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# IEA Offshore Wind Energy



## IEA Offshore Wind Energy Technology and Deployment Activities

**Jørgen Lemming**  
Risø National Laboratory

**Operating Agents:**

**Jørgen Lemming**

**Walt Musial**

**Supported by Sandy Butterfield and  
Flemming Øster**



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# Organizational Structure



## Task 23 Operating Agents Risø and NREL

### Subtask 1 (Risø)

Experience with critical deployment issues

Research Area # 1  
Ecological Issues and Regulations  
NL

Research Area # 2  
Grid Connection of Large Scale  
offshore wind power  
UK

Research Area # 3  
External Conditions, Layouts and  
Design of Offshore Wind Farms  
DK

### Subtask 2 (NREL)

Technical Research for deeper water

Research Area # 4  
Offshore Code Comparison  
Collaboration  
USA

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# Task 23 Participation



Country	Membership Status/ Contracting Party	Organization
United States	Committed/ US Department of Energy	<ul style="list-style-type: none"><li>• NREL</li><li>• MIT</li><li>• University of Massachusetts</li><li>• GE Energy</li></ul>
Denmark	Committed/ Danish Energy Authority	<ul style="list-style-type: none"><li>• RISØ National Laboratory</li><li>• Vestas, Siemens</li><li>• Elsam</li><li>• DnV</li></ul>
Norway	Committed/ Enova SF	<ul style="list-style-type: none"><li>• NTNU-BAT</li></ul>
United Kingdom	Committed/ Department of Trade and Industry	<ul style="list-style-type: none"><li>• Garrad Hassan</li><li>• Ceasa</li></ul>
Netherlands	Committed/ CenterNovem	<ul style="list-style-type: none"><li>• We@sea</li><li>• KEMA</li></ul>
Germany	Committed/ Ministry of Environment, Nature Conservation and Nuclear Safety	<ul style="list-style-type: none"><li>• University of Stuttgart</li><li>• GE Energy</li></ul>
South Korea	Committed/ Ministry of Commerce, Industry and Energy	<ul style="list-style-type: none"><li>• Inha University</li></ul>
Sweden	Committed/ Swedish Energy Agency	<ul style="list-style-type: none"><li>• Chalmers</li></ul>
Spain	TBD	<ul style="list-style-type: none"><li>• Cener</li></ul>

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# Ecological Issues and Regulations



## Areas of collaboration:

- Baseline data and research methods
- Impacts on the environment (assessment criteria)
- Experience and application of Environmental Impact Assessments
  - Summarize preliminary conclusions from EU COD project.
  - Potential cumulative effects to the marine ecology
  - Conclusions from avian and mammal surveys
- Permitting processes
  - Streamlining planning and approval procedures
  - Educating the regulators and facilitating interagency cooperation
- Pre- and post-construction monitoring of operating wind facilities
- Public (stakeholder) involvement and acceptance
- Decommissioning processes and procedures

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# Grid Connection of Large Scale offshore wind power



- **The five critical issues included in the work program:**
  - Offshore wind meteorology and impact on power fluctuations and wind forecasting
  - Behavior and modeling of high-voltage cable systems
  - Grid Code and security standards for offshore versus onshore
  - Control and communication systems of large offshore wind farms
  - Technical architecture of offshore grid systems and enabling technologies.

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# Grid Connection Meeting Plan



Work item	Initiative	Action
Technical architecture Grid codes	UK	Workshop early 2007
Offshore meteorology and electrical power Connection and control strategies	DK	Workshop late 2007
Transient behavior	NL	Workshop 2008



Results from workshop on at Risø (30 experts from 9 countries discussed the following five main areas)

- **1) Wake modeling and benchmarking of wake models**
  - 1. Step: Workshop on status existing works
  - 2. Step: Workshop on evaluating the quality of models and results
- **2) Marine boundary layer characteristics.**
  - The marine boundary layer is defined here as the lowest ~1 km of the atmosphere between the height of the geostrophic wind speed and the wave surface of the ocean.
  - To review current experience particularly with regard to developing wind farms in coastal areas (~50 km from the coast)
  - To assess the reliability of remote sensing methods offshore including satellite observations, sodar and lidar where the aim is to observe wind and turbulence profiles at 100 m and above and to include tall mast measurements where available
  - To assess the accuracy of model predictions including local scale, mesoscale and LES models as available.
- **3) Met-ocean data and loads.**
  - To be formulated

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## Workshops?



