Energy Policy 36 (2008) 4005–4007

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Forum

# The costs and impacts of intermittency: An ongoing debate "East is East, and West is West, and never the twain shall meet."

Robert Gross, Philip Heptonstall *

*Imperial College Centre for Energy Policy and Technology and UK Energy Research Centre, Room 328, Mechanical Engineering Building, London SW7 2AZ, UK*

ARTICLE INFO

*Article history:*
Received 6 June 2008
Accepted 11 June 2008
Available online 31 July 2008

*Keywords:*
Electricity
Intermittency
Wind power

ABSTRACT

A recent issue of Energy Policy carried a new contribution to the ongoing debate over the implications of a high penetration of wind power for the UK electricity system [Oswald, J., Raine, M., Ashraf-Ball, H., 2008. Will British weather provide reliable electricity? Energy Policy 36 (8), 3202–3215]. That paper made a number of points that require comment or qualification, in relation to both system-wide impacts and the impact on conventional thermal generation. The purpose of this forum piece is to respond to these points, and to explain where we believe the Oswald paper risks repeating the mistakes of the past by interpreting data in a selective manner, or by erroneously singling out alarming sounding findings which do not reflect how electricity systems and markets operate. The latest EU renewable energy targets do imply a wind penetration level which is considerably higher than that which has hitherto been envisaged, and new research is require to understand the potential impacts. However, such research must be based on statistical or time series simulation modelling.



## 1. Introduction

In 2006 the UK Energy Research Centre (UKERC) set out to provide a comprehensive synthesis of the long-standing, often vexed and sometimes downright confusing debate around the costs and impacts of 'intermittency' in wind, solar, wave and some other renewable energy sources (Gross et al., 2006). The report reviewed over two hundred studies from industry, academic and government sources around the world. A group of leading experts was convened to oversee the work, and some key areas of controversy were debated and (the authors hope) resolved (see Skea et al., 2008).

The UKERC report could only ever provide a 'snapshot' of the intellectual state of the art in an evolving field. Ongoing analysis, and increasing experience around the world, is allowing engineers and economists to gain ever better insights into the costs and impacts associated with incorporating renewable energy into electricity networks (for example see Strbac et al., 2007). A recent issue of Energy Policy carried a new contribution to the ongoing debate over the implications of significant penetrations of wind power for the UK electricity system (Oswald et al., 2008).

The authors of the UKERC report welcome the contribution of Oswald et al. One of the primary objectives of the 2006 UKERC review was to bring some common understanding to what had become a highly polarised debate. Some commentators had adopted stylised and selective interpretations of data which do not reflect how electricity systems and markets actually operate. In other cases controversy stemmed from semantic differences. The Oswald et al. paper is evidence that the debate has moved forward constructively since 2006, but the paper makes a number of points that require comment or qualification. These comments can be very broadly grouped into two categories; the first are general comments and system-wide issues, the second relate to the impact of renewable output on conventional thermal generation.

## 2. General comments and system-wide issues

There is an apparent mismatch between the title of Oswald et al. and the substance therein. The title is 'Will British weather provide reliable electricity?' but the substance is about the analysis of the impact of variable wind on *individual* conventional generators—which is a different issue. As their title implies analysis of the impacts on the *system*, there is potential for some misapprehension.

Assessing the impact on individual generators might provide a rationale for not taking a statistical, electricity system-wide approach. Unlike the majority of analyses reviewed in the UKERC

DOI of original article: 10.1016/j.enpol.2008.04.033
* Corresponding author.
*E-mail addresses:* robert.gross@imperial.ac.uk (R. Gross), philip.heptonstall@imperial.ac.uk (P. Heptonstall).

0301-4215/$ - see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.enpol.2008.06.013

report, the Oswald et al. paper does not use a power system simulation or statistical model of (for example) loss of load probability. Yet such techniques have been deployed and developed throughout the long history of analysis of 'the intermittency issue', and there is consensus amongst power system engineers that the only way to quantify and assess the impact of power swings on a power system is through a time series representation of demand and supply using statistical analysis and/or a power system simulation (for examples see Farmer et al., 1980; Grubb, 1991; Halliday, 1984; Ilex and Strbac, 2002; Skea et al., 2008). If this type of analysis is not undertaken we are in danger of moving back into the realm of the headline-grabbing fact selection that provides very limited insight into the power system implications of intermittent generation.

