

# ASHES: A Novel Tool for FEM analysis of Wind Turbines with innovative visualization techniques



# Content:

1. Introduction: Status for aeroelastic software
2. ASHES:
  1. What?
  2. Why?
  3. Benchmarking (OC4, Norcowe/Nowitech Blindtest)
  4. DEMO (hopefully live...)
  5. What's next?

# 1. (Incomplete) status for Aeroelastic software

- Def: Coupled analysis of a wind turbine including:
  - Aerodynamics
  - Blades/rotor
  - Tower
  - Control system
- Mode shape analysis, Multi Body Systems, and/or FEM

- Main results:
  - Natural frequency analysis
  - Time domain simulation (for fatigue design)
- Recent trend:
  - Adapting for offshore wind turbines
  - Moving to FEM analysis

- There are many different codes in use and under development, e.g.:
  - NREL: FAST (free and open source)
  - DTU: Flex (quasi-commercial)
  - Risø: HAWC2 (half-commercial)
  - GL GH: Bladed (leading commercial program)
  - Many others!

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# 2.1 ASHES: What is it?

- Aero-Servo-Hydro-Elastic-Simulation
- Developed at NTNU, so-far funded mostly by the Statkraft Ocean Energy Research Program
- How we hope it will be different:
  - Simultaneous focus on
    - Numerical results
    - GUI (Graphical User Interface)
    - Visualization
  - Fun to use

- New users groups:
  - Traditional: Experienced professionals
  - New: Inexperienced professionals
  - New: Students
- Based on an object oriented FEM framework with full access to C++ source code



## 2.2 ASHES: Why bother?

- Does the world really need another aeroelastic code?

# Signs there are reasons to bother:

- The huge interest indicates that it makes sense!
- International cooperation
  - OC4 project
- Google isn't interested (yet)
- The market (wind energy) has a huge growth

## 2.3 ASHES Benchmarking

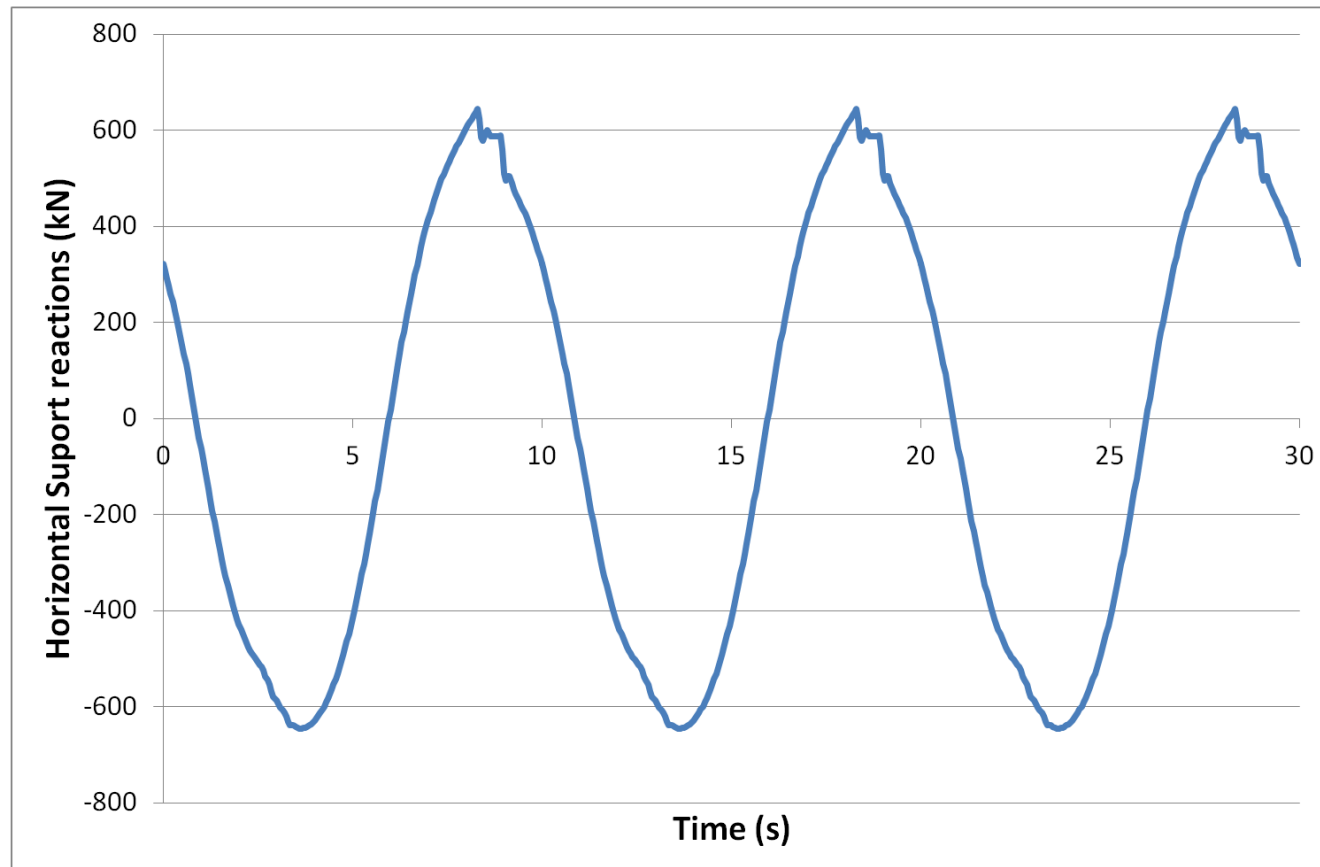
- A. OC4 project
- B. NORCOWE/NOWITECH Wind tunnel blindtest
- C. Comparison with other experimental data from NTNU

