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Quantitative assessment of the electricity system

1 Introduction and recommendation

IESIS has published 4 papers, summarised here in Sections 2 and 3, on the present and future status of the GB electricity system We believe that the results of this work by Capell Aris and Colin Gibson represent the most reliable information about the cost and security of supply for the electricity system that is available in the public domain. Their work should be recognised as a very important contribution to the public understanding of the effects of adding intermittent renewables to the system.

To some, their results will be counterintuitive. How can wind and solar energy, for which there are no fuel costs, be significantly more expensive than gas and coal generation that do have fuel costs? If the installed generating capacity is significantly increasing, why is the risk to security of supply also increasing? These questions can be answered on the basis of logic but what Aris and Gibson have done is to quantify the situation. Reactions to the values that they have produced include:

a) Disbelieve and ignore them.
b) Be sceptical about the results and call for the calculations to be checked.

Ignoring information from experts is a high risk approach but being sceptical is a main strategy for controlling risk. Rather than just check the calculations, a new analysis based on detailed data of the whole system (not available to Aris and Gibson) and using the Total System Cost Method (not feasible in the absence of the detailed data) should be called for. That is, a *Total System Analysis* of the electricity system should be carried out having the following attributes:

- All issues that may affect consumers, the economy and the environment should be taken into account.
- The most advanced method methods should be used.
- The study should be managed by people who have appropriate levels of competence in such endeavours and who are, as far as is practical, independent of commercial and political constraints.
- A rigorous quality control strategy should be used.
- The methodology and the results should be transparent to the public.

While a great deal of work is being carried out to assess the electricity system, we see no evidence that these studies are being properly coordinated nor that there is adequate drive to ensure that the results are reliable.

We assert that:

1. the provision of electricity is too important to society to settle for less than the a Total System Analysis.
2. the Total System Analysis approach, as outlined above, is used by the Government in other infrastructure projects (although not called by that name). The same duty of care should be applied to the electricity system.

For detailed information about the levelised cost model used by Gibson and Aris see: http://www.iesisenergy.org/lcost/. Interested parties can use the 2016 Spreadsheet that is linked from that page to assess the effect of variation in the values and probabilities of the underlying cost items.

2 Papers on the GB electricity system

2.1 Paper on wind power

Aris C, (2014) Wind Power Reassessed: A review of the UK wind resource for electricity generation http://www.iesisenergy.org/agp/Aris-Wind-paper.pdf

Capell Aris used data from airfields around UK and Europe to establish a fleet of virtual windfarms from which model he was able to assess the effect of wind generation on the GB electricity system. He shows that:
'The model wind fleet reveals wind energy production is unlike that of all conventional fossil fuelled or pumped storage plants; it does not follow grid demand on diurnal or even seasonal time patterns. Wind generation will therefore make heavy claims on the UK's response and reserve market.'

The model included assessment of the degree to which low levels of wind occur across northern Europe. Based on the results of the pan-European model, the author concludes that:
'European interconnectors may have other uses for grid management, but they will have little impact upon the mitigation of wind fleet intermittency and variability.'

2.2 Paper on solar power and combined wind and solar

Aris C, (2016)*Solar power in Britain The impossible dream* - http://www.iesisenergy.org/agp/Aris-Solar-paper.pdf
For a review of this paper see Section 3.

2.3 Paper on the future cost of electricity

Gibson C and Aris C (2016) *An Examination of National Grid's Future Energy Scenarios How much do the scenarios cost?*
http://www.iesisenergy.org/agp/Gibson-Aris-paper-cost.pdf

The summary states:
'Despite having installed more than 38GW of renewable energy generating capacity in the last decade, we have reached a capacity crisis. There is no hard evidence that this push for renewables has been an effective way to reduce CO_2 emissions, and the cost has certainly been very large. The analysis presented in these two papers [papers 2.3 and 2.4 referenced here] makes a strong case for a radical review of energy policy from an engineering perspective, placing equal weight on cost, security and environmental impacts.'

