Offshore CREYAP Part 2 – preliminary results

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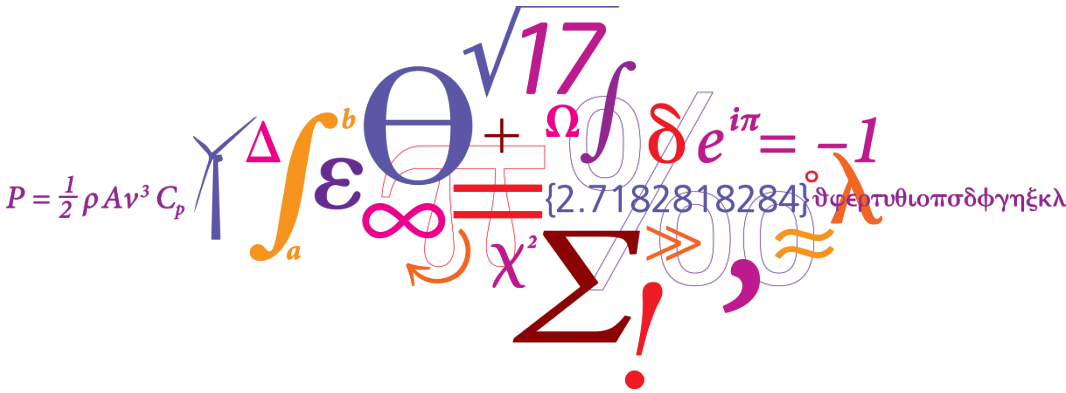

DTU Wind Energy
Department of Wind Energy

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- 22 teams from 8 countries; thanks for making the comparison and presentation possible!
- EWEA team for arranging the 2015 Offshore CREYAP Part 2, thanks to Tim Robinson et al.

Comparison of Resource and Energy Yield Assessment Procedures

EWEA CREYAP concept

- Industry benchmark
- In-house training and R&D
- Identification of R&D issues

Three issues today

- Long-term adjustment
- Wake modelling
- Modelled vs observed yields

CREYAP history

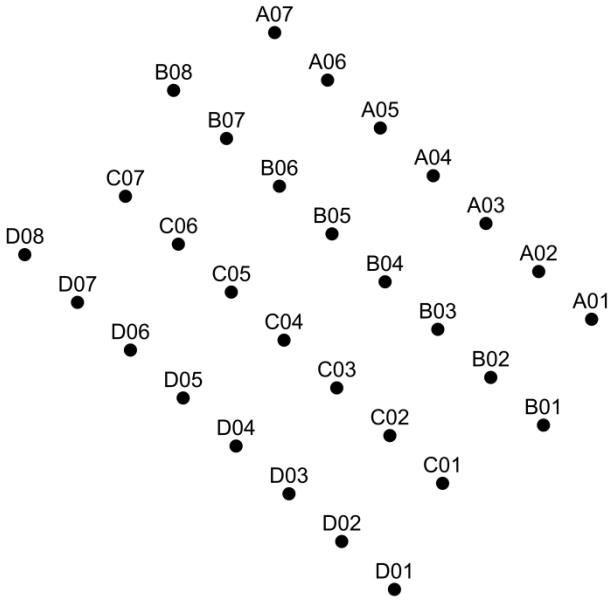
- Onshore Part 1, Bruxelles 2011
  - Scotland, 28 MW, 37 teams
- Onshore Part 2, Dublin 2013
  - Scotland, 29 MW, 60 teams
- Offshore Part 1, Frankfurt 2013
  - Gwynt y Môr, 576 MW, 37 teams
- Offshore Part 2, Copenhagen 2015
  - Barrow, 90 MW, 22 teams