# A. The OC4 project

- Offshore Code Comparison Collaboration Continuation
  - Continuation of OC3
- [http://www.ieawind.org/Task\\_30](http://www.ieawind.org/Task_30)
- Phase 1: 5MW WT with tubular tower and jacket on 45 m depth
- (Later: Phase 2: Semi-sub floater)
- 15 different codes and groups actively taking part
- Paper for ISOPE 2012

# OC4 Load case 2.3a, Airy wave $H=6\text{m}$ , $T=10\text{s}$ , no wind

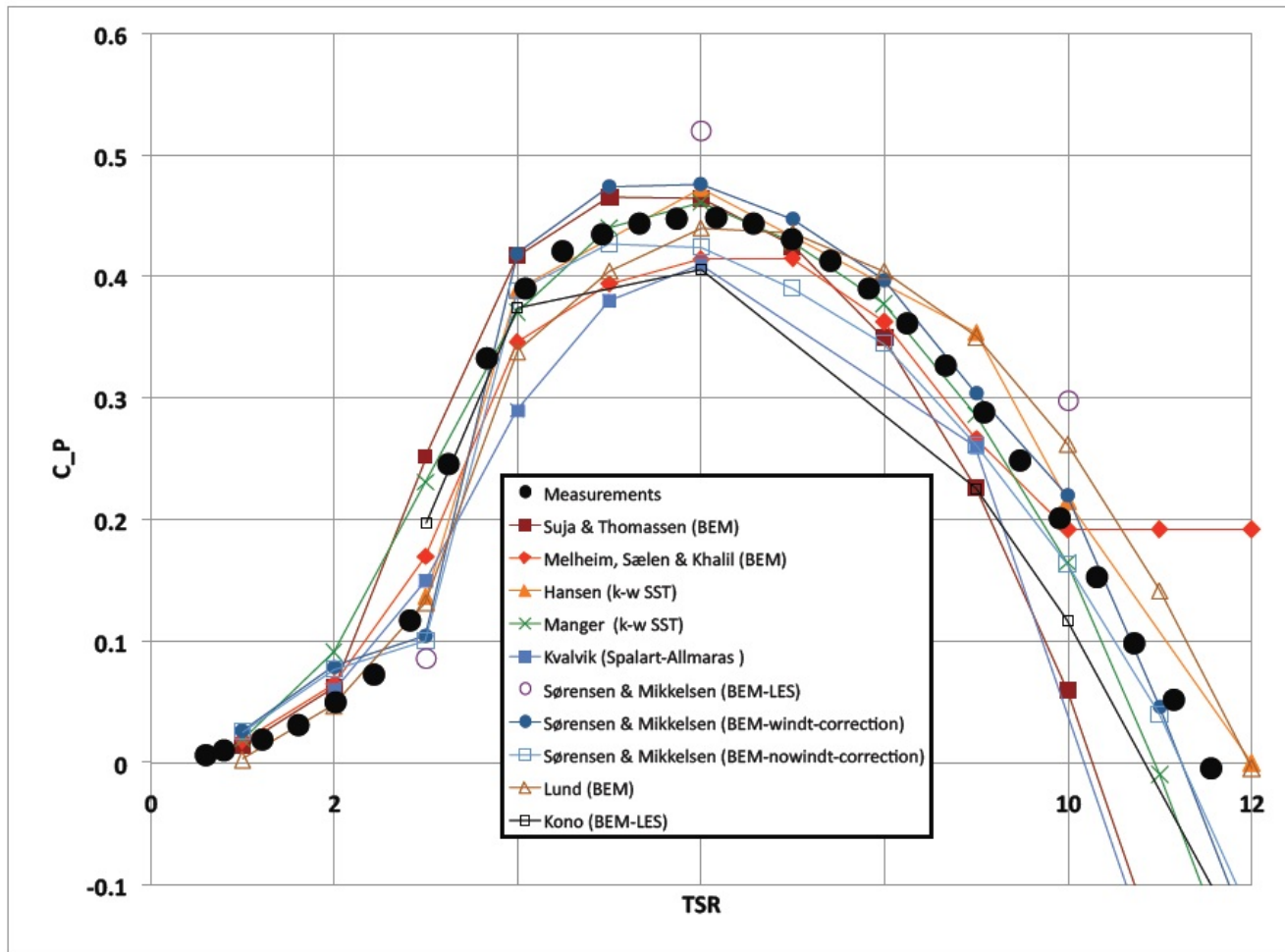
## Sensor 53: Sum of horizontal support reactions



# NORCOWE/NOWITECH Blindtest Workshop

- Calculations for a model wind turbine tested in the NTNU wind tunnel
- Test of the BEM implementation

# Cp curve



# C. Comparison with experimental data from NTNU

- Tidal turbine in towing tank (Celine Faudot/Ole G. Dahlhaug)
- Yawed rotor in wind tunnel (Tania Bracchi/Per Åge Krogstad)



# ASHES Demo

# ASHES: What is it? Part II

## GUI focus

- An effective and attractive GUI is expected from a modern tool
- The GUI is very useful also in the development process
- NB: A non-GUI option will also be provided for the end user

# Real-time analysis

- No video
- Start-Pause-Stop
- Increase – decrease analysis speed

# Effective visualization

- Simple vs. complex
- Investigate
  - Blade visualization
  - Load visualization
  - Velocity triangle

# “Professional” software development practices

- Source control
  - Effective and safe development
  - Enables (international) hands-on cooperation
- Object oriented programming
  - Visual studio, C++
- Documentation, testing
- “Group” programming

## 2.4 ASHES: What's next?

- New functionality governed by needs from ongoing research, benchmarking ,and model tests
- Flexible (FE) blades also in time domain analysis
- Blade design and optimization (MSc thesis project)

- Advanced wave models
- Combined waves and current (for tidal turbine)
- Define and run multiple analyses
- Optimization for speed
- Make available for pilot users