Losses and Uncertainties

What's new?

Wiebke Langreder

Wind Energy Denmark

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EMD International

The journey

- P50 – where are we?
- Uncertainties – some critical thoughts
- Losses
- Are we getting wiser?

P50 – where are we?

Methodology: Pre-construction AEP ⟺ post-construction data (SCADA)

WP3 Benchmark, US (= Super-size CREYAP)

- Phase 1: 10 projects, 8 participants (incl EMD)
- Planned in total: >100 projects
- Challenge: Public database of annual production might bias results

Validation Studies

- ArcVera, DNV, EMD, Natural Power, Vaisala, and others
- Challenge: Time lag between pre- and post-construction

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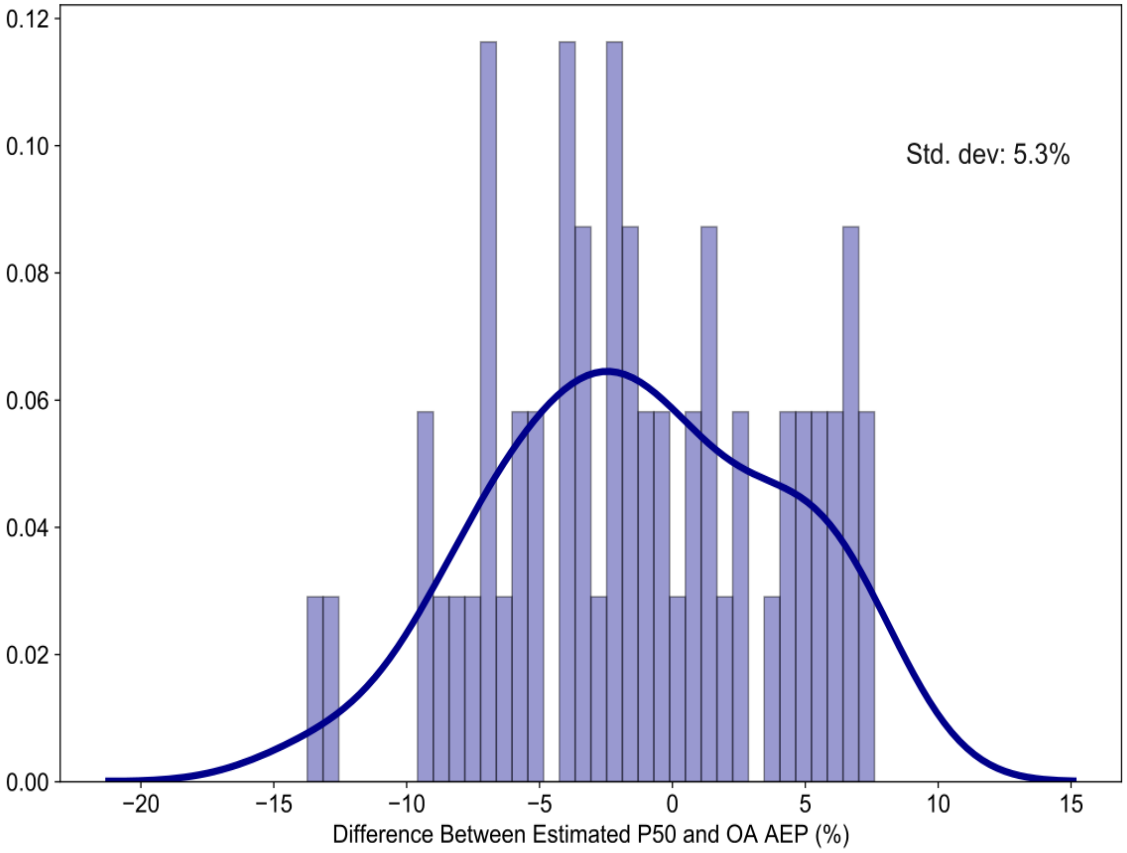
P50 – Preliminary Result WP3 Phase 1

- Spread of results (how certain are we?): around 5ish %



*Calculated using all received submissions (not all projects have been 100% of consultant submissions)