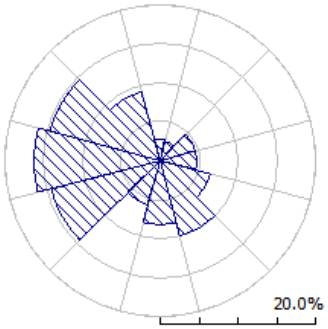
Summary

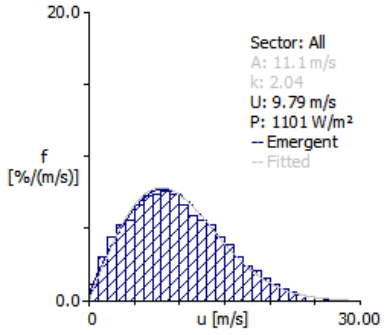
- 156 submissions from 27 countries

Barrow Offshore Wind Farm

- 30 V90 wind turbines (90 MW)
  - Rated power: 3.0 MW
  - Hub height: 75 m MSL
  - Rotor diameter: 90 m
  - 4 staggered rows, 5.5×8.5 *D*
  - Air density: 1.24 kg m^{-3}
  - SCADA: 2008-02 to 2009-01
- Site meteorological masts
  - One 80-m and 50-m mast
  - Wind speed and direction
  - Temperature and pressure
  - Data: 2011-07 to 2012-08
- Auxiliary data
  - MERRA reanalysis 1998-2013
  - Topographical data by choice







Offshore CREYAP II in two parts

Long-term comparisons (10 y)

- Observed wind climate
- Observed turbulence
- Long-term adjustment
- Reference yield
- Gross yield
- Wake effects
- Net yield P50
- Uncertainty estimates
- Net yield P90
- Per-turbine results

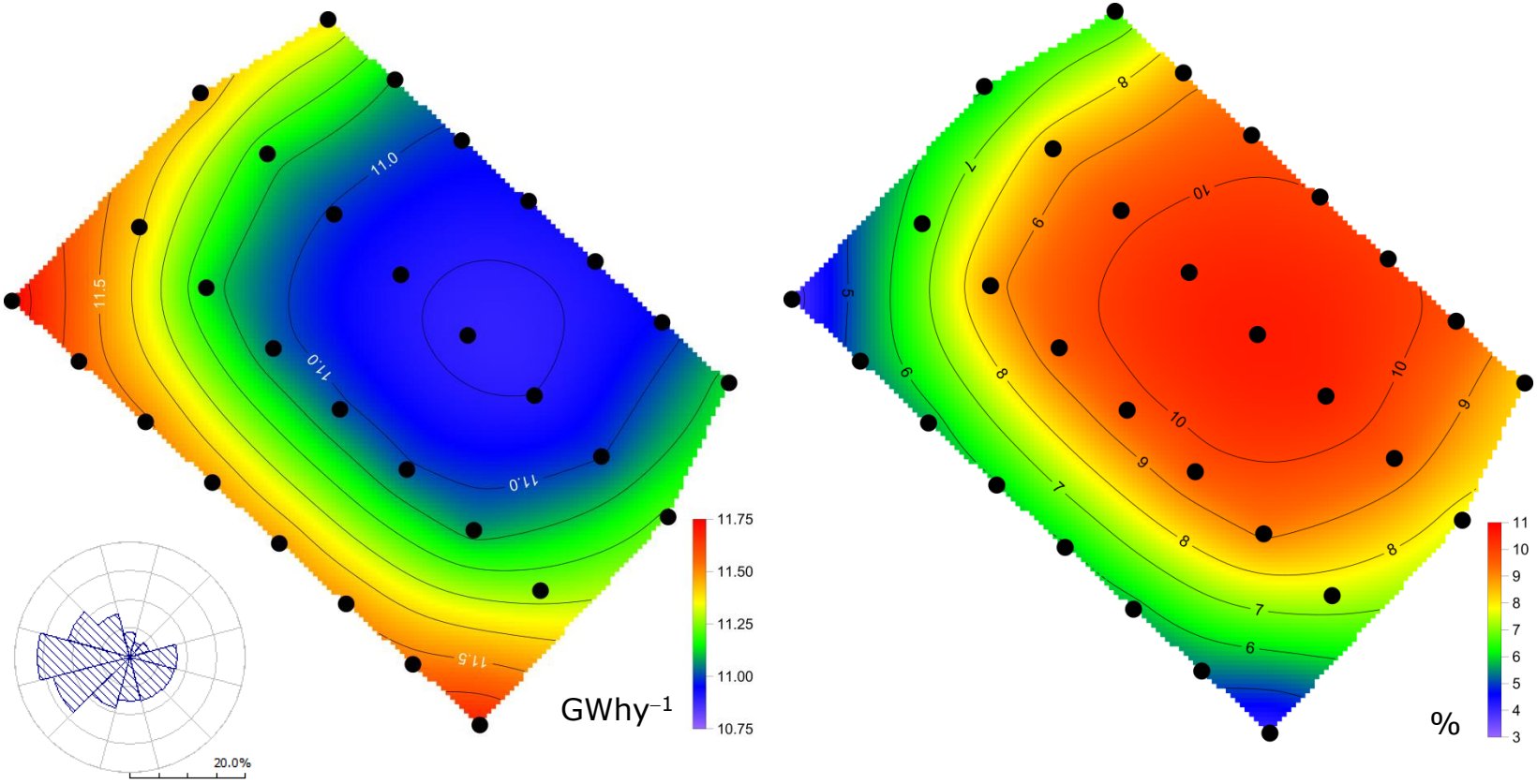
- Team characteristics
- Methodology information