- First Workshop was Held at Risoe Dec 2005
- Three working groups were formed:
  - 1) Wake modeling and benchmarking of wake models*
  - 2) Marine boundary layer characteristics*
  - 3) Met-ocean data and loads*
- Wake modeling subgroup have met Sep 7-Sep 8.
  - 1) Step: Workshop on status existing works*
  - 2) Step: Workshop on evaluating the quality of models and results*
- Other sub-group meetings are being planned.

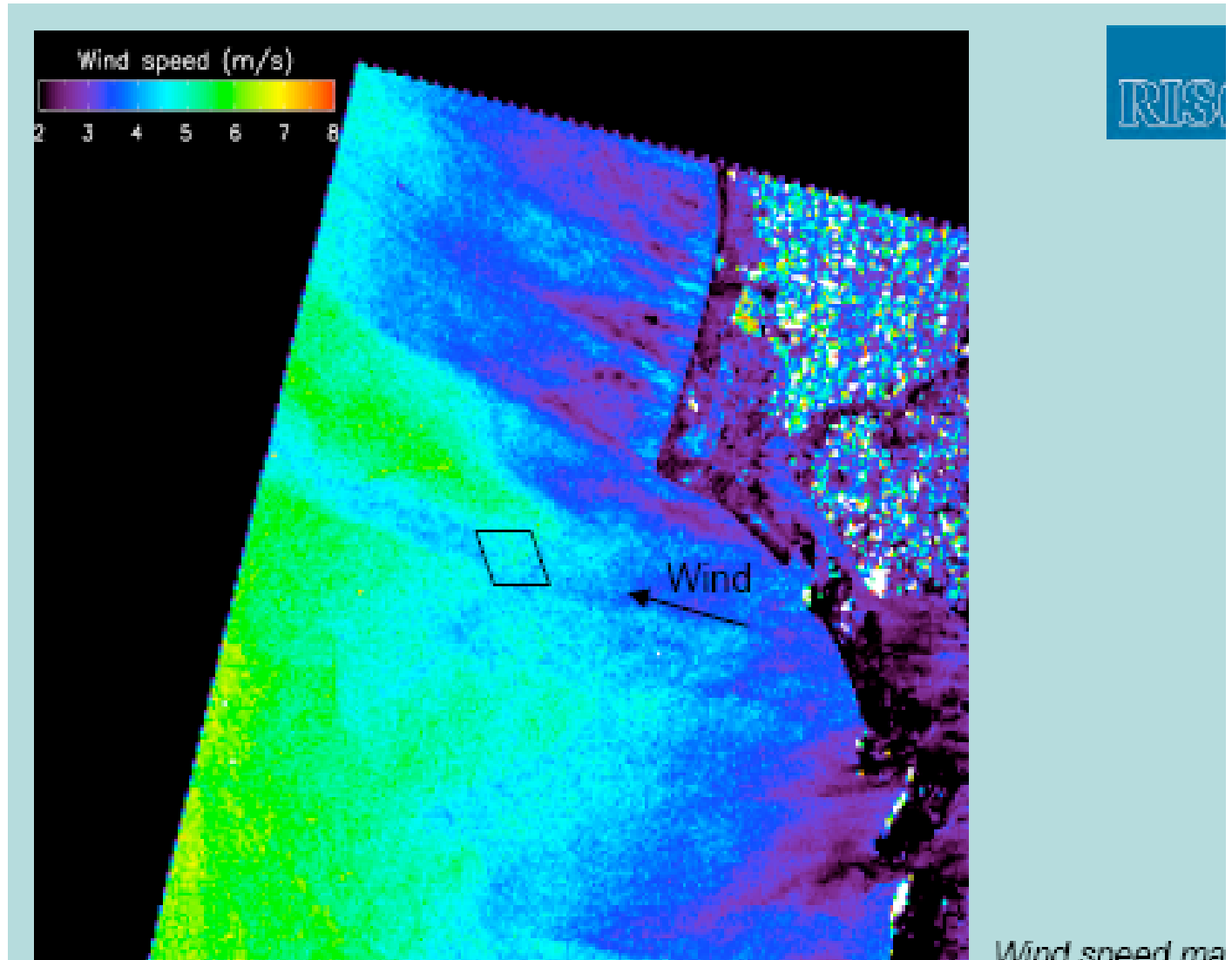
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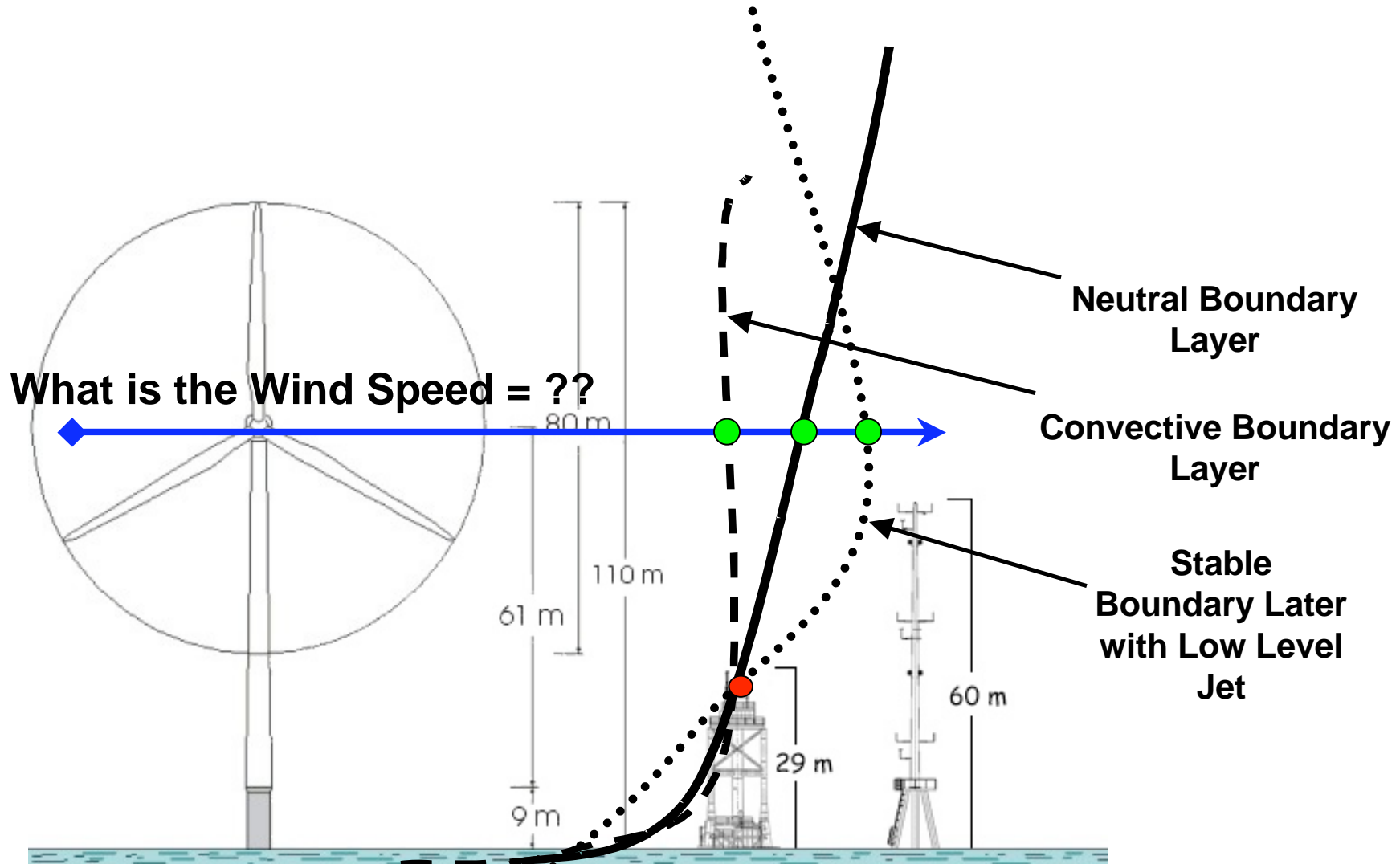
# Wake loss Assessment at Horns Rev