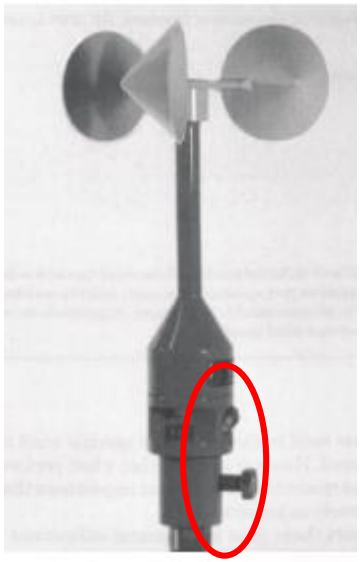
Are industry's uncertainty assumptions (often around 10%) too high?

Source: AWEA WRA workshop Renton 10-11 September 2019: WP3 preliminary results

Uncertainties – some critical thoughts

- Anemometer calibration -> classification:
  - Known: Inter-tunnel deviations of 1% wind speed
  - Known: Bias are converted to uncertainty
  - Not often talked about: Asymmetry

Svend Ole Hansen 2017 : Impact of Azimuth



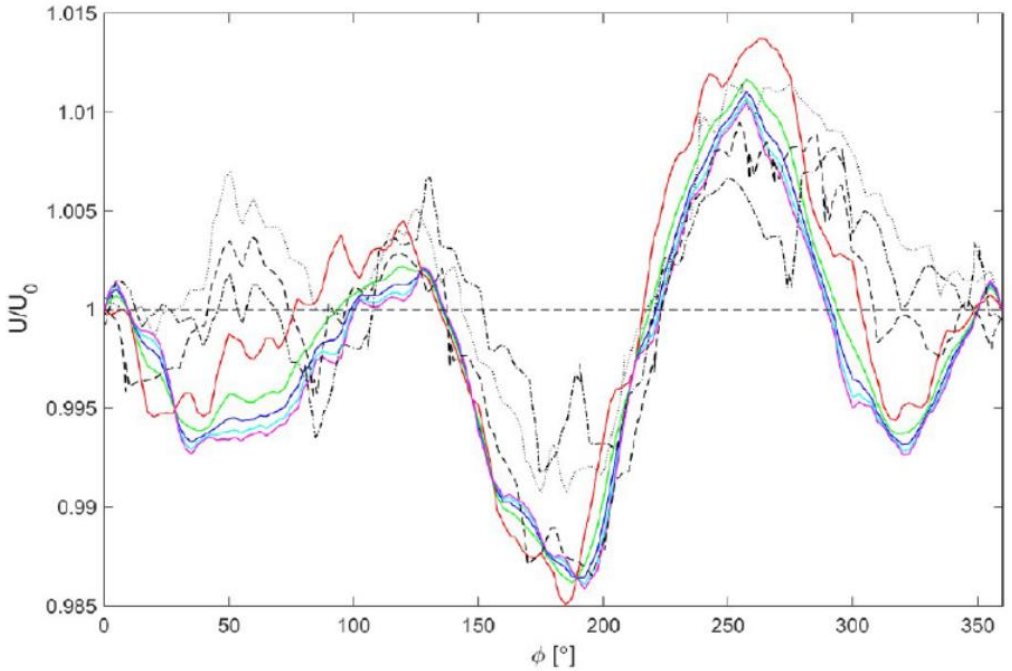


Figure 8. Directivity of NRG Class1 cup anemometer at 0 deg

Uncertainties – some critical thoughts

- Anemometer calibration -> classification:
  - Known: Inter-tunnel deviations of 1% wind speed
  - Known: Bias are converted to uncertainty
  - Not often talked about: Asymmetry
  - Classification processes?

