Generation Adequacy and Capacity Credits

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Outline

What's different about renewables?

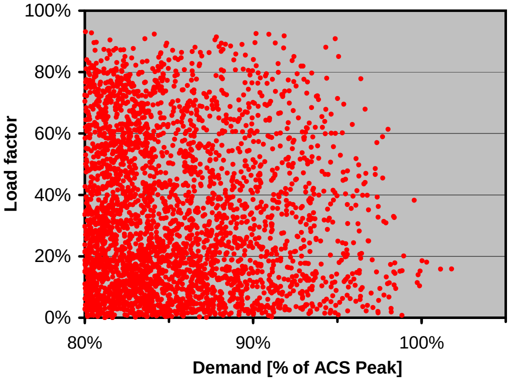
- The availability of renewable capacity has very different statistical properties to that of conventional plant.
- Conventional plant
  - Availabilities of units at different stations are to a very good approximation independent
  - The probability distribution for total available capacity is therefore tightly concentrated about its mean
  - e.g. for GB conventional units, mean $\sim$ 65 GW, SD $\sim$ 2 GW
  - Close to zero total available capacity is impossible
  - Contribution to securing demand analysed using plant margin
- Renewable generation
  - Availability of capacity is largely a matter of resource availability
  - Close to zero percent available capacity is therefore possible
  - Contribution to meeting demand must be analysed differently
  - Subject of this presentation

Two wind availability datasets used in this presentation

- ‘Metered’
  - Three years of metered data from GB transmission connected wind farms (winters 06-09)
  - Use of real metered data is the ideal...
  - ... but all transmission-connected wind is in Scotland
  - Three years not really enough
- ‘Olmos’
  - Six years of GB-wide data simulated from meteorological records by Pablo Olmos at Edinburgh (winters 00-07)
  - More years of data...
  - ... and GB-wide coverage (but still onshore only)

Renewable resource visualisation

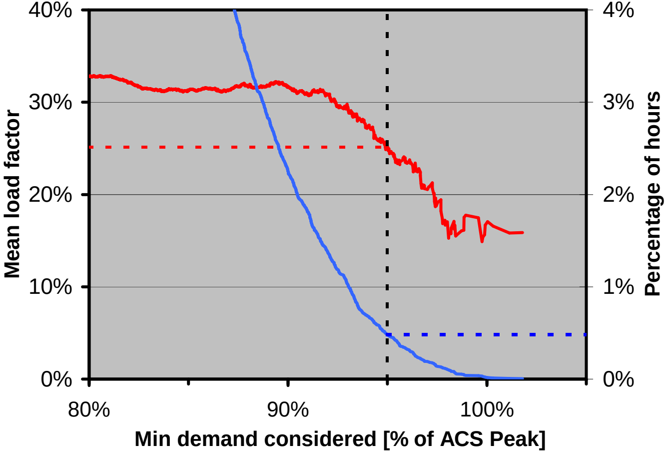
- A scatter plot in principle contains much statistical information on the wind availability/demand relationship
- It's hard to identify trends due to variation about them
- e.g. 'metered' dataset



Visualising the wind resource

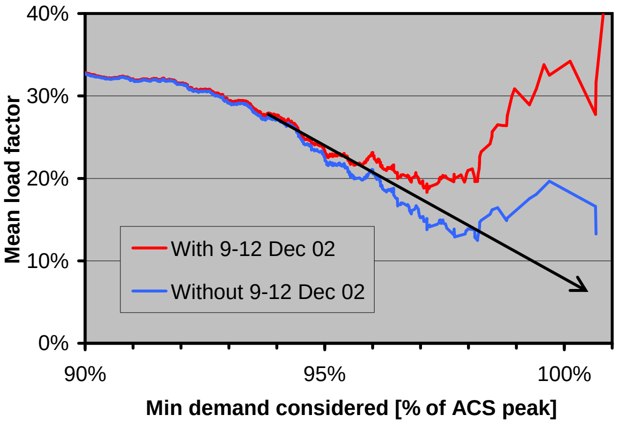
- What's the question?
  - If it's generation adequacy, it's high risk (=demand?) hours which matter
  - Important to choose a visualisation method which focuses on the relevant hours
  - Aggregated ('binned') data might conceal patterns in highest demand hours...
  - ... but in raw data trend is concealed beneath variation

