ENERGY

Calibration of a numerical model with experimental data and evaluation of a simplified aerodynamic model for the Pelastar TLP

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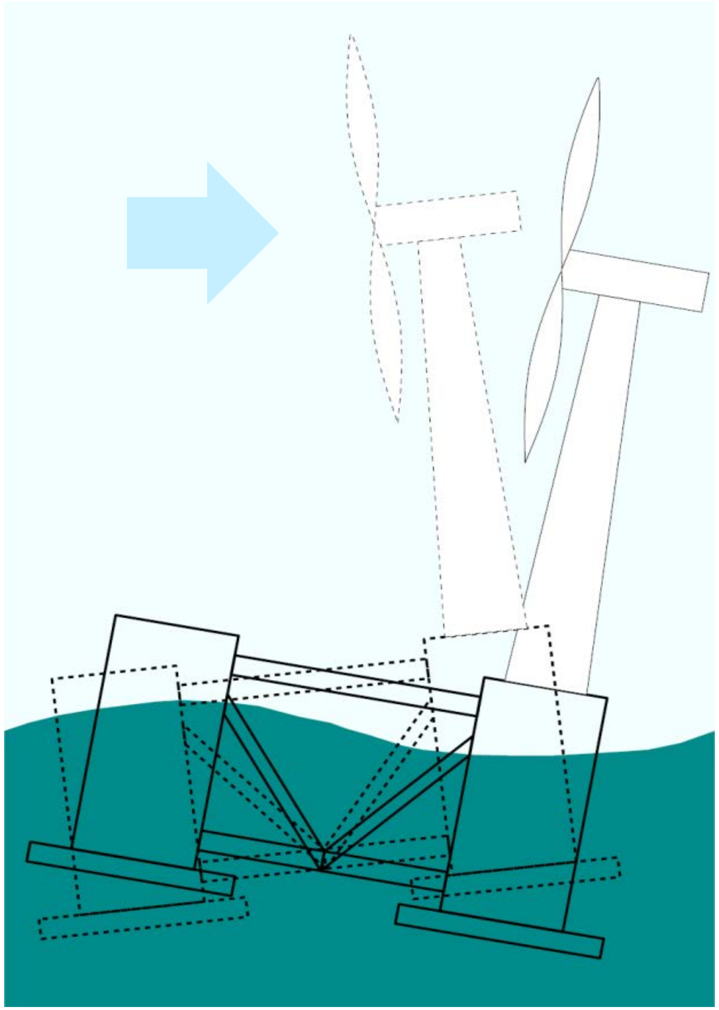
Outline