	Class A (flat)	Class B (complex)
WindGuard	0,9	3,0
DTU	1,48	5,11
SOH	1,56	5,14

Example: Thies First Class Advanced

Wind speed uncertainty

	Class A		Class B	
u [m/s]	WindGuard	SOH	WindGuard	SOH
6	2.1%	3.6%	6.9%	11.9%
7	1.9%	3.3%	6.3%	10.8%
8	1.8%	3.0%	5.8%	10.0%
9	1.6%	2.9%	5.5%	9.4%

- Now the more or less correct anemometer is used to benchmark lidars…

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Uncertainties – some critical thoughts

- Initiative from Carbon Trust
  https://www.carbontrust.com/media/676998/owa-w-lusr_nov-2018.pdf

Lidar Uncertainty Standard Review Methodology Review and Recommendations

Offshore Wind Accelerator – Wakes and Wind Resource

LUSR – LiDAR Uncertainty Standard Review

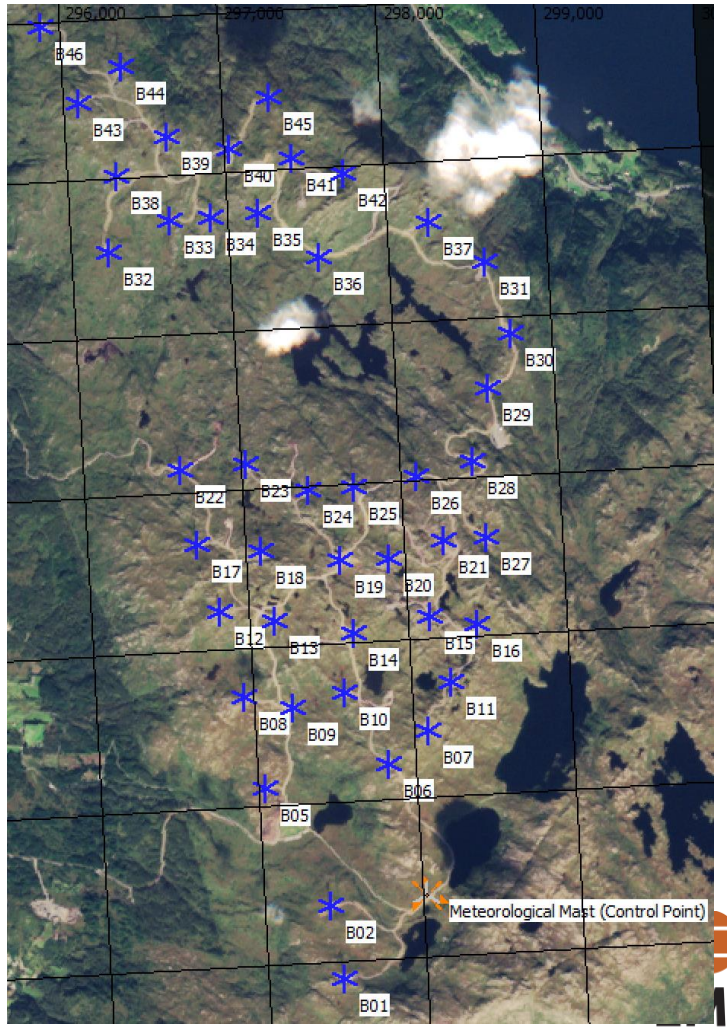
[June, 2018]

Data Set	Calculation	Revised Methodology	Indicative Wind Speed Standard Uncertainty (%)	Indicative AEP Standard Uncertainty (%), Average Wind Speed = 7 m/s	Indicative AEP Standard Uncertainty (%), Average Wind Speed = 10 m/s
Onshore	Lidar		4.0	6.9	3.7
Onshore	Lidar	Yes	2.5	4.7	2.4
Offshore	Float. Lidar		8.0	12.7	6.8
Offshore	Float. Lidar	Yes	2.1	3.3	1.8

