EERA-DTOC: Design tools for off-shore wind farm clusters including new results on wake bench

Schepers, G.; Hasager, Charlotte Bay; Hansen, Kurt Schaldemose; Madsen, Peter Hauge; Réthoré, Pierre-Elouan; Badger, Jake; Giebel, Gregor; Iuga, D.; Cantero, E.; Faiella, M.; Barthelmie, Rebecca Jane; Larsen, Torben J.; Prospathopoulos, J.; Palma, J.L.; Gomes, V.C.; Young, T.; Stuart, P.

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EERA-DTOC: DESIGN TOOLS FOR OFF-SHORE WIND FARM CLUSTERS

INCLUDING NEW RESULTS ON WAKE BENCH

G. Schepers, C. Bay Hasager, K. Hansen, P. Hauge Madsen, P.E. Rèthorè, J. Badger, G. Giebel, D. Iuga, E. Cantero, M Faiella, Rebecca Barthelmie, T. Larsen, J. Prospathopoulos, J. L. Palma, V. C. Gomes, T. Young, P. Stuart
Contents

- Introduction into project/objectives
- EERA-DTOC concept
- Status of project
- WakeBench: Comparison between wake model calculations and measurements from Horns Rev offshore wind farm
Coordinated by DTU (Charlotte Bay Hasager)

EERA = European Energy Research Alliance
DTOC = Design Tool for Offshore Clusters

Project period: January 2012 to June 2015

Funding total ~4M Euro, hereof ~2.9M Euro from EU FP7
EERA-DTOC summary slide

EERA-DTOC
European Energy Research Alliance - Design Tools for Offshore Clusters
Charlotte Hasager, Gregor Giebel, Pierre-Elouan Rethore. EERA Wind members and Industry
Contact: cbha@dtu.dk or ggr@dtu.dk, m: +45 4056 5995

Start 1 January 2012, runs for 3.5 years
Total funding is ~4 M€, EU share is 2.9 M€.

Product Vision:
A robust, efficient, easy to use and flexible tool created to facilitate the optimised design of individual and clusters of offshore wind farms.

A keystone of this optimisation is the precise prediction of the future long term wind farm energy yield and its associated uncertainty.
Contents

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• WakeBench: Comparison between wake model calculations and measurements from Horns Rev offshore wind farm
Use and bring together existing models from the partners
Develop open interfaces between them
Implement a shell to integrate
Fine-tune the wake models using dedicated measurements
Validate the final tool where possible and otherwise demonstrate its value through likely scenarios
EERA-DTOC concept

Meteorological data / Cluster layout / Turbine data

Grid data

Wake models

Grid models

Yield models

System services

Energy yield

Optimised Cluster Design
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</table>
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Where are we now?

- User requirements have been defined
- The integrated design tool has conceptually been designed
  - A first ‘dry run’ on a coupled meso/cluster/wake model is currently carried out.
  - Coupling with grid models in progress.
- First wake bench data as based on Horns Rev off-shore wind farm measurements is carried out
  - Other wake benches (e.g. on cluster scale) are in progress
- More measurements for validation are underway (e.g. Lidar measurements on Bard Off-Shore)
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• Introduction into project/objectives
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• *WakeBench: Comparison between wake model calculations and measurements from Horns Rev offshore wind farm*
Horns Rev(DK) offshore wind farm

Horns Rev wind farm

- Wind turbines
- Masts

Reference winddir

[Diagram showing Horns Rev wind farm with wind turbines and masts marked with labels.]
Horns Rev

- SCADA data = 10 minute statistics;
  - Power, pitch, rotorspeed, yaw position (uncalibrated);
- Wind speed and direction from (wake) mast M6 & M7;
- Derived signals:
  - Wind speed determined from power value with reference to the official power curve;
  - Wind direction is based on M7 & calibrated for 8 wake sectors;
- Data qualification includes: 2005-2009;
- The following flow cases are simulated by several wake models:
  - Normal operation, 270°, 7D spacing;
  - Atmospheric stratification, 270°, 7D spacing;
  - Variable turbulence intensity;
  - Normal operation, variable spacing 7, 9.4 & 10.4D;
Wake Bench (Horns Rev), maximum power deficit at 270 degrees (narrow inflow sector)
Wake Bench (Horns Rev), maximum power deficit at 270 degrees (wide inflow sector)
Wake Bench (Horns Rev), power deficit distribution

HornsRev-270dist; spacing 7D; \( \text{wdir}=270 \pm 20^\circ \), \( \Delta=5^\circ \), \( \text{ws}=8 \pm 0.5 \text{ m/s} \)
Wake Bench (Horns Rev), maximum power deficit at different turbulence levels

HornsRev-090Neutral; spacing 7D; wdir=90±5°; ws=8±0.5 m/s
Conclusions

• Work is underway to deliver an integrated tool for the design of individual wind farms and clusters of wind farms
• The tool is composed of existing models as available throughout Europe
• The tool will be available in December 2014
• Generally speaking the results from the anticipated EERA-DTOC wake models fit well with the measured results from the Horns Rev wind farm
Invitation to workshop on Offshore Wind Farm Clusters: Focus on Northern European Seas
London, UK, 6 June 2013 from 9.00 to 17.00

In line with the targets of the European Strategic Energy Technology Plan (SET Plan) of the European Commission, the offshore wind energy industry in Europe is to benefit by research and development by two large international projects co-funded by the European Union.

The projects are *Cluster Design* and *EERA DTOC*. The workshop is aimed at developers of offshore wind farm clusters, strategic planner and transmission system operators.

The workshop will include a series of presentations from the participants of Cluster Design and EERA DTOC. Keynote speakers: Peter Hauge Madsen (DTU Wind Energy), Rory Donnelly (3E), Mariano Faiella (IWES Fraunhofer), Elena Cantero (CENER), Gerard Schepers (ECN), Gregor Giebel (DTU Wind Energy), Pierre-Elouan Réthoré (DTU Wind Energy),

EERA DTOC is European Energy Research Alliance – Design Tools for Offshore Wind Farm Clusters
Venue: Renewable Energy Systesm (RES) in London

For further information, please visit our web-sites
Thank you very much for your attention