Center for Wind Turbine Aerodynamics and Atmospheric Turbulence

Projektstatus

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DTU Wind Energy
Technical University of Denmark

Styregruppemøde - DTU
11. april, 2012

Department of Mechanical Engineering
Technical University of Denmark

Dagsorden

13.30-13.50:
Intro og generel oversigt

13.50-15.20:
Status for 2011 og planer for 2012

- **13.50-14.20: Rotor-aerodynamik**
- **14.20-14.50 : Wakes og vindfarme**
- **14.50-15.20 : Siting og atmosfærefysik**

15.20-15.40:
Wakebench projektet

15.40-16.00:
Generel diskussion

Center for Wind Turbine Aerodynamics and Atmospheric Turbulence

- **DSF-bevilling under Bæredygtig Energi og Miljø**
- **Start: 1. Januar 2010**
  Slut: 31. December 2015
- **<u>DSF-bevilling</u>:**
  Direkte udgifter: 22.246.666 kr.
  Overhead/adm: 9.788.533 kr.
  I alt: <u>32.035.199 kr.</u>
- **In-kind og medfinanciering: 32.000.000 kr.**
- **Forskningspartnere: MEK, VEA-Risø, MET-Risø**
- **Industripartnere: LM, Vestas, Siemens, Vattenfall**

Overview of tasks:

Task 1. Rotor/ABL Aerodynamics (NNS)

Task 2. Wind Turbine Wakes and Clusters (JNS)

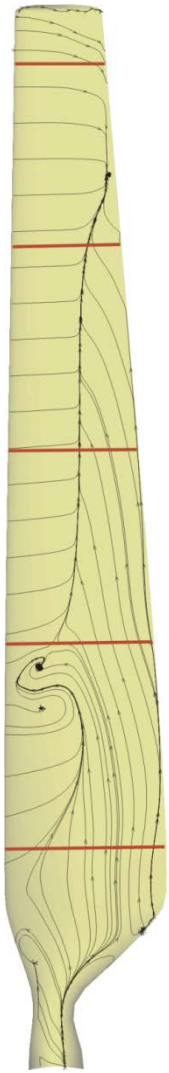
Task 3. Wind Farms (JNS)

Task 4. Siting in Forested and Complex Terrain (JM)

Task 5. Atmospheric Boundary Layers (JM)

Task 1. Rotor/ABL Aerodynamics

Comparison of state of the art turbulence models with multi-scale aerodynamic data. Development of phenomenological 'engineering' models describing dynamic stall and yaw