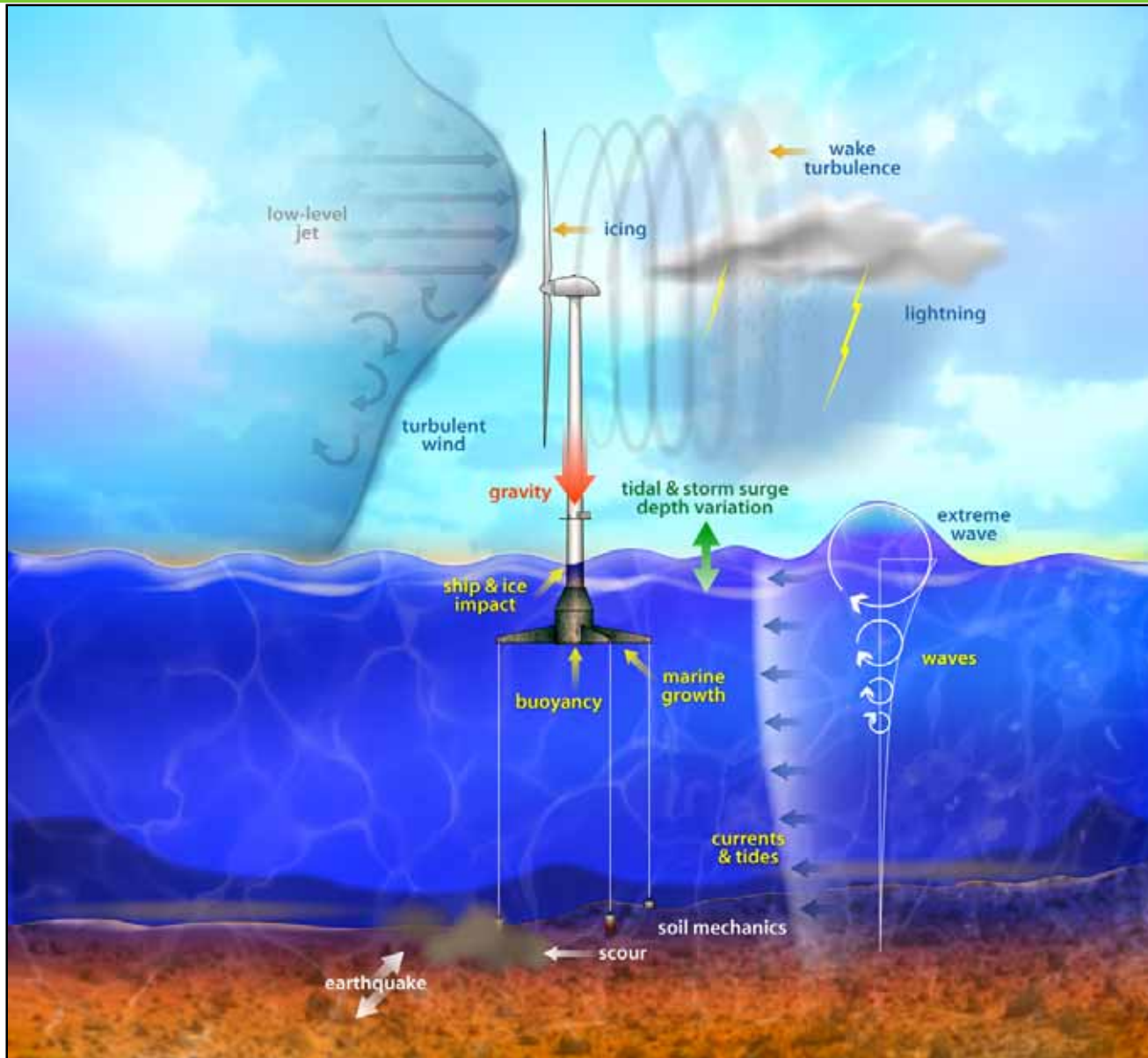
European Remote Sensing Satellite -2  
Global Measurements  
and Images including  
Sea State, Sea  
Surface Winds,  
Ocean Circulation,  
and Sea and Ice  
Levels.