2.4 Paper on security of supply

Aris C and Gibson C (2016) *An Examination of National Grid's Future Energy Scenarios - Security of Supply*
http://www.iesisenergy.org/agp/Aris-Gibson-paper-security.pdf

The summary states:
'The dependable (despatchable) power from installed conventional, nuclear and hydro generators plus continental inter-connectors would be insufficient to meet peak demand, and this gap could not reliably be bridged using wind generation. Solar generation would make no contribution at all to meeting peak demand.
To meet peak demand in the period up to 2025, an additional 5 to 12 GW of firm, despatchable generating capacity would be required: six or more gas-fired power stations. As renewable energy capacity is increased, these power stations would lie idle for large periods, but would be essential to maintain security of supply in the winter.'

3 Review of paper on solar power in Britain - The impossible dream

http://www.iesisenergy.org/agp/Aris-Solar-paper.pdf

Dr Capell Aris has estimated the performance of the 2015 wind and solar electricity generation fleets in the GB electricity system. The model used has installed capacity: Wind 10 GW, Solar 8.4 GW

Data for wind and solar power generation is not publicly available so Dr Aris had to establish a set of model wind and solar farms and calculate their potential power output from weather data. Data from the Met Office would have been prohibitively expensive to purchase so data available without cost from airfields throughout GB and Europe was used.
The conversion from wind speeds to generated power levels took account of type of turbine, height of turbine, wind shear, etc. The solar fleet conversion took account of temperature, cloud conditions, etc. The estimates spanned a period of 10 years.

Copied below are three diagrams from the paper for solar, wind and combined energy production.

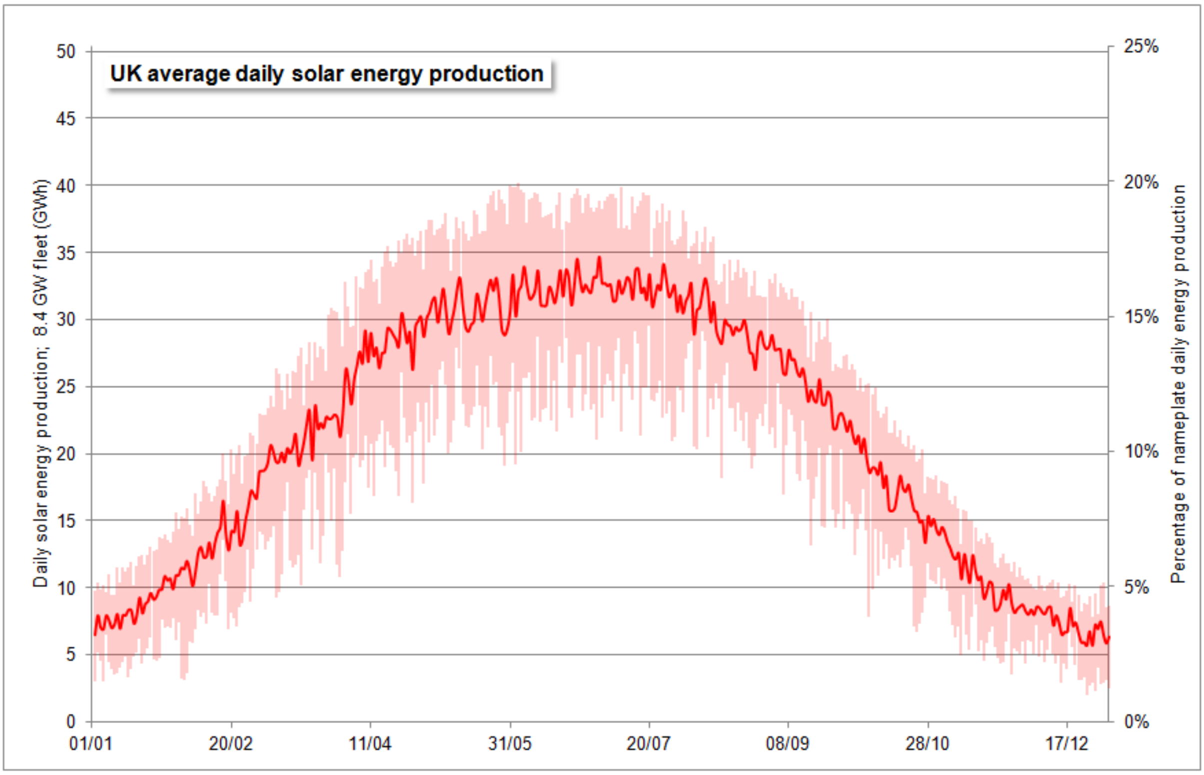

Figure 14 Daily solar energy production (dark red line) throughout the year calculated by averaging model data over the ten year sampling period. The pale red bars show the extremes of production throughout the sample. The vertical axis on the right of the diagram represents load factor.