Predicted vs observed yields (1 y)

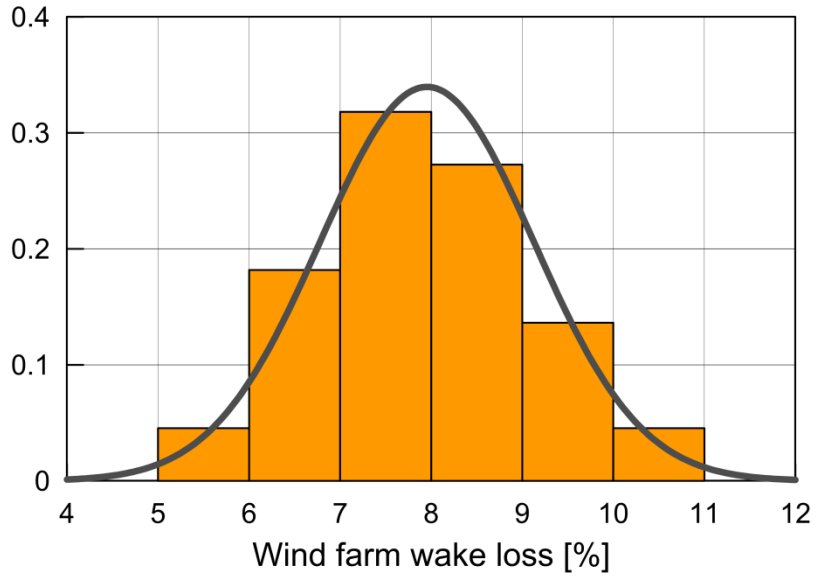
- Reference yield
- Potential yield
- Array efficiency
- Net P50 (losses given)

- SCADA calculation
  - Sum of WTG power readings
  - Curtailment correction
  - Availability correction to 100%
  - Two independent calculations
  - Checked with sub-station meter

Estimated turbine mean yield and wake effect (10 y)



Predicted wind farm wake losses



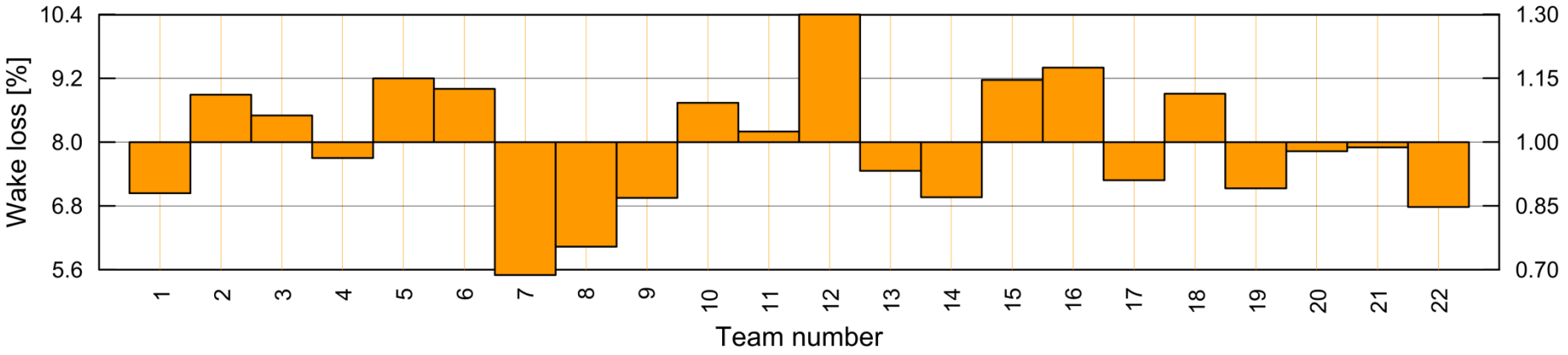
Data points used = 21 (of 22)

