Reducing the Cost of Uncertainty in Wind Energy Prediction

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CEC Wind Industry Forum
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Comparative Resource and Energy Yield Assessment Procedures II (CREYAP II)

- 28.6 MW (22 x 1.3 MW)
- Site, wind and turbine data
- Slightly complex terrain
- 60 different groups produced energy estimates

Observed AEP = median of 58 results!

Mortensen, N. G. and Jorgensen (2013)
Comparative Resource and Energy Yield Assessment Procedures (CREYAP) Part II,
Presentation at EWEA Technology Workshop: Resource Assessment 2013.
Variation in Predictions – CREYAP II


Reducing the Cost of Uncertainty in Wind Energy Prediction · Katrina Swalwell · 18/03/2014
Process of an Energy Estimate – Today’s Discussion

Predict Gross Yield
- Steps
- Mast Data
- Long term

Calculate Losses
- Steps
- Turbine Performance

Estimate Uncertainties
- Steps
- Importance of Mast Data

Financial Model
## Gross Yield – Steps & Importance of Mast Data

<table>
<thead>
<tr>
<th>Step</th>
<th>Main way to reduce variations in predictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Measurements</td>
<td>Good records and high data availability</td>
</tr>
<tr>
<td>Long term correction</td>
<td>See next slide</td>
</tr>
<tr>
<td>Correction to hub height</td>
<td>Hub height measurements &amp; multiple measurement heights</td>
</tr>
<tr>
<td>Gross yield</td>
<td>Representativeness of mast locations</td>
</tr>
</tbody>
</table>

![Wind turbine production graph](image)

Mortensen, N. G. and Jorgensen (2013)
Comparative Resource and Energy Yield Assessment Procedures (CREYAP)
Gross Yield – Long Term Correction

- Long term data needs to be carefully checked
  - CREYAP II results being revised due to discontinuity in the long term data.
- Potential to introduce error related to when measurements at different heights

- Several more sophisticated options have been proposed and used.
  - UK MET OFFICE – remodelling of data to site location and turbine elevation before long-term correction performed
  - More sophisticated analysis for the correlation step – for example a multivariate analysis could consider not only wind speed and direction but also factors such as temperature, pressure and humidity.
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<table>
<thead>
<tr>
<th>Category</th>
<th>Covers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wake Effects</td>
<td>Current &amp; Future Turbines</td>
</tr>
<tr>
<td><strong>Availability</strong></td>
<td>Turbine, Balance of Plant &amp; Grid</td>
</tr>
<tr>
<td><strong>Turbine Performance</strong></td>
<td>Power Curve, High Wind Hysteresis, Wind Flow &amp; Other</td>
</tr>
<tr>
<td>Electrical</td>
<td>Loss &amp; Facility Consumption</td>
</tr>
<tr>
<td><strong>Environmental</strong></td>
<td><strong>Performance Degradation</strong> Icing, Shutdown, High and Low Temperature, Site Access &amp; Tree Growth or Felling.</td>
</tr>
<tr>
<td>Curtailment</td>
<td>Wind Sector Management, Grid, PPA, Noise, Birds &amp; Bats</td>
</tr>
<tr>
<td>Other</td>
<td>?</td>
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**Main turbine related factors**
Turbine Performance

- **Availability**
  - Integrated Service Package - Senvion’s full service concept
  - Long term O&M agreements available in two alternatives:
    - ISP-T (availability guarantee)
      Time-based wind farm average technical availability guarantee
    - ISP-E (production guarantee)
      Energy production guarantee based on the potential yield of your wind farm.
      (e.g. we’ll service in low wind speed times). The ISP-E depends on the wind conditions on your site and we are happy to explore this option with you.

- **Performance degradation**
  - Blade designs which are insensitive to soiling
  - Sound and Power Guarantee Extension
    - Only for new WTGs under ISP contract for the duration
    - Up to a maximum of 10 years
    - Subject to Technical Review
Demonstrated turbine performance in wide range of shear and turbulence conditions

- 37 IEC power curve measurements
- Sites located around the world
- Mix of simple and complex sites
- All IEC compliant data used
- Approx. 350,000 data sets
- Expected power calculated for each 10 min
- Deviation of expected to measured power determined.

Performance matrices can be determined

Extrapolation required for some conditions so each matrix has an associated uncertainty matrix that should be considered in calculations.
Power Deviation Matrix

Matrix approach improves accuracy of yield calculations

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Inner - Outer Range

See Power Curve Working Group proposal (EWEA website)

Inner - Outer Range: simple way to extend power curve guarantees
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Two main methods

1. Normal distributions - assume each uncertainty in modelled by an independent, normal distribution

2. Monte-Carlo modelling - assume an uncertainty and distribution for each item

A site calculation leads to a conversion between uncertainties in Wind Speed (WS) and Annual Energy Production (AEP)

Many uncertainties are estimated
## Uncertainties

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Conclusion
Wind Farm Energy output is not the only uncertainty

Change in CPI since Reserve Bank Target Officially Made 2-3%
Conclusions

- Working together energy and uncertainty estimates can be improved to more accurately capture the proposed wind farm
  - Site developer
  - Independent Consultants
  - Turbine Manufacturers
  - Financiers

- High quality site data is the single thing that most improves the quality of the energy estimate and reduces uncertainty
Thanks for your attention
Variation in Predictions – CREYAP I