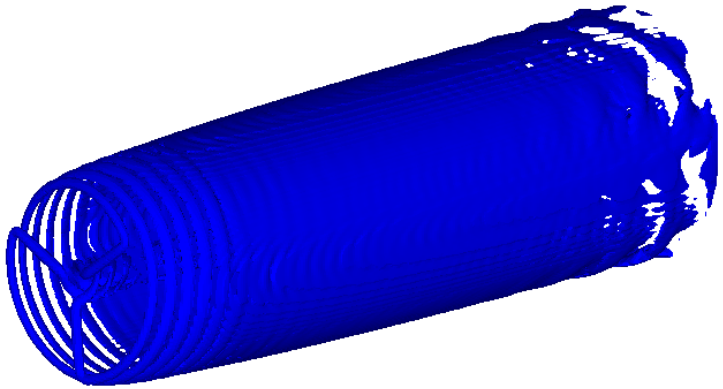


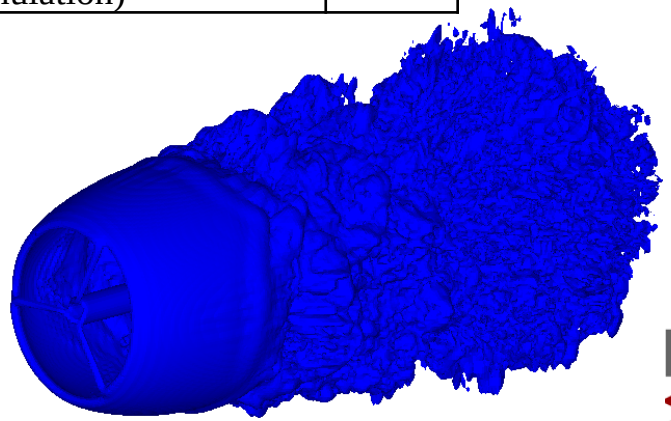
Task	Milestone	Description of Milestone	Month
1	M1	Parametric study of RANS/DES computations of two modern turbines (NM80, Siemens 2.3MW) in atmospheric shear compared to experiment. (Using resolved rotor geometry and laminar/turbulent transition.)	12
1	M2	Evaluation of the importance of cross flow instabilities for modern wind turbine rotors.	24
1	M3	Parametric study of two modern turbines (NM80, Siemens 2.3 MW) turbine in yaw compared to experimental results. (Using resolved rotor geometry and laminar/turbulent transition)	24
1	M4	Development of refined 'engineering' yaw model	36
1	M5	Evaluation of dynamic stall models and airfoil characteristics with respect to dynamic inflow and inflow turbulence	48
1	M6	Simulation of various unsteady inflow conditions for the NM80. (Using resolved rotor geometry and laminar/turbulent transition)	36

Task 2. Wind Turbine Wakes and Clusters

Objectives: New insight into turbulent wake structures, including wake to wake interaction. Development of dynamic wake and parabolised Navier-Stokes models

Task	Milestone	Description of Milestone	Month
2	M7	Study of far wakes behind single turbine, comparison with experiments and results from Task-1. (Actuator Disk/Line)	24
2	M8	Refined model for the far wake	24
2	M9	Parabolized stand-alone N-S park model	14
2	M10	Parametric study of the wake stability for varying inflow turbulence, and comparison with M-1.3A (Actuator Disk/Line formulation)	38
2	M11	Refined modeling in the framework of Dynamic Wake Modeling, using input from M-2.1A and M-2.2A.	48
2	M12	Parametric study of the wake/wake interaction between two or more turbines, compared to experiments. (Resolved geometry, and Actuator Disk/Line formulation)	36





Task 3. Wind Farms

Development of cost effective models for park to park effects, including optimized numerical methods and i nfluence of stratification

Task	Milestone	Description of Milestone	Month
3	M13	Computations and validation of neutral ABL RANS simulations of wind farms, compared to experimental results from Horns Rev. (Using Actuator Disk)	38
3	M14	Computation and validation of LES simulation of wind farms, using experimental results from Horns Rev and Lillgrund. (Using Actuator Disk/Line)	24
3	M15	Development of low-dimensional turbulence model for wind farms.	36
3	M16	Parametric study of the influence of the stratification of the ABL on wind farm performance.	48
3	M17	Evaluation of the mutual interaction of two wind farms located in close proximity. (Using Actuator Disk/Line and LES)	60

Task 4. Siting in Forested and Complex Terrain

Objectives: New insight about the interference between turbines and terrain, and more reliable predictions of wind energy production and wind turbine loads in complex terrain

Task	Milestone	Description of Milestone	Month
4	M18	Validation of complex terrain flow models using data from the Bolund and the Vestas India site	6
4	M19	Beta version of terrain flow solver available to industry partner Vestas.	7
4	M20	Beta version of forest model available to industry partner Vestas.	12
4	M21	Forest model Version-1.0 using parametrization from SCADIS	24
4	M22	Terrain flow model that includes atmospheric stratification	40
4	M23	Parametric study of the mutual turbine/terrain influence. (Using Actuator Disk/Line, both with RANS and LES)	44