Wind availability and demand in GB: 'metered' data



- e.g. across the 0.5% of hours where demand was within 5% of ACS peak (blue), the mean load factor was 25% (red)

Wind availability and demand in GB: ‘Olmos’



- Similar trend in ‘fairly high’ demand hours
- But trend at close to ACS peak changes dramatically on removal of one week in 2002

What are capacity credits?

- Capacity credits quantify the contribution of generating technologies, or individual units, to supporting demand
- Why use them?
  - Full risk calculations give the most comprehensive view of system adequacy
  - However, while numerical simulations are good at giving a quantitative result, they are often do not show transparently what the key factors driving the result are
  - In this sense, capacity credits are a visualisation tool
- Capacity credit is an indicative quantity
  - Because of different definitions and model structures, even in principle there cannot be a single definitive value
  - This is in contrast to (e.g.) the annual load factor, which can be measured directly

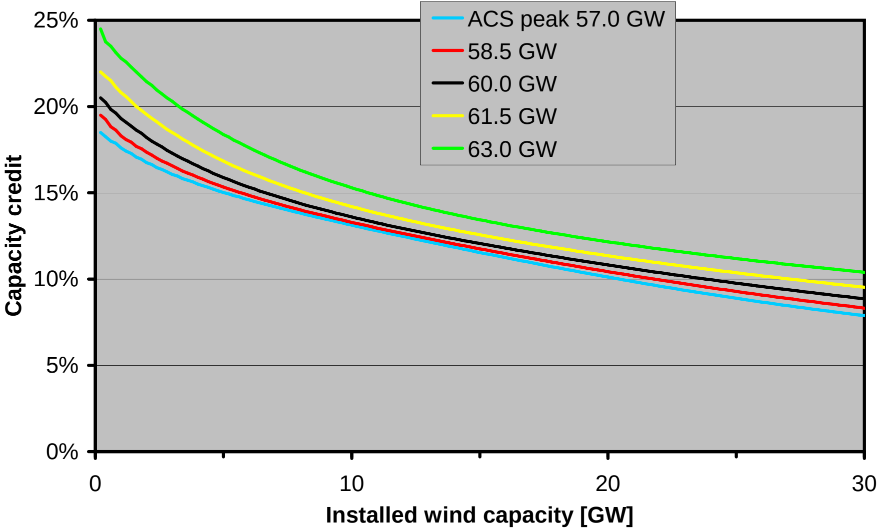
Capacity credit definitions

- Effective load carrying capability (ELCC)
  - On adding the new generation, how much can the load be increased before the system risk returns to its original value
- Or look at how much conventional generation is displaced without increasing risk
  - The question is then ‘which conventional plant?’
- ELCC requires fewer parameters to be defined, and load may be more naturally be varied continuously in a simulation
  - Wind ELCCs can still be compared with those of conventional plant