Mean wake loss = 8.0%

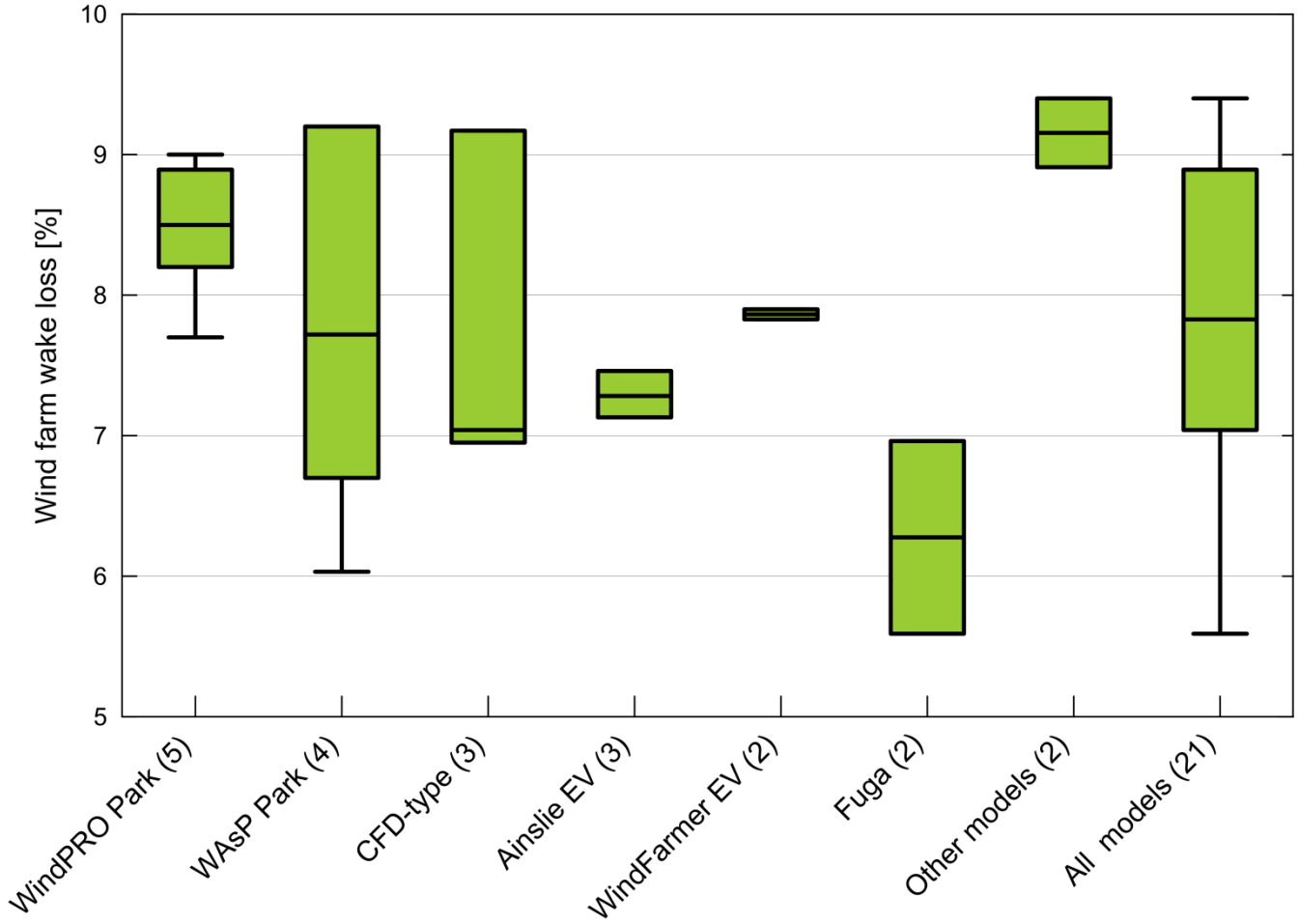
Standard deviation = 1.2%

Coefficient of variation = 15%

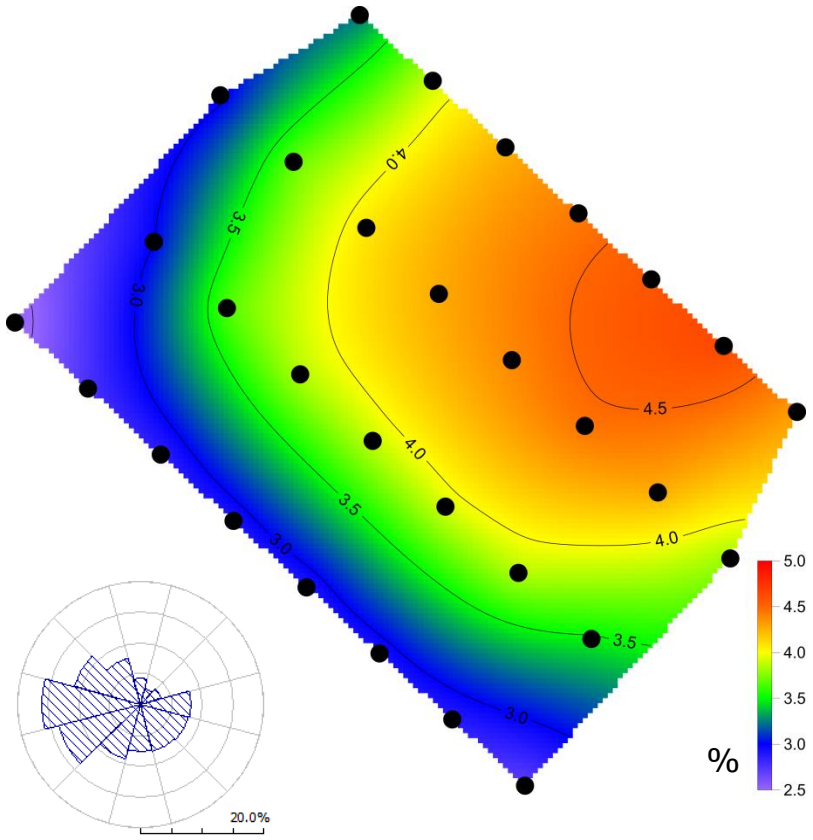