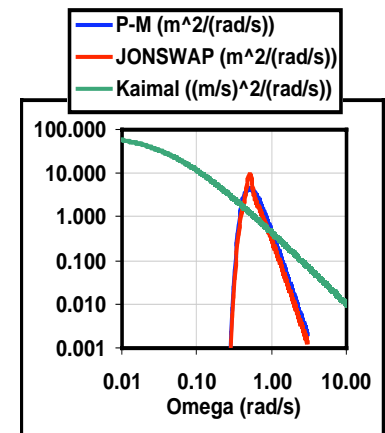
# 2) Marine boundary layer characteristics



# RISO3) *Met-ocean data and loads*



- Turbulent winds
- Irregular waves
- Gravity / inertia
- Aerodynamics:
  - induction
  - skewed wake
  - dynamic stall
- Hydrodynamics:
  - scattering
  - radiation
  - hydrostatics
- Elasticity
- Mooring dynamics
- Control system
- Fully coupled



Wind and Wave Spectra

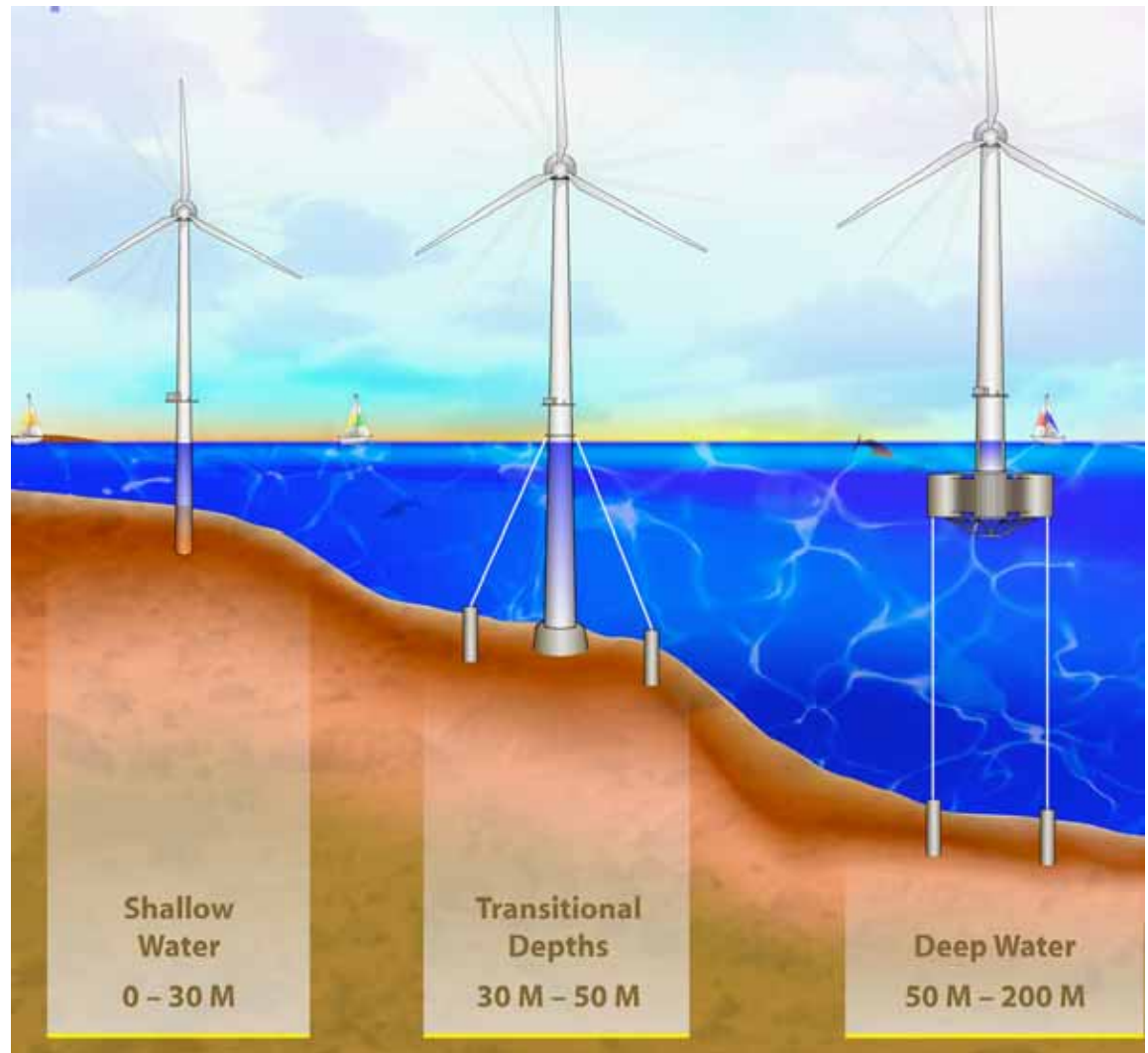
## Goal

1. Quantify offshore load prediction capability
2. Identify critical modeling deficiencies common to all codes.

## Scope

Code Comparisons for:

- Wave loading
- Support structures
- Geotechnical
- Coupled system dynamics



Lead: Sandy Butterfield-US DOE/NREL

Includes technologies ranging from the current shallow-bottom monopiles to deep water floating platforms.