Features of the solar production are the dominant sinusoidal variation throughout the year due to the corresponding variation in the altitude of the sun, The load factors on dates close to the winter solstice are less than 5% even for the extreme values. Summer values of load factor are never greater than 20% The average load factor is about 10%.

After the sun has set there is no solar radiation so the load factor drops to zero. Peak demand is normally in the winter after the sun has set and therefore solar generation cannot contribute to peak demand.

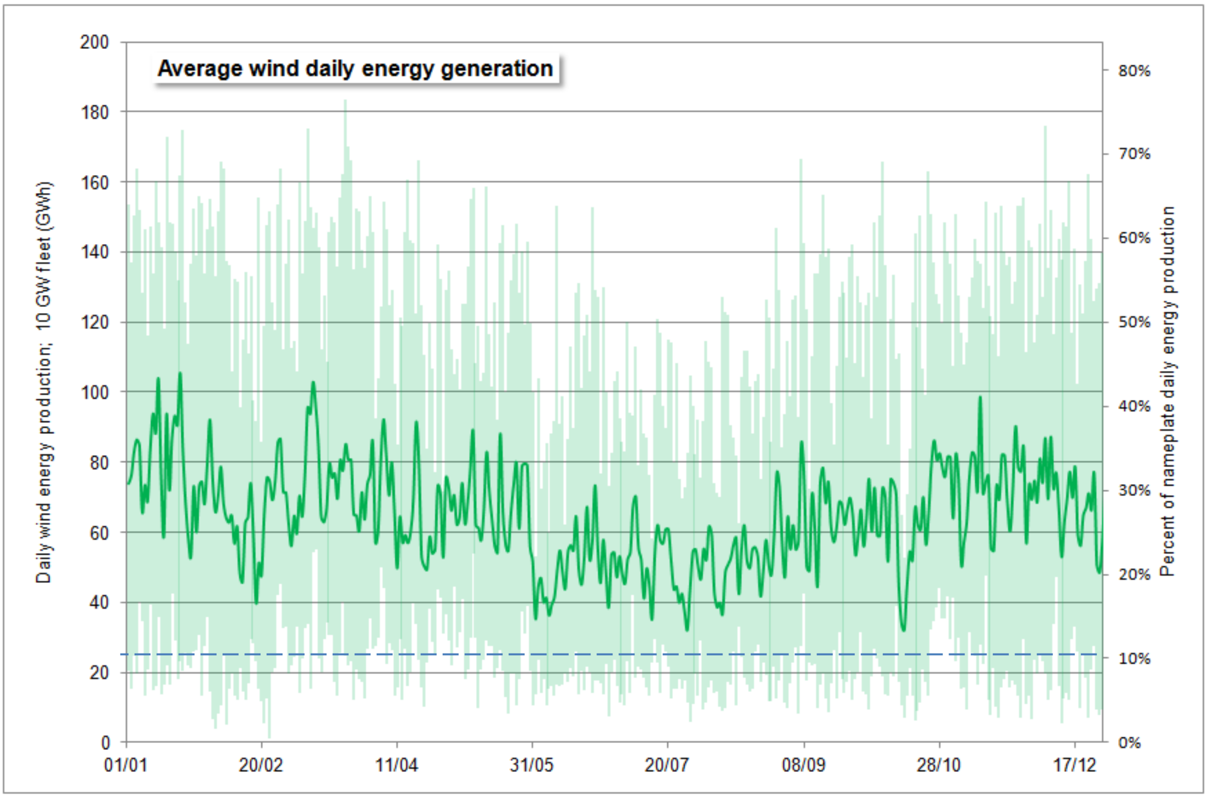

Figure 15 Daily wind energy production (dark green line) throughout the year calculated by averaging model data over the nine year sampling period of the *Wind Power Assessed*(3,4) study carried out last year. The pale green bars show the extremes of production throughout the sample. The vertical axis on the right of the diagram represents load factor.

For wind, the load factors are higher in the winter than in the summer but are much more variable in the winter. The average load factor is about 27%. The extremes of production often give values of load factor less than 10%

The very high level of intermittency of wind generation shows that it needs most of its capacity to be backed up. The paper gives results of a calculation that shows that the capacity credit for the wind fleet may be taken as 9.% i.e. that proportion of the installed capacity of the wind fleet can be assumed to be available to meet peak demand. This means that with 10 GW of installed wind capacity, less than 1GW of that capacity can be expected to contribute to peak demand.