Range = 5.5 to 10.4%

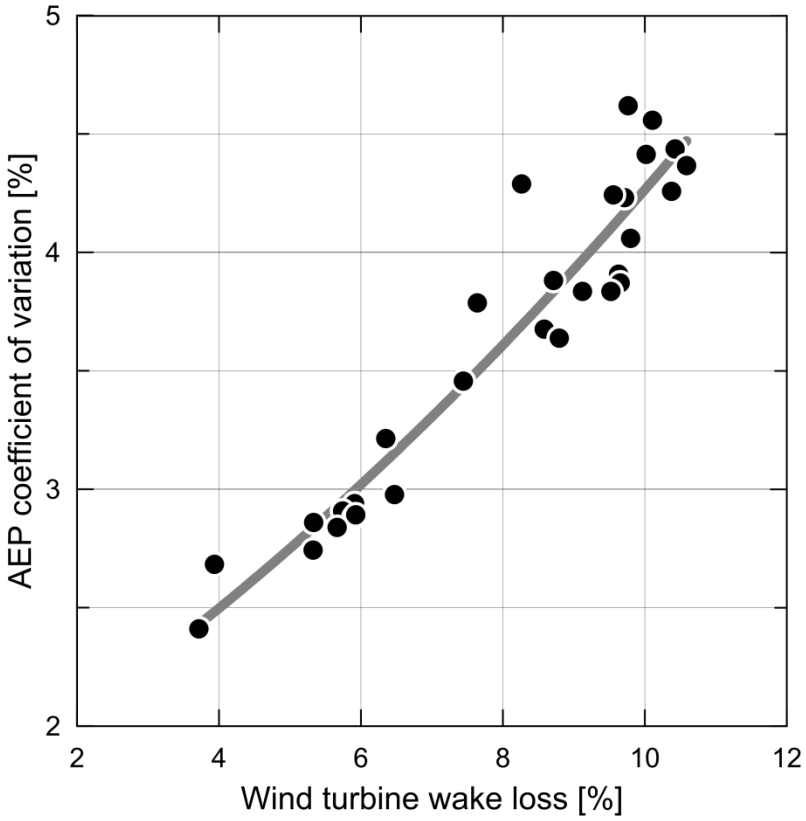


Comparison of wake models

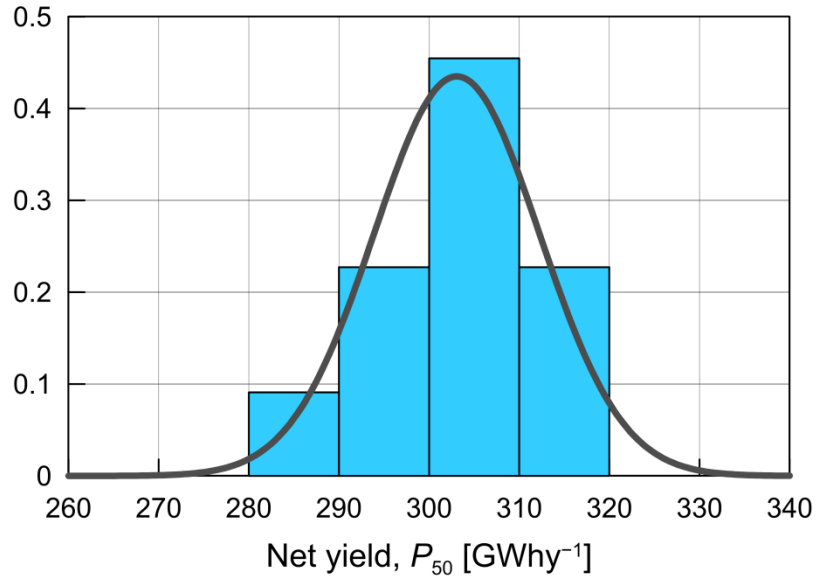