- **Water depth:** 5 m – greater than 200 meters.
- **Support structures:** none and floating monopiles.
- **Wave loading models:** linear and non-linear (breaking).
- **Coupled dynamic models:** FAST, ADAMS, BLADED, HAWC, HAWCB, HAWC2, FLEX5, DHAT

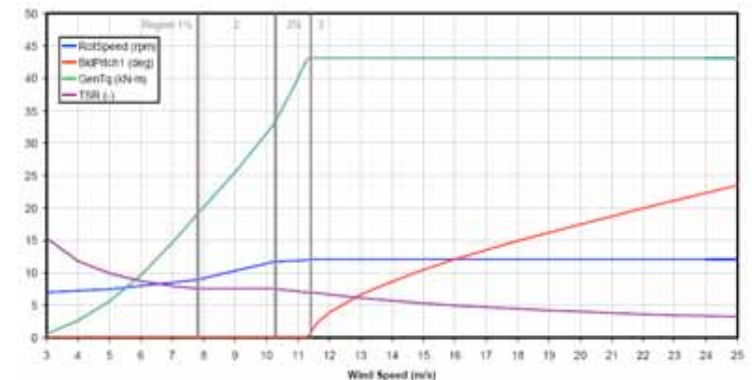
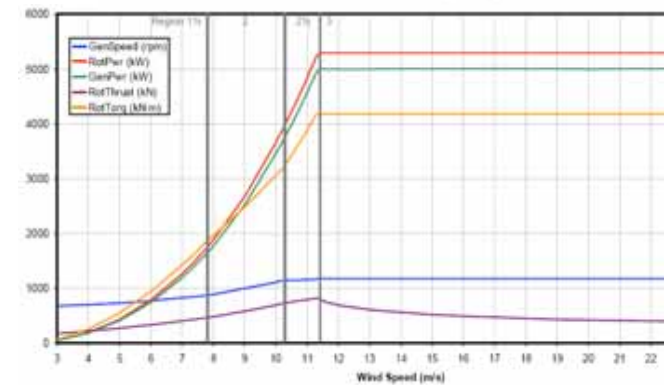
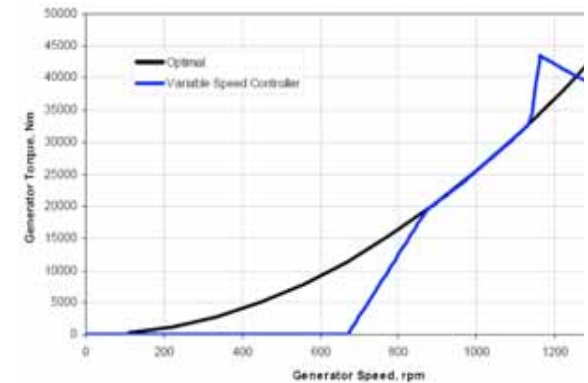
**Not included:** aerodynamic models, turbulence models, various turbine types, controls.



