# matters arising

## Short-term storage and wind power availability

ANDERSON *ET AL.*[1] present a further analysis of Ryle's suggestion on the role of alternative energy sources[2] that wind power could be used in conjunction with 150-h thermal storage to provide domestic space heating. Ryle contended that "as soon as such storage is introduced a number of alternative sources of energy can be compared on an equal basis with a nuclear system"; in other words, that wind power can not only replace nuclear power as an energy producer but, when used in conjunction with 150-h storage, can contribute just as reliably to meeting peak electricity demands. Our disagreement with Ryle is on the latter point.

In our previous paper[3] and our comments on Diesendorf and Westcott[4], we attempted to show that 150-h storage was inadequate for matching wind generator output to the heating load and as a result would have little, if any, effect in reducing the amount of firm generating capacity needed for meeting peak demands on the electricity supply system. We believe that the data presented by Anderson *et al.*[1] support this view.

Figure 1 of ref. 1 shows that over the 17-yr period considered, wind power in conjunction with 150-h storage would have failed to maintain room temperature to within 3 °C of the target temperature (20 °C) for 14% of the time, while Fig. 2 shows that during the period February–March 1975 the temperature would have fallen below 17 °C for 65% of the time. We contend that the occupants would resort to supplementary direct electrical heating during such periods with the result that the peak load on the supply system would be little different from what it would have been in the absence of wind generation. Consequently, unless storage of the type advocated by Ryle could be economically provided for periods much longer than 150 h, wind power would operate only as a fuel saver.

Anderson *et al.*[1] also suggest that the optimum ratio of rated to annual average wind speed for a wind turbine would be closer to a value of 1.5 than the 2.3 ratio used by ETSU in Energy Paper 21, which we also adopted for our estimates. We acknowledge that such a choice of ratio would reduce the time of zero output and hence the storage requirement. However, an estimate we have made from an analysis of 16 yr of wind data from four of the sites of ref. 3 suggests that the reduction in energy output would be well above the estimate of 20% so far as the higher wind speed sites, including offshore locations, are concerned. For such sites a mean annual wind speed of 14 knots at the standard 10 m recording height would be more typical than the 12 knots on which calculations are based in ref. 1. We estimate that, in the former case, the energy loss would be closer to 40%, a reduction which would outweigh the savings on capital cost. We agree, however, that the economic optimum is likely to be somewhat lower than 2.3 even for very windy sites, the exact value being machine design dependent. Anderson *et al.* suggest that the energy deficit resulting from operation at a ratio of 1.5 can be regained by increasing the radius of the rotor. It would seem to us that having optimised the ratio of the rated to mean wind speed at a given site for a given design of machine, the size of rotor would be maximised within the constraints of engineering feasibility.

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ANDERSON *ET AL.* REPLY—Leicester *et al.* have for the most part accurately restated our quantitative results[1]. With reference to the need for a supplementary supply, we would stress that the system we assumed was (intentionally) the most stringent in that, even with perfect correlation between available wind energy and heating demand, the house temperatures would only just be maintained at 20 °C. Nevertheless, the lowest temperature reached over the entire 17-year period was 10 °C, at a time when the outside temperature was ~0 °C. The system was, therefore, always able to supply at least 50% of the energy required (heating demand being assumed proportional to the difference between internal and external temperatures). Even if the energy shortfall on this isolated occasion had to be met entirely by the conventional grid, the electrical heating demand would be reduced by ~50% over that necessary in the absence of wind power, which we would not describe as 'hardly different'.

The question of turbine rating has apparently not been fully appreciated by Leicester *et al.* Our analysis (which was based on calculations involving actual wind data and not just estimates) depends only on the statistics of the wind distribution at a particular site and is otherwise completely independent of the precise value of mean wind speed. The loss in total annual energy output for a change of turbine rating from 2.3 $\bar{V}$ to 1.5 $\bar{V}$ is relatively independent of the particular site and corresponding mean wind speed as can be seen from Fig. 7 of the ETSU report[2]; this figure, which shows the results for seven sites, including one of the higher wind speed sites referred to by Leicester *et al.*, indicates values of this loss in the range 15–25%, rather than the 40% estimated by Leicester *et al.* The specific value of 12 knots used in our Table 2 (ref. 1) was adopted simply to allow actual figures for power output and so on to be quoted; the conclusions would have been similar for any reasonable value of adopted mean wind speed.

The optimisation of costs for a particular design is a complex problem and the engineering constraints involve not only the size of the rotor but also, for example, the limitations of gearbox torque and tower strength. The same annual energy output can be obtained by the use of a larger but more lightly-loaded rotor operating over a lower range of wind speeds, allowing the use of a smaller gearbox and alternator and reducing the structural loadings of the tower. On the basis of the relative costs given by ETSU[2] this will usually lead to a more economical design.

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TO CONCLUDE this correspondence the authors have been invited to provide a

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