Simulation of wake effects between two wind farms

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Simulation of wake effects between two wind farms

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• Introduction EERA-DTOC;
• Layout of the offshore wind farm cluster;
• Participants & models;
• Identification of a flow case;
• Results from SCADA data analysis;
• Results from the cluster models;
• Comparison of park efficiency;
• Conclusion & acknowledgement;
Introduction to EERA-DTOC

EERA: European Energy Research Alliance

The DTOC project combines expertise to develop a multidisciplinary integrated software tool for an: optimised design of offshore wind farms and clusters of wind farms.

The wake models results are compared to the measurements of wake effects:
1) between wind turbines and;
2) between wind farms;
Offshore wind farm cluster

Rødsand II wind farm
- Owner: E•ON
- SWP: 2.3-92.6m, VS & VP
- Spacing: variable 5 – 6 – 7 - 10D
- Operational status: good
- 1 month data 5-10 m/s representing East & West

Problems
- Lack of inflow reference & time stamps

Nysted wind farm
- Owner: DONG Energy A/S
- Bonus 2.3-82.4 m, 2-speed, active stall
- Principal spacing: 10.1 & 5.6 D
- Annual eq. full load hours≈3300

Problems
- Different owner
- Lack of synchronization

Cluster wake

EWEA OFFSHORE 2015, Copenhagen, 10th March 2015
Cluster layout

by courtesy of E•ON
Wind farm clustering

Offshore wind farm cluster: Rødsand II & Nysted

Rødsand II: 90 x SWT-2.3-92.6m

Nysted: 72 x Bonus-2.3-82.4m

Reference diameter: D=92.6m

Model inflow 77-117° 8 m/s

SCADA reference
Visualisation of SCADA analysis

Rødsand II: WDIR=72° Δ=5°; U=8±1 m/s
# Participants & models

| Models          | Affiliation                   |
|-----------------|-------------------------------|
| SCADA(BA)       | DTU Wind Energy/K.S. Hansen   |
| 1 FUGA/SO       | DTU Wind Energy/S. Ott        |
| 2 NOJ(GU)       | DTU Wind Energy/A. Pena       |
| 3 NOJ/Penã      | DTU Wind Energy/A. Pena       |
| 4 WRF/UPM       | Ciemat/A. Palomares           |
| 5 Meso/PV       | DTU Wind Energy/P. Volker     |
| 6 AD/RANS       | UPORTO/J.L. Palma             |
| 7 CFDWake       | CENER/B.G. Hevia              |
| 8 CRESflowNS    | CRES/ J. Prospathopoulos      |
| 9 FarmFlow      | ECN Wind Energy/J.G Scheepers |
| 10 RANS/fPC     | DTU Wind Energy/P.vd Laan     |
Model results for Rødsand II, U=8 m/s; WD=97

Offshore wind farm cluster: Rødsand II & Nysted

Model inflow 
$U_{hub}=8 \text{ m/s} \quad \text{WDIR}=97^\circ$
Model results for Rødsand II, U=8 m/s; WD=97°
Cluster modeling results, U=8 m/s; WD=97°
**Park efficiency comparison**

Rødsand II: Measured and simulated sectorwise park efficiency; U=8 m/s & Α=5°

**Definition of park efficiency:**

\[ \eta_{\text{park}} = 100 \times \frac{P_i}{\text{max}(P_i)}; \]

1) **Inflow sector:** ∆ = 5°
2) **Inflow speed:** U = 8 ± 0.5 m/s
3) \( P_i = \text{mean power for turbine } i \)
4) \( P = \text{mean power for all turbines} \)

**Park efficiency comparison**

Problem with Inflow reference
Conclusion

• The benchmark have demonstrated that both size and location of the distinct deficit zones - caused by the Nysted wind farm have been predicted well by the models.

• The benchmark concludes that several park models are able to handle the clustering of wind farms and ready to be integrated in the software, developed as part of “Design Tool for Offshore Wind Farm Cluster” (EERA-DTOC).

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