Oswald et al. contend that their findings 'significantly undermine the case for connecting the UK transmission grid to neighbouring grids'. This is because they argue that there is little potential for geographical distance to smooth wind farm outputs, because weather fronts create common wind conditions across large areas. Indeed Oswald et al. describe very large correlations in wind farm output across a wide geographical area based upon Met Office wind speed data. This finding is at odds with other empirical work, which finds that correlations between power swings from operating wind farms drop off markedly as distance increases (Holttinen, 2005; Holttinen and Pedersen, 2003). We note that the sites chosen run in a line from north to south that for some reason neglect important offshore sites in the south-east.[1] Moreover, other recent studies use data from operating wind farms and extrapolate as appropriate rather than using raw Met Office data alone (Ilex and Strbac, 2002). One reason for this is that geographically 'low resolution' wind speed data are not always a good indicator of local wind conditions and wind output. Future analysis needs to consider why it is that Oswald et al. appear to have found data that run counter to the established view that distance between wind farms reduces correlations in output.

Geographical smoothing is not the only reason interconnection assists system operators with the management of intermittency. It also allows the impact of intermittent plants to be shared across a much larger pool of conventional generation and demand variation. This mitigates the effects of intermittency, and reduces the cost of balancing, *even if* intermittent output is indeed widely correlated across large areas. This is because additional system-balancing requirements are a function of demand prediction errors, *overall* probability of supply failure and renewable output unpredictability. See Gross et al. (2006) or Ilex and Strbac (2002) for an exposition of the principles of assessing requirements for system balancing and how intermittent renewables impact upon them.

Our last general point relates to the whole-system carbon savings achieved by adding wind power, although the point could equally be made about any other form of low carbon generation. There is of course a need for this to be carefully assessed, but for the levels of renewable penetration reviewed in the UKERC report (most studies typically look at penetrations of 20–30% electricity) there is no evidence available to date to suggest that in aggregate efficiency reductions due to load following amount to more than a few percentage points.

[1] The statement that 'South-Eastern England is not expected to make a large contribution to wind power in the future' has overlooked several projects located in the south-east including the Kentish Flats 90 MW offshore wind farm, operational since 2005 (Vattenfall, 2008), and the London Array project, a 1 GW wind farm in the Thames estuary that was granted planning consent in 2006 and is currently in the detailed planning process and tendering phase (London Array Limited, 2008).

## 3. Impact on conventional thermal plants

Oswald et al. provide a review of a number of impacts on conventional generation. A key concern is that increased frequency of ramp-up/down will affect thermal plant reliability. This is of course possible. Unfortunately, statements such as 'swings of 70% within 12 h are to be expected in winter' tell us very little how such swings may impact on thermal plant reliability. In the absence of more detailed analysis of system operation, plant mix and other factors, all of which are currently hypothetical, it is not possible to do anything more than raise a question over reliability.

The Oswald et al. example of a 1 GW CCGT plant supplying the '30th GW' of power into the grid is a simplification too far. Fossil-fired plants do not participate in the market in 1 GW on–off blocks, rather a number of plants ramp up and down together, each varying output to a greater or lesser extent, depending on market drivers and plant capabilities. Stylising this as one plant going on and off line 23 times in a month provides a vivid imagery, but is ultimately unhelpful.

The paper also suggests, not unreasonably, that lower capital cost and lower-efficiency plants may be installed because generators anticipate lower load factors. Oswald et al. suggest that this will undermine emissions savings. What typically happens in electricity markets is that most new plants are expected to operate at or close to maximum load factor and older plants to move down the 'merit order'. The past may not be a guide to the future given the combined effects of the large combustion plant directive, a new build of nuclear power stations and the development of renewables. Reliable and flexible output would be expected to be at a premium. With the right market signals it may well be that in future there will be a higher proportion of more flexible and lower capital cost plant. However, understanding the future development of the electricity mix is immensely complex. It requires a scenario-based system simulation that considers a range of technologies and indeed tries to take a view on private sector investment choices, as the government has attempted to do (Redpoint Energy, 2007). It is not possible to form a meaningful judgement about the effect of lower efficiencies on emissions unless an accurate picture of the overall mix and utilisation of thermal and renewable plant is developed so that the trade-off between efficiency and flexibility can be assessed. Again an important question has been raised. It is certainly possible that lower-efficiency plants will undermine some of the emissions savings from renewables, but it is by no means certain that they will.

Oswald et al. argue that high penetrations of wind generation in the UK 'would restrict continuous base load operation of (thermal) plant'. This is correct, and the average load factor for thermal plants would decline in a high renewables scenario. However, a large number of fossil-fuelled thermal plants do not or need not run as base load, see Fig. 1. The real issue here is that 'must run' plants such as wind power and nuclear would be competing to meet minimum demand. In the absence of storage or transferable loads, wind or nuclear would occasionally need to curtail. Oswald et al. comment that curtailment of wind output may be a practical option under some circumstances, but dismiss the option on the basis that 'the level of curtailment is not finalised'. It is correct that the level of curtailment is not finalised but it never will be, since which plant will curtail in high-wind, low-demand periods is for the market, not the government or system operator, to decide. It certainly is not feasible to form a judgement about this perhaps two decades before the event. Nevertheless, as the UK Government has ambitious plans for new nuclear plants and the latest EU renewable energy targets are likely to require a very substantial expansion of wind power, Oswald et al. are right to draw attention to challenges the UK would face with high penetrations of both wind and inflexible plant, such as nuclear.