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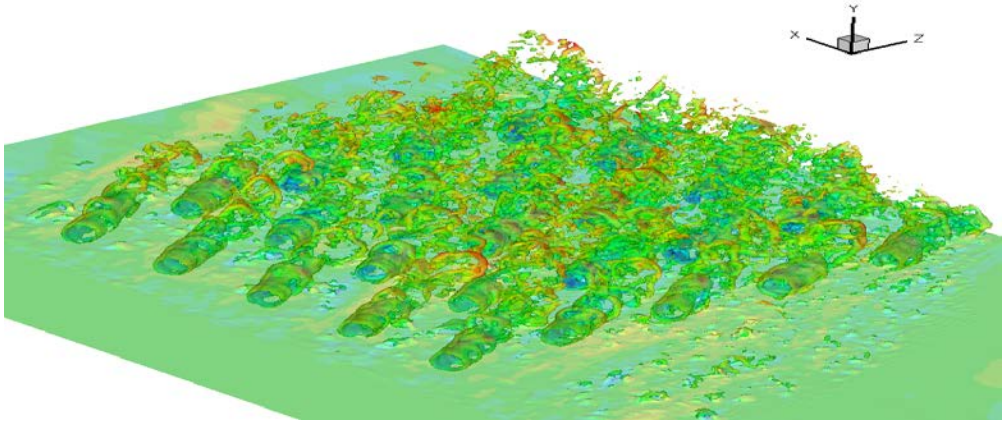
Task 5. Atmospheric Boundary Layers

Models of the atmospheric flow over terrain that take into account stability effects and boundary layer height. A model of the three-dimensional structure of turbulence affected by atmospheric stability and suited for inflow turbulence simulation

Task	Milestone	Description of Milestone	Month
5	M24	Implementation and validation of stability and boundary layer temperature inversion in EllipSys3D	44
5	M25	Development and verification of a model of the spatial structure of atmospheric turbulence under influence of stratification	48
5	M26	Parametric study of stratified boundary layer from Horns Rev. and Høvsøre.	60
5	M27	Assessment of stratification impacts on rotor performance	70



PhD students

- **Søren Juhl Andersen (start: July 1, 2010)**
  'Simulation and prediction of wakes and wake interaction in wind farms'

- **Hamid Sarlak (Start: January 1, 2011)**
  'Simulation and prediction of wakes in offshore wind farms subject to turbulent and stratified atmospheric boundary layers'

- **Dmitry Kolmogorov (Start: January 1, 2011)**
  'Navier-Stokes simulations of flow past wind turbines'

- **Evan Machefaux (Start: November 1, 2011)**
  'Measurements and LES simulations of multiple turbine wakes'

- **Louis-Étienne Boudreault (Start: November 1, 2011)**
  'Flow of air over complex forested terrain'

- **Paul van der Laan (Start: December 15, 2011)**
  'Development of Efficient Turbulence Models for CFD Wake Simulations'

Dissemination

Results are presented at conferences and through international journal publications. A dedicated conference is organized every year.