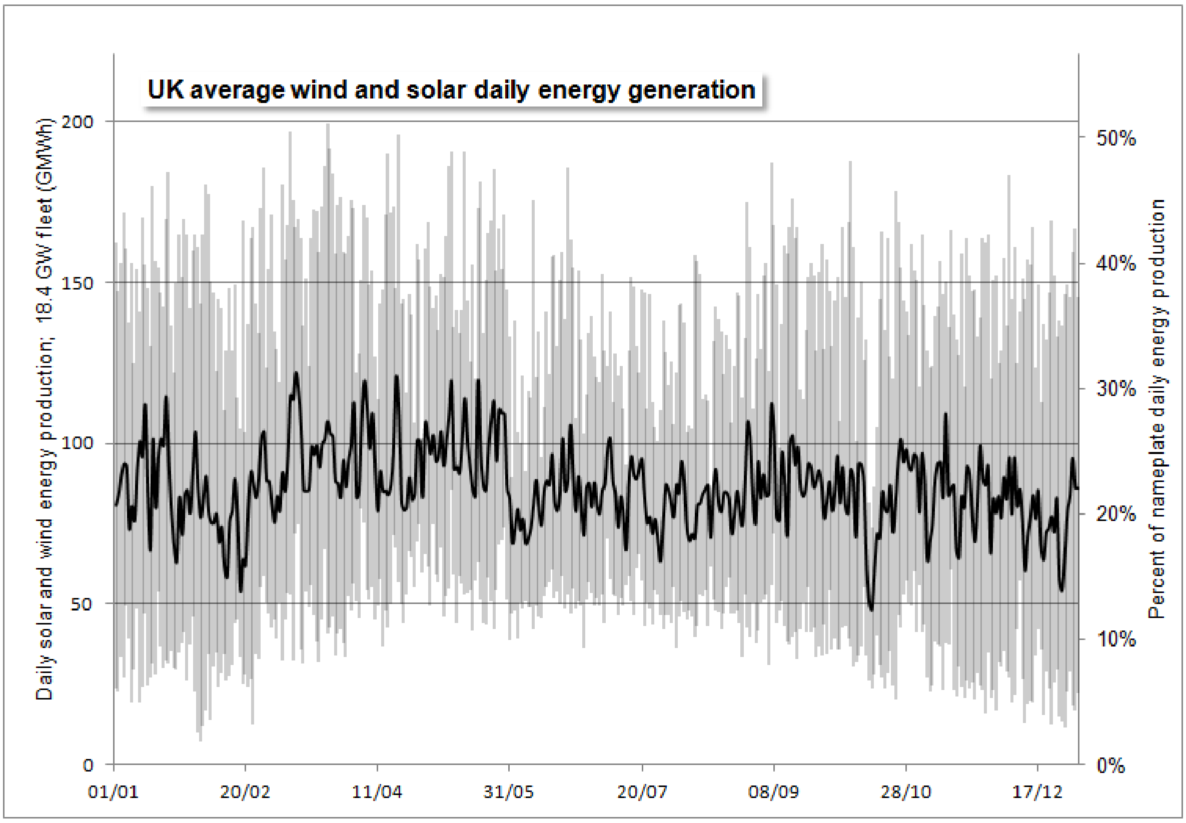

Figure 16 As Figures 14 and 15 for the combined, modelled, wind and solar fleets.

The combined fleets produced best results (load factor around 25%) in spring months but the load factor for other months would be about 20%.

Storage

Included in the paper are the results of a model of how the system might operate with pumped storage to provide backup for the intermittency of the wind and solar fleets. The Dinorwig pumped storage facility in Wales has a storage capacity of 10 GWhrs. Aris's model predicts that an equivalent of 30 of these, as an alternative to backup using thermal generation, would be needed to meet a security of supply criterion. Such provision would be expensive and there are few sites in the UK that are suitable for large scale pumped storage. 'Back of an envelope' calculations have shown equivalent predictions but this is the first time, as far as we know, that a model of the system has been used for such a calculation. It is worth noting that Dr Aris worked for many years as a technical analyst at Dinorwig.

Versions:
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