Estimated turbine yields – coefficient of variation





Net energy yield of wind farm, P_{50}



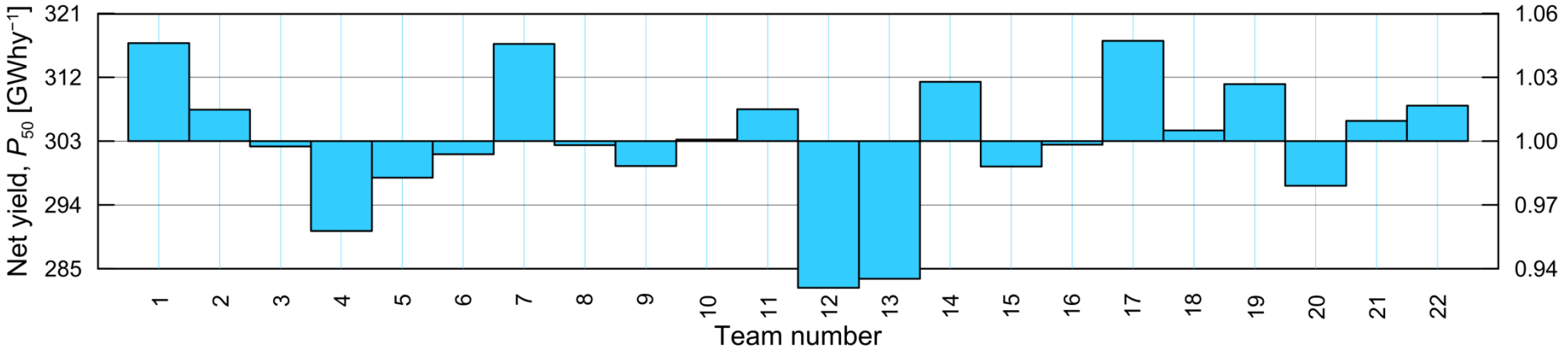
Data points used = 22 (of 22)