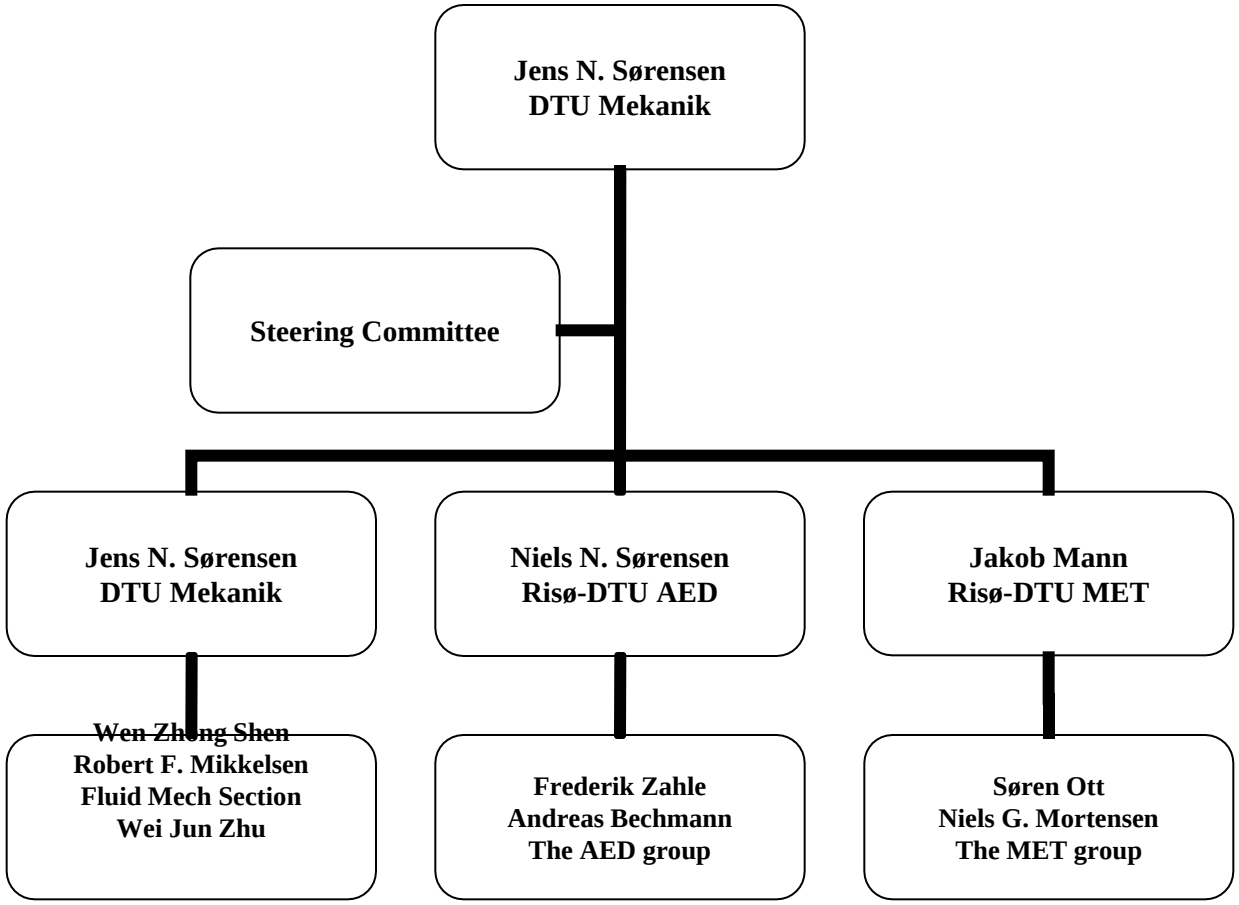
Publications 2011:

- **Peer-reviewed articles: 23**
- **Conference proceedings: 25**

Symposia and courses 2011

- **Wake topical workshop, 25. maj, Risø DTU**
- **PhD Course: LES in Hydrodynamics and Offshore Wind Energy.**
  Part I: Oslo University, August 15-17;
  Part II: DTU-Lyngby, August 24-26.
- **PhD Seminar, November 7, Risø DTU**
- **Center meeting, December 13, Risø DTU**

Organisationsdiagram



Steering Committee:

- **Peter Hauge Madsen (Risø DTU)**
- **Henrik Carlsen (DTU Mekanik)**
- **Kenneth Thomsen (Siemens WP)**
- **Line Gulstad (Vestas Wind Systems)**
- **Rebecca Barthelmie (Indiana University)**
- **Jesper Madsen (LM Wind Power)**

International collaboration

- **Monash University (Australia):**
  Vortex structures in wind turbine wakes and their modification

- **KTH, Univ. of Gotland (Sweden):**
  Nordic consortium for optimization and control of wind parks

- **Johns Hopkins University (USA):**
  PIRE: USA/Europe Partnership for Integrated Research and Education in Wind Energy

- **IRPHE/CNRS (France):**
  HELICE: Helical Vortex Wakes

- **IEA Wakebench network:**
  Collaboration between various European and American partners

- **NREL Collaboration (USA)**

Guest professors, senior researchers, Post-docs's, PhD-students

The center cover stravelling expenses, accomodation and per diem.
A stay can last between a few days up to 3 months.

Guests 2011:

- **John Grue: Professor, Oslo Universitet**
- **Dan Henningson: Professor, KTH**
- **Mehmet Özgün Korukçu: Post-doc,**
  Uludag University Faculty of Engineering and Architecture
- **Stefan Ivanell; Lektor, KTH/HG**

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Home page:

http://www.comwind.mek.dtu.dk/

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