation increased, to achieve balance. Research in America aims to make this option more attractive to System Operators by providing more sophisticated controls over certain types of commercial and industrial demand.
12. Considerable research activity is in progress, worldwide, to enable better forecasts of wind power production to be made available to System Operators. This is already beginning to bear fruit and it is likely that the amounts of reserve required may be significantly reduced - possibly halved - as a result.
13. Another reason why System Operators do not face intractable problems in dealing with modest amounts of wind energy is that they never depend on all the wind plant generating at the same time. Data from Denmark suggests that the maximum power available rarely exceeds about 80% of the installed capacity. However, the amount of power that System Operators expect, on average, to be available is less than this and is roughly equal, with small amounts of wind, to the average output of the plant -- about 30 to 35% of the rated output. This is the "capacity credit" of the wind plant.

Related issues – capacity credit

14. The capacity credit of wind plant - or other intermittent renewable sources - is the amount of thermal capacity that would be displaced by the wind plant. This is an important issue, as more thermal plant will need to be provided to meet increasing demands if some intermittent renewable sources have no capacity credit.
15. The key question is whether the introduction of intermittent sources onto an electricity network allows some thermal plant to be retired (or removes the need for some new build). Numerous studies, worldwide, have shown that wind can displace

thermal plant and still enable the system to operate with a specified level of reliability. In this country, 1000 MW of wind would displace around 400 MW of thermal plant, 6,000 MW of wind (c.5% of demand) around 2000 MW and 12,000 MW (c.10% of demand) would displace around 3300 MW of thermal plant. Three quite independent UK studies have all yielded results similar to these.

16. Calculation of the capacity credit is complex, although interest tends to centre on the amount of wind available at times of peak demand, since this has a strong influence on the value that is derived. Several studies have shown that peak demands tend to be associated with cold, windy days, rather than still, cold days. It is, moreover, extremely unlikely that the whole country would be becalmed in winter -- when winds are stronger. Moreover, as more wind comes onto the system, it is likely to be more widely dispersed, geographically, especially with the growth of offshore wind.
17. It may be noted that the amount of wind power available in western Denmark over the 10 days with the highest peak demands in early 2003 was always equal to, or greater than, the theoretical capacity credit.
18. Given that 10% of electricity from wind would require about 12,000 MW of wind plant, which has a lower load factor than thermal plant, it may be noted that the "apparent" plant margin would increase, as this would replace 3300 MW of thermal plant, as noted in paragraph 15. The plant margin is the total amount of generating plant that an electricity system needs, over and above the maximum demand, to guarantee supplies. With an all-thermal system, that margin is about 15%.

Conclusions

19. The overall conclusion to be drawn -- from studies of the UK and other electricity systems -- is that the additional plant requirements for reserve associated with amounts of wind energy up to 10% are very modest. Improved forecasting methods and other research may reduce these requirements. There are unlikely to be problems in acquiring this extra reserve, or in operating the system with wind or other intermittent sources of renewables. Even if, contrary to expectations, the "capacity credit" of wind plant is not realised, this simply means that closures of old thermal plant will be deferred.
20. The introduction of wind energy, or other intermittent plant, onto an electricity network increases the apparent plant margin, but this does not affect the ability of all the generating plant to deliver high reliability. Whether or not the introduction of wind plant increases the overall costs of electricity to the consumer is a separate issue, but the author has contributed to a paper which suggests that, when all the relevant factors are taken into account, the additional costs are modest[2].

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[1] National Grid Company, 2001. National Grid and distributed generation. PRASEG Annual Conference, July.

[2] Dale, L, Milborrow, D, Slark, R and Strbac, G, 2003. A shift to wind is not unfeasible. Power UK, Issue 109 (March), 17-25

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