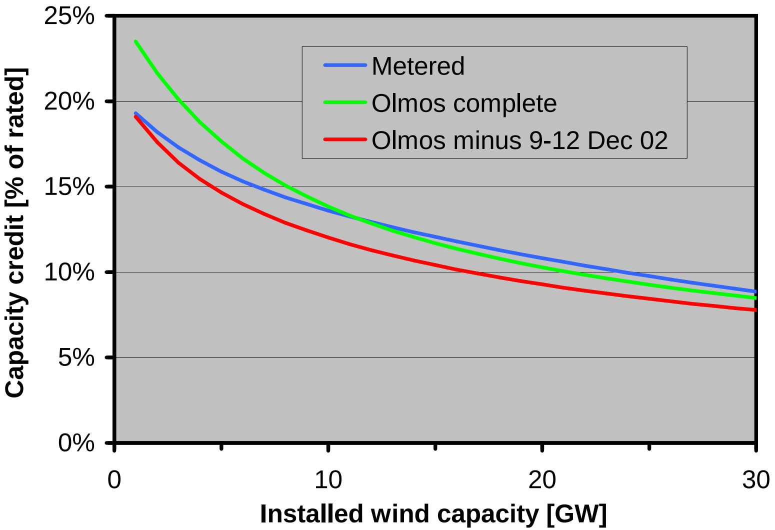
Choice of risk index

- Time series index (Loss of Load Expectation, LOLE) used here
  - Sum over hours of Loss of Load Probability (LOLP)
  - Explicit use of historic wind and demand time series automatically accounts for any relationship between wind availability and demand (alternative is probabilistic representation)
- Alternative is annual peak Loss of Load Probability
  - Requires wind resource at time of annual peak to be characterised; data relevant to absolute peak is limited
  - Results in 09/10 Winter Outlook based on preliminary work using peak LOLP, following on from data published in 08/09 WO; more robust approaches for future applications are currently under discussion

Time-series-based capacity credit results (‘metered’ data)



Effect of 9-12 Dec 02 ('Olmos' data)



Effective plant margin

- In all-conventional systems, plant margin has traditionally been used as the generation adequacy measure
  - e.g. 1: CEGB generation planning standard (gross margin)
  - e.g. 2: Winter Outlook and 2020 Consultation

$$[\text{Net margin}] = \left(\sum_{\text{Technologies}} [\text{Installed capacity}] \times [\text{Availability}] \right) - [\text{Peak demand}]$$

- It works well and is transparent
  - Capacity credits of conventional units are directly related to their availability probabilities
  - Easy to see contribution of different units
  - Experience over a number of years indicates what is an acceptable margin

Example from Winter Outlook 2009/10

Power Station Type	Full Metered Capacity (GW)	Assumed Availability	Assumed Availability (GW)
Nuclear	10.4	80%	8.4
French Interconnector	2.0	100%	2.0
Hydro generation	1.1	80%	0.9
Wind generation	1.6	27%	0.4
Coal	28.1	85%	23.9
Oil	3.5	95%	3.3
Pumped storage	2.7	95%	2.6
OCGT	1.3	80%	1.0
CCGT	26.3	90%	23.6
Total	**77.0**		**66.1**
Overall availability		**86%**	

- Assumed availabilities for conventional plant are central estimates
- Assumed availability for wind is derived using a risk-based capacity credit

Explicit use of risk metric

- Effective plant margin gives limited view of risk
  - Justification somewhat heuristic for renewables
  - May not adequately consider interaction between technologies
- An alternative is to supplement this by presenting the LOLE metric as a second measure of system adequacy
  - It is required anyway for the capacity credit calculation
- Main challenge may be presentational
  - LOLE calculation is much more complex than effective plant margin
  - A full understanding requires substantial mathematical expertise

Use of risk metric: relevant issues

- When performing or interpreting risk calculations, it's important to remember what information they do/don't contain, e.g.
  - Comparing relative risks in different circumstances is more robust that aiming to calculate absolute risk levels
  - Limitations of risk model structure (independence between units, adequacy not security)
  - Should this probabilistic approach be supplemented by a 'black scenario', c.f. 1 in 20 demand and low availability assumptions from Winter Outlook?
  - Historic risks extremely low; what does a risk calculation mean under these circumstances?

Conclusions

- Importance of visualising wind resource
  - A precursor to detailed risk calculations
  - Understand the available data (and its quality)
- Capacity credits and risk calculations
  - Annual peak or whole winter?
  - Historic time series or probabilistic approach?
- Effective plant margin in systems with renewables
  - Scale installed capacity by capacity credit?
  - Use an explicitly risk-based metric?
- Many opportunities for further R&D