How well can the industry predict the wind resources? Overview of the results from EWEA CREYAP exercises

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How well can the industry predict the wind resources? Overview of the results from EWEA CREYAP exercises

Niels G Mortensen, Hans E Jørgensen and Morten Nielsen, DTU Wind Energy
Sample 28-MW onshore wind farm in Scotland

One site wind climate
4y (92%)

One wind farm layout

One reference climate
14y

One terrain specification

z₀ = 3 cm
RIX < 2%

N different teams:
Resulting AEP and σ_{AEP}?
CREYAP = Comparative Resource and Energy Yield Assessment Procedures

- EWEA initiative from 2011 and onwards
  - Industry benchmark, input to R&D, learning and training

- **2011 EWEA Wind Resource Assessment Technology Workshop, Brussels**
  - On-shore UK wind farm, 28 MW, hilly terrain, simple land cover
  - Focus on long-term adjustment, loss and uncertainty estimations
  - 37 different teams from 16 countries (49 slides)

- **2013 EWEA Technology Workshop: Resource Assessment, Dublin**
  - On-shore UK wind farm, 29 MW, hilly terrain, complex land cover
  - Focus on long-term adjustment, flow modelling, observed AEP
  - 60 teams from 17 countries (79 slides)

- **2013 EWEA Offshore, Frankfurt**
  - Off-shore UK wind farm, 576 MW, 160 wind turbines, simple terrain
  - Focus on terminology, wake modelling, energy yield calculations
  - 38 teams from 13 countries (47 slides)
EWEA Technology Workshop: Resource Assessment 2013
Purpose and participants

CREYAP Pt. II

- 60 teams from 56 organisations in 17 countries submitted results!
  - consultancy (41)
  - developer (7)
  - R&D/university (5)
  - wind turbine manufacturer (3)
  - electricity generator/utility (2)
  - certification body (1)
  - service provider (1)

Reliable energy yield predictions are obtained when the bias and the uncertainty are both low.
Note, that the ‘true value’ is often measured – with some uncertainty...
Energy yield prediction process

- Site wind observation
- Site wind climate
- Reference yield
- Virtual yield
- Gross yield
- Net yield
- Flow modelling
- Wake modelling
- Loss estimation
- Uncertainty modelling
- Project planning
- Long-term adjustment
- Vertical extrapolation
- Horizontal extrapolation
Onshore wind farm in hilly/complex terrain
Comparison of flow models

Box Wisker Plot
- outliers
- upper fence
- 75% quantile
- 25% quantile
- lower fence

Topographic effect [%]

WASP (30)  CFD (9)  WindSim (6)  Meteodyn (3)  OpenWind (4)  Meso/NWP (4)  Misc. (3)  All models
Onshore wind farm in hilly/complex terrain

Turbine yields – which type of flow model is best?

- Linearised models (32)
- CFD-type models (18)
Onshore wind farm in hilly/complex terrain

Spread for different steps in the prediction process
Offshore CREYAP, Gwynt y Môr, Irish Sea
Turbine sites: mean gross AEP [GWhy$^{-1}$]
Offshore wind farm
Comparison of wake models

[Box plot showing comparison of wake models across different models, including WASp Park (11), WindPRO Park (8), WindFarmer EV (6), OpenWind (3), Ensemble (3), Fuga + CFD (3), Misc. (4), and All models (38)].
Offshore wind farm

Spread for different steps in the prediction process

[Bar chart showing the spread for different steps in the prediction process]

- Loss estimation
- Uncertainty estimation
- Wake modelling
- Potential yield
- Net yield, P50
- Net yield, P90
- Flow modelling
- Vertical extrapolation & yield calculation
- LT correlation
- Reference yield
- Gross yield
- LT wind @ 85 m
- HH air density
Summary and conclusions

Onshore (NW Europe)
• Important uncertainty factors
  – Long-term adjustment
  – Flow modelling
  – Loss estimation
  – Uncertainty estimation
• Overall uncertainty
  – About 7-8% minimum
  – Similar self-evaluation
  – Mean bias still not known!

Offshore (NW Europe)
• Important uncertainty factors
  – Yield calculations
  – Wake modelling
  – Loss estimation
  – Uncertainty estimation
• Overall uncertainty
  – About 8-9% minimum
  – Similar self-evaluation
  – Mean bias still not known!

Common conclusions
• The ‘human factor’ is largely unknown, but seems to be significant
• Standards and guidelines should be improved (IEC, IEA, Measnet, etc.)
• We need access to reliable wind farm data for benchmark exercises + R&D
Thank you for your attention!