# NREL 5 MW Baseline Wind Turbine



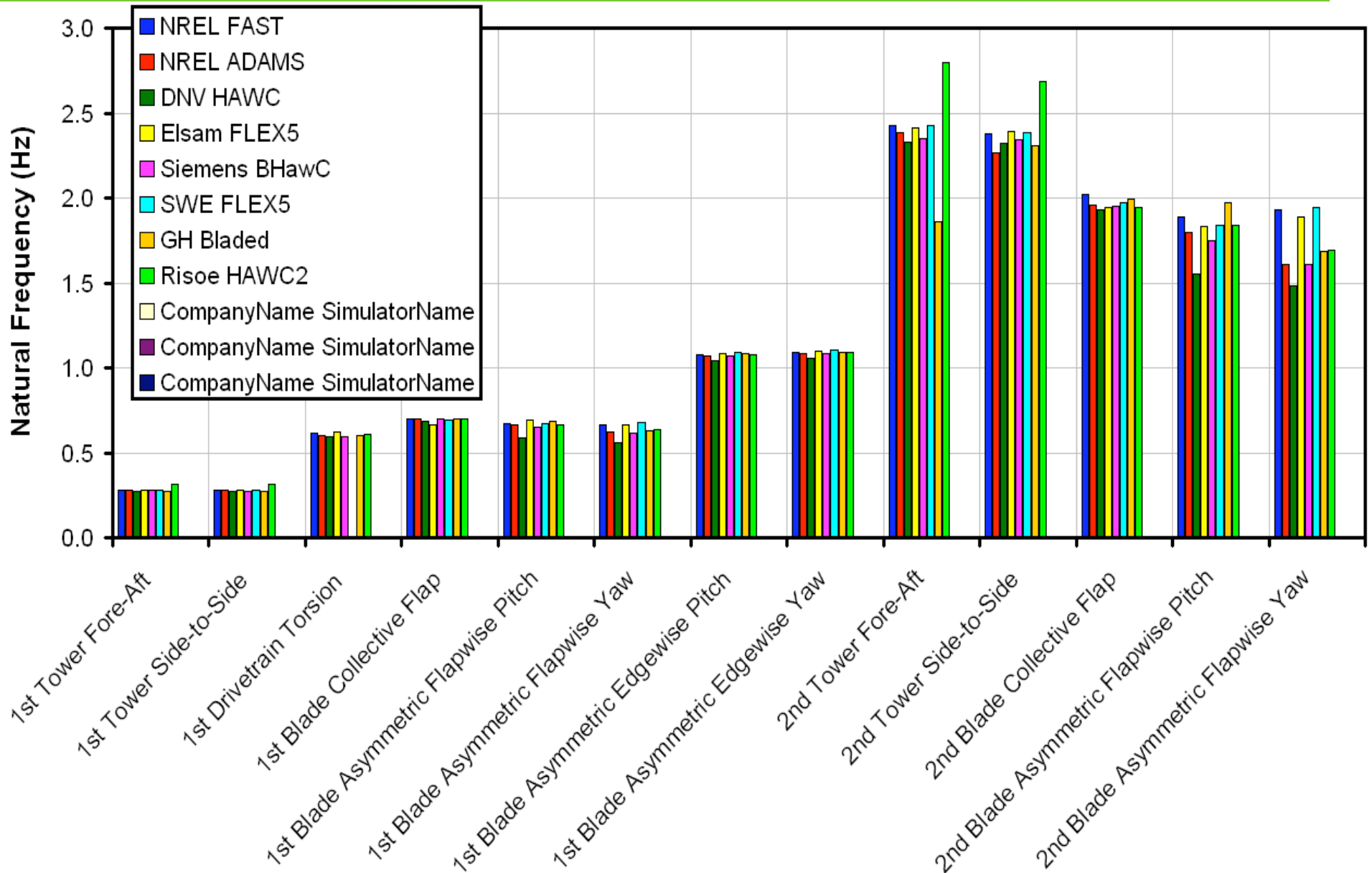
Nominal power	5 MW
Rotor diameter	126 m
Blade length	61.5 (LM 61.5)
Hub height	90 m
Tower (Deep water)	90 m fixed at bottom
Tower (Shallow water)	80 m tower + 30 m monopile
Power control	Variable speed Collective Pitch
Rated rotor speed	12.1 rpm.
Gear ratio	97:1
Overhang / Shaft Tilt / Precone	5m / 5° / -2.5°
Blade mass	17.7 t
Rotor mass	110 t
Nacelle mass	240 t
Tower mass	348 t / 523 t



# Example Results

## Phase 1.1: Baseline Model

### dynamics Comparisons (8 codes)



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# Work done



- **Baseline models complete (rotor, aerodynamics, controls, tower, turbulence model, wave kinematics)**
  - **Baseline model has been adopted for two Up-Wind Work Packages.**
  - **OC3 work could form basis for Up-Wind WP 1A1 “Integrated Design and Standards”**
- **Basic turbine dynamics comparison complete.**
- **Monopile and tripod support structure models defined**
- **Geotechnical model defined**

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# Task 23 Summary



## Current Status:

- 4 research areas are planned with 3 making good progress starting the second year (4 year time line)
- Active collaborative technical working groups are formed with eight countries currently participating
- Offshore Ecological Issues and O&M within subtask 1 to be decided on