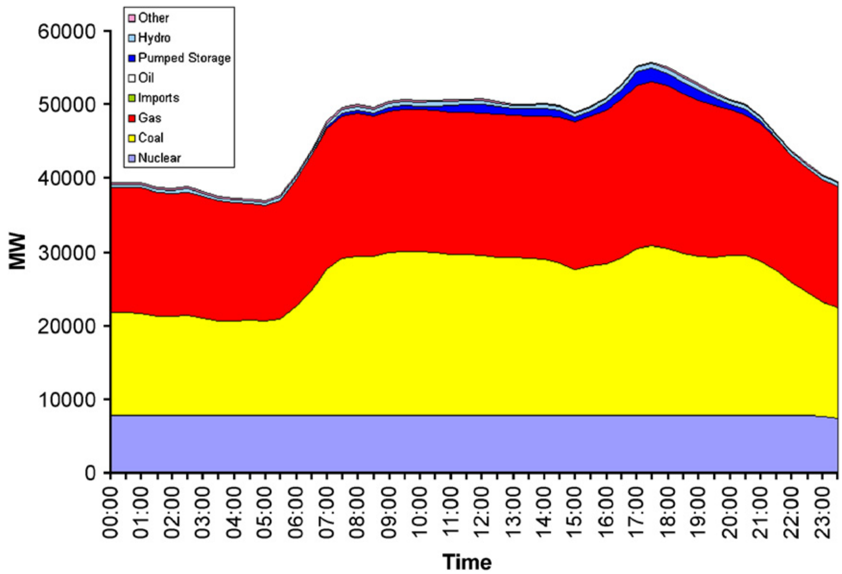


**Fig. 1.** Typical UK Winter Demand, January 2007 (National Grid, 2007).

## 4. Conclusion

In 2006 the UKERC and our collaborators sought to find common ground in a controversial arena. The Oswald et al. paper recognises some of this common ground and many of the concerns it raises are very valid, not least in the light of ambitious plans to expand renewables and nuclear power. But on occasion it risks repeating the mistakes of the past by interpreting data in a selective manner, or singling out alarming sounding findings. Alarm calls are perfectly valid; they can help identify problems and raise important questions. In many areas there is a need for ongoing research and debate; however, answers can only be sought through a statistical or time series simulation model of the British electricity system that takes into account how the electricity system and market operate, and the complexities of assessing its ongoing development.

## References


Farmer, E., Newman, V., Ashmole, P., 1980. Economic and operational implications of a complex of wind-driven power generators on a power system. In: IEE Proceedings A, fifth ed.

Gross, R., Heptonstall, P., Anderson, D., Green, T., Leach, M., Skea, J., 2006. The Costs and Impacts of Intermittency. UK Energy Research Centre, London.

Grubb, M., 1991. The integration of renewable electricity sources. Energy Policy 19 (7), 670–688.

Halliday, J., 1984. Analysis of wind speed data recorded at 14 widely dispersed UK meteorological stations. Wind Engineering 8 (1), 50–73.

Holttinen, H., 2005. Impact of hourly wind power variations on the system operation in the Nordic countries. Wind Energy 8 (2), 197–218.

Holttinen, H., Pedersen, J., 2003. The effect of large scale wind power on a thermal system operation. In: Proceedings of the Fourth International Workshop on Large-Scale Integration of Wind power and Transmission Networks for Offshore Wind Farms, Sweden, Denmark.

Ilex, Strbac, G. 2002. Quantifying the system costs of additional renewables in 2020, DTI, 080SCARreport_v3_0.

London Array Limited, 2008. London Array Wind Farm Project. 〈www.londonarray.com〉.

National Grid, 2007. GB Seven Year Statement. 〈www.nationalgrid.com〉

Oswald, J., Raine, M., Ashraf-Ball, H., 2008. Will British weather provide reliable electricity?. Energy Policy 36 (8), 3202–3215.

Redpoint Energy, 2007. Dynamics of GB Electricity Investment (supporting document for the Energy White Paper). DTI, London.

Skea, J., Anderson, D., Green, T., Gross, R., Heptonstall, P., Leach, M., 2008. Intermittent renewable generation and maintaining power system reliability. In: Generation, Transmission & Distribution, vol. 2, no. 1. IET, pp. 82–89.

Strbac, G., Shakoor, A., Black, M., Pudjianto, D., Bopp, T., 2007. Impact of wind generation on the operation and development of the UK electricity systems. Electric Power Systems Research 77 (9), 1214–1227.

Vattenfall AB, 2008. Kentish Flats Wind Farm. 〈www.vattenfall.com〉.