Mean net yield = 303 GWhy^{-1}

Standard deviation = 9.4 GWhy^{-1}

Coefficient of variation = 3.1%

Range = 282 to 317 GWhy^{-1}

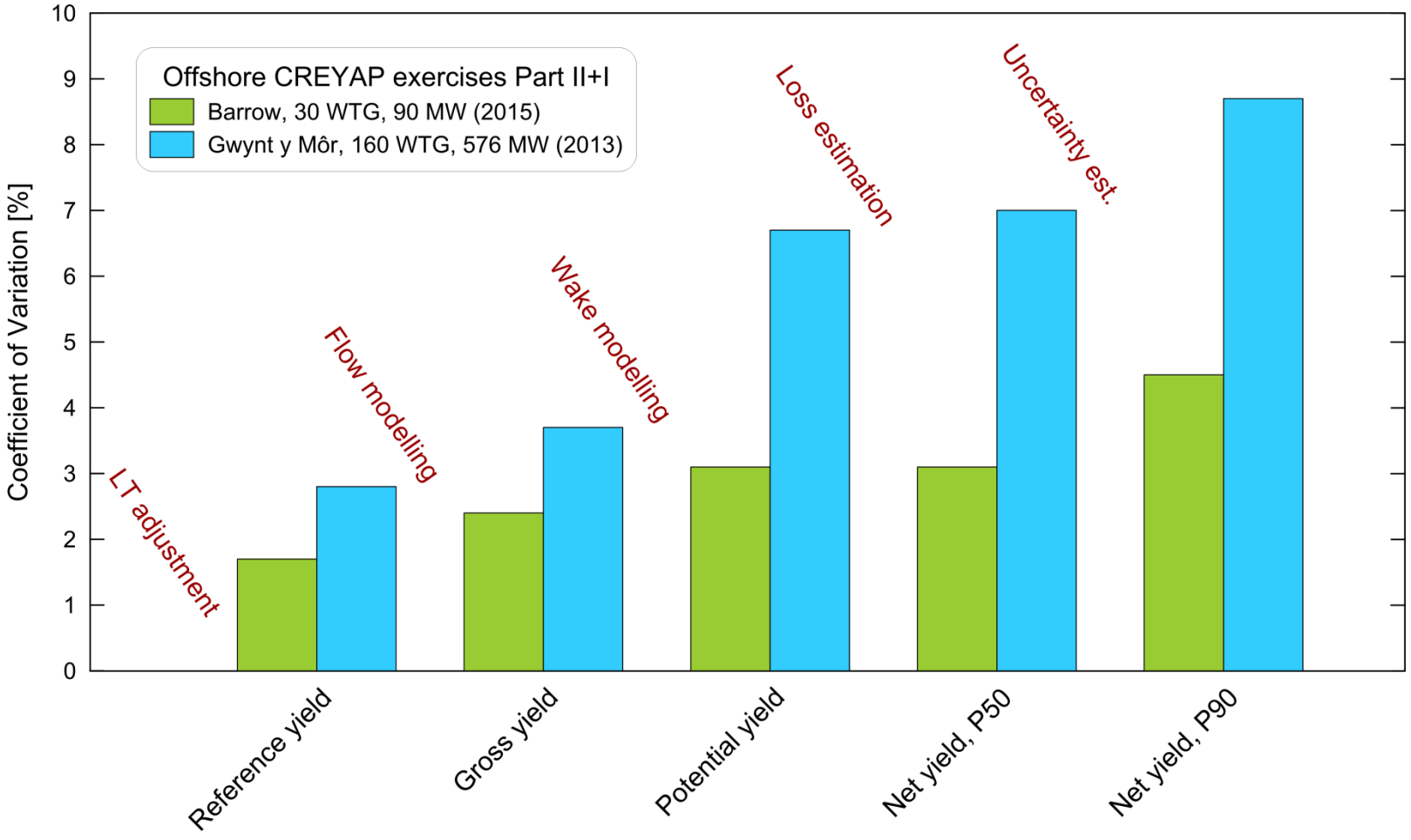


Wind farm key figures – 10-year estimates

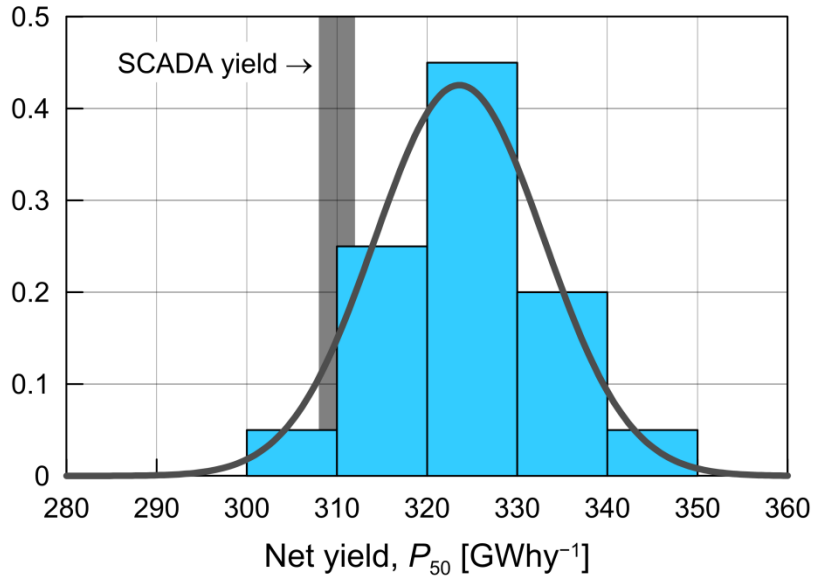
Barrow (10 y)		Mean	σ	CV*	Min	Max
Gross yield	GWh	366	8.9	2.4	338	377
Wake loss	%	8.0	1.2	15.1	5.5	10.4
Potential yield	GWh	334	10.3	3.1	311	350
Technical losses	%	9.3	0.1	1.0	9.2	9.6
Net yield P_{50}	GWh	303	9.4	3.1	282	317
Uncertainty	%	9.7	2.3	23.4	6.1	13.7
Net yield P_{90}	GWh	267	12.1	4.4	245	282

* Coefficient of Variation in per cent.

Spread for different steps in the prediction process



Comparison of predicted to observed P_{50}



Data points used = 20 (of 22)

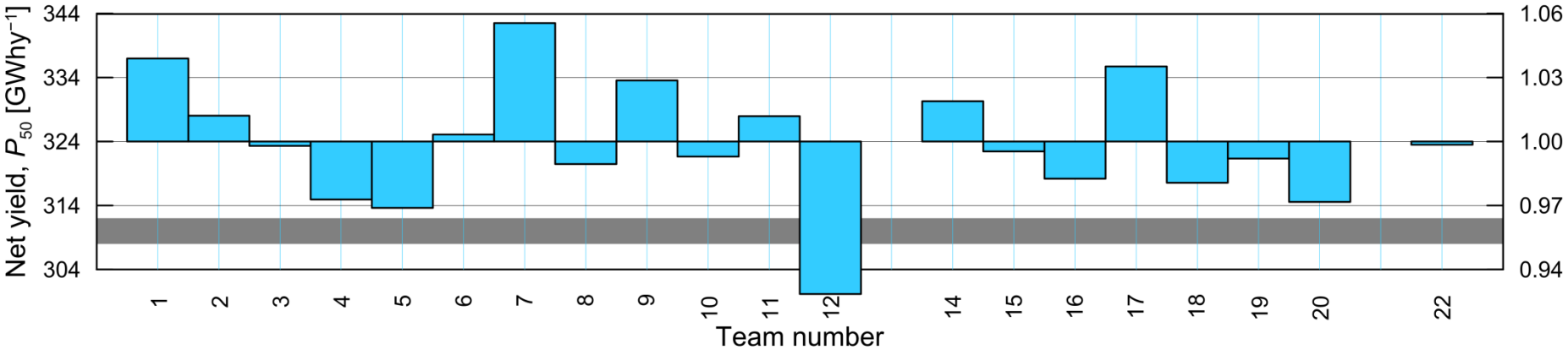
Mean predicted P_{50} = 324 GWhy^{-1}

Standard deviation = 9.6 GWhy^{-1}

Coefficient of variation = 3.0%

Range = 300 to 343 GWhy^{-1}

Prediction bias = +4%



Summary and conclusions

- Long-term adjustment (applied twice)
  - Average effect = 5.7%, spread = 1.2%
- Wake modelling
  - Average wind farm wake effect = 8%, spread = 15%
  - Wake modelling spread increases with depth into wind farm
- Modelled vs observed 1-y yields
  - Estimated = 104% of observed, spread = 3%
  - Measured yield has an uncertainty too
- CREYAP results seem to improve over time
  - No or fewer outliers in present study
  - Loss and uncertainty calculations improved
- Outlook for future
  - Comprehensive results at EWEA Resource Assessment (June 2015)
  - High-quality wind farm data in high demand for future studies!


Thank you for your attention!
More results to be presented at EWEA Resource Assessment in Helsinki, 2-3 June 2015