Improvement: Impact of Map Quality on AEP

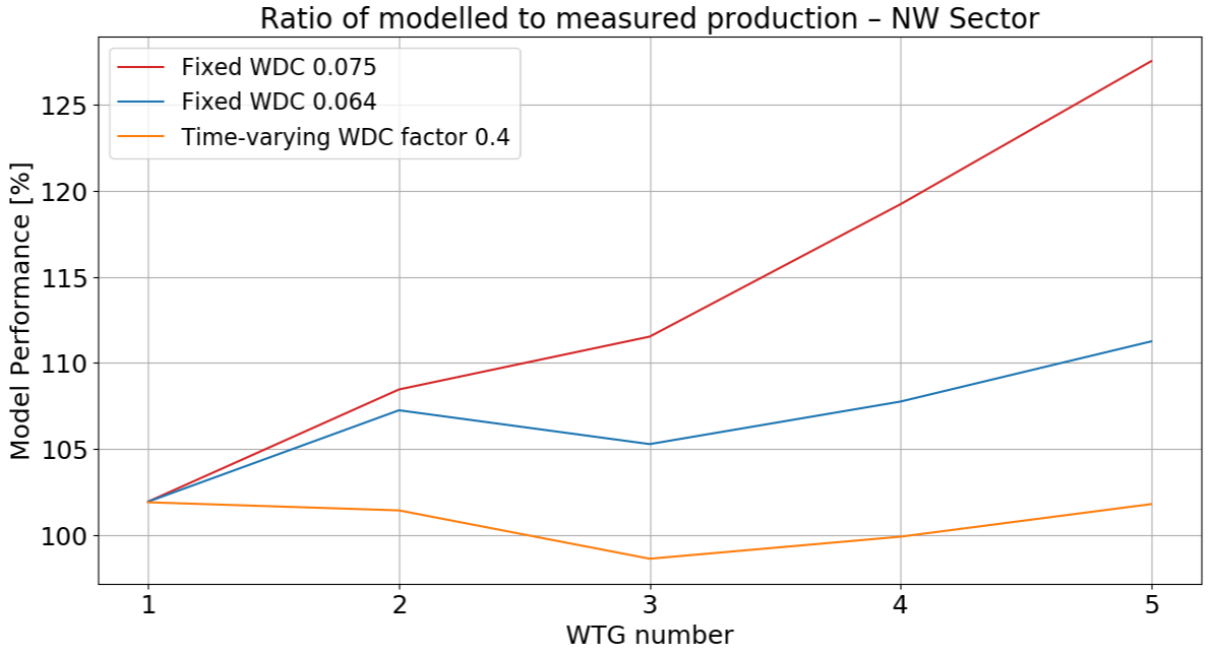
- Example: Midtfjellet, Norway
  - Benchmark: AEP calculated with DHM1 (1m resolution lidar data)
  - Compared on WTG level with AEP calculated with various maps (all available in windPRO)

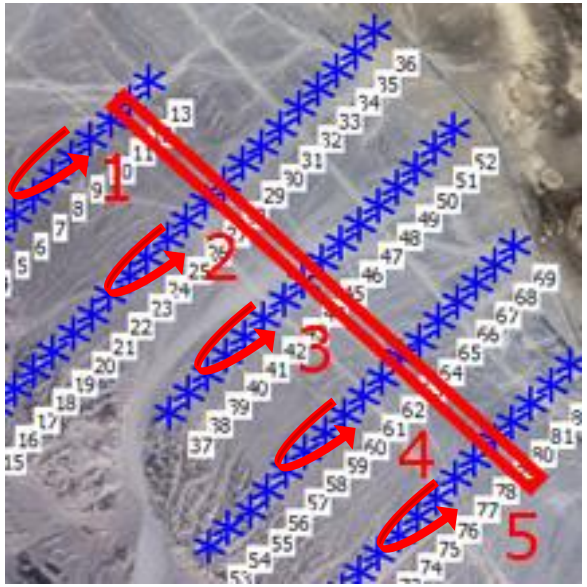
	Mean deviation [% AEP]	Stdev [% AEP]
DHM10	0.1	0.2
STRM1	-0.4	0.3
AW3D30	0.6	0.3
View Finder	-0.6	0.5
SRTM3	-0.7	0.6
EUDEM	-2.6	1.2



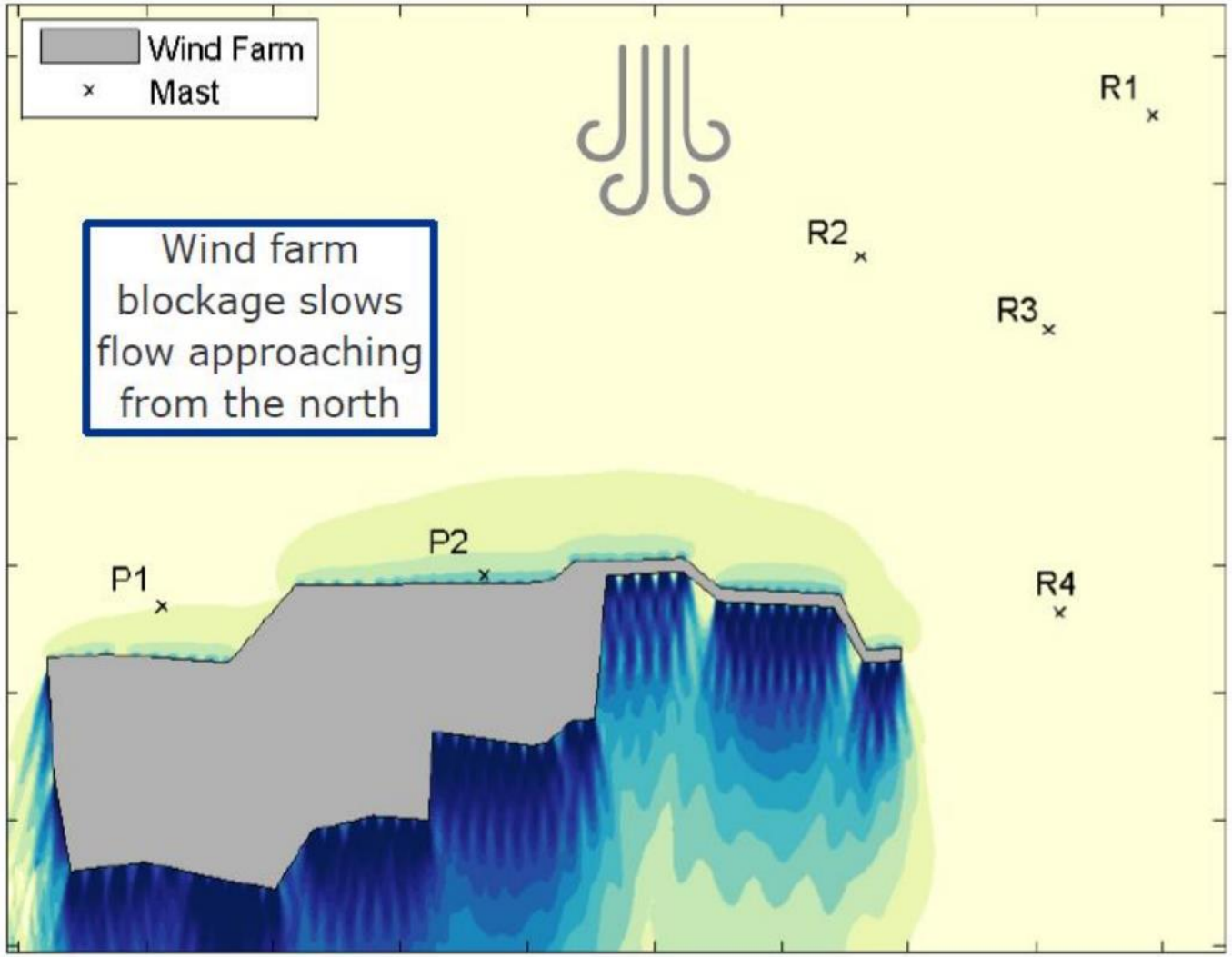
Losses – the good part of the story

- Time-varying calculations leads to more precise/accurate calculation of losses:
  - Environmental curtailment (noise, bats, flicker…)
  - Power Matrix: TI and shear impact, boost, de-rating etc
  - WTG performance: hysteresis (depending on documentation from OEM)
  - Time-varying wake decay constant





New Kids in Town: Wind Farm Blockage



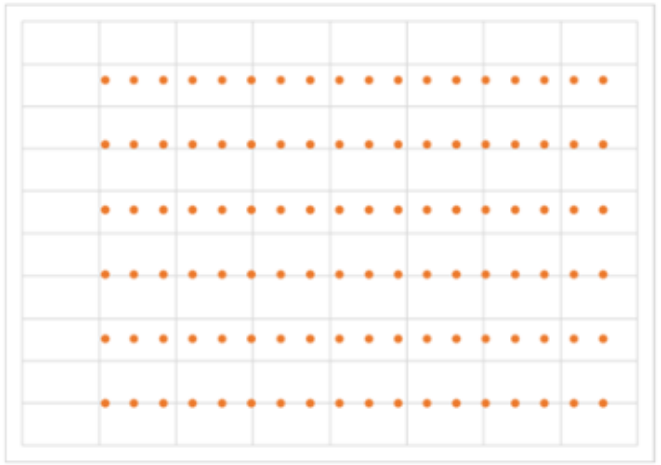
James Bleeg, "Accounting for Blockage Effects In Energy Production Assessments, " 12 Sep 2019, WRA 2018

New Kids in Town: Wind Farm Blockage

Layout 1: 50 MW; 3 RD

Layout 2: 150 MW; 4 x 8 RD

Layout 3: 300 MW; 6 x 12 RD



Expert	Blockage loss [% energy]
ArcVera	-
DNV GL	0.94
Natural Power	0.21
UL	0.0

Blockage loss [% energy]
-
1.76
0.53
2.0

Blockage loss [% energy]
-
0.37
0.47
2.4

Uncertainty AEP

1/3 of loss

20% of loss

Source: AWEA WRA workshop Renton 10-11 September 2019

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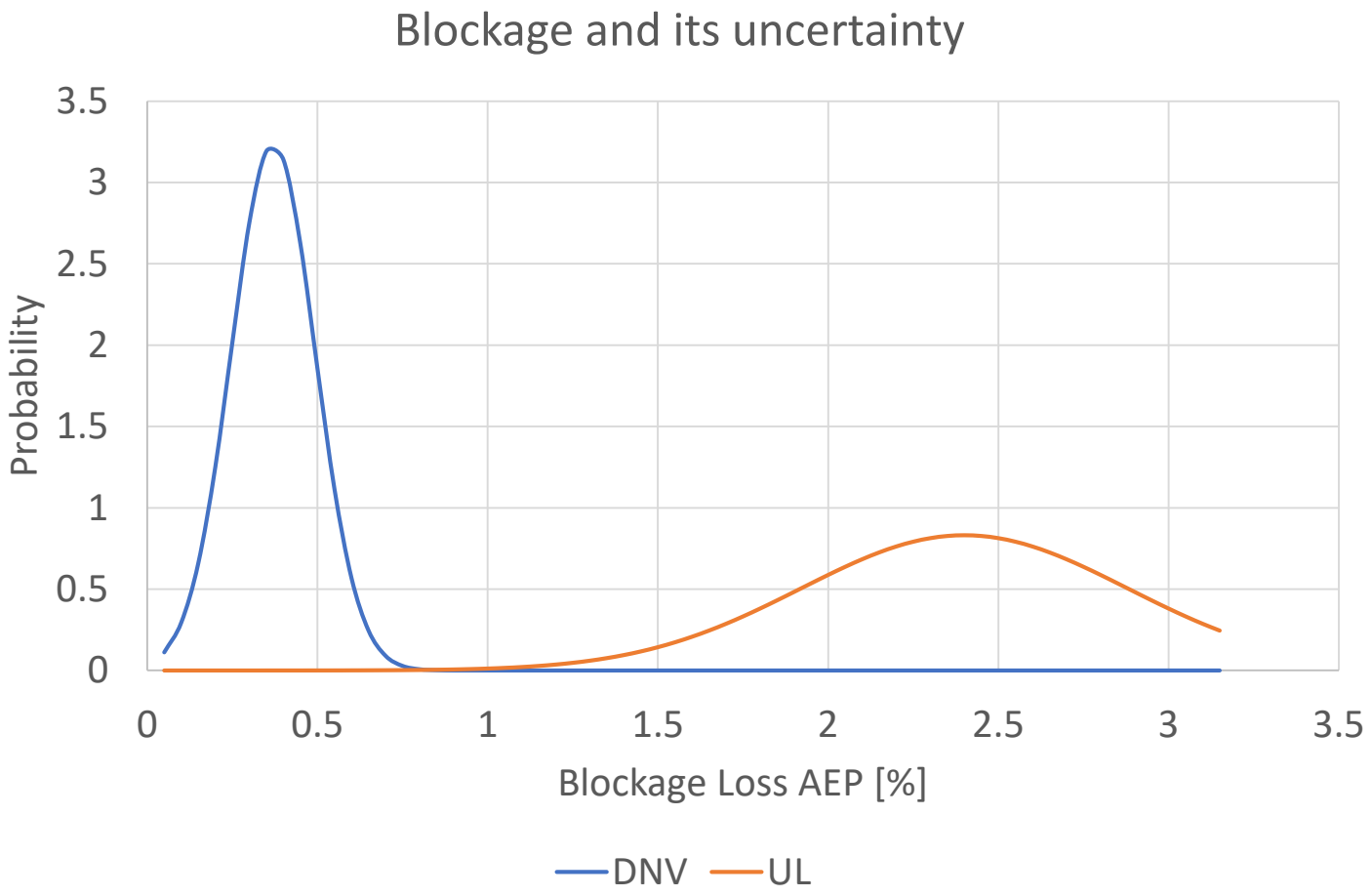
Does that make sense?

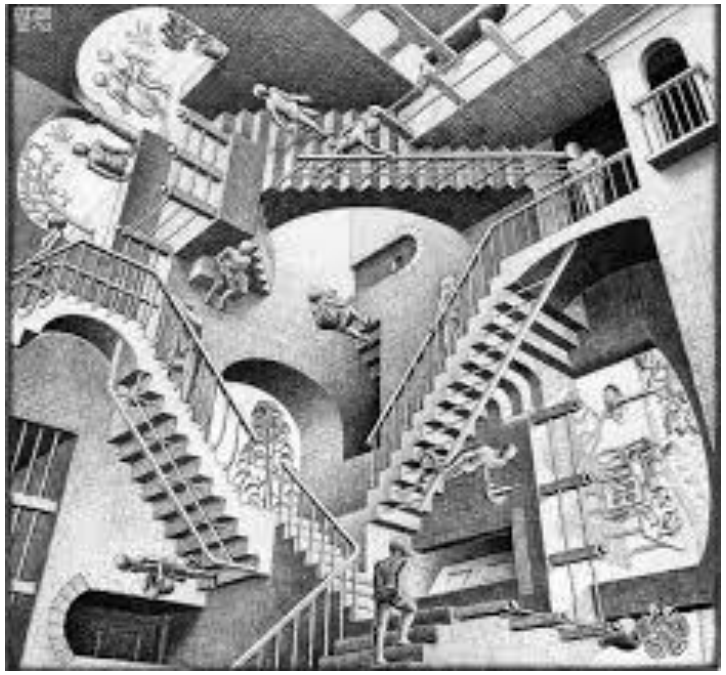


Both blockage models went through some validation process

UL points out that P50 validation study shows no bias
-> re-categorising some losses

Important to keep perspective right

- General
  - p50 is not too much off
- Uncertainty:
  - Some indications that assumptions are conservative
  - Large discrepancies anemometer classification (factor 2 wind speed uncertainty)
  - Uncertainty in IEC 12-1 (lidar) disputed (factor 4 wind speed uncertainty)
- Losses:
  - Better grip on some components through time-varying calculations
  - Blockage creates confusion, in some cases it contradicts P50 validation studies of main players



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Contact:

Wiebke Langreder
Head of Wind Consulting
EMD International A/S
Phone: +45 98354444
Email: wl@emd.dk
www.emd.dk

Selected EMD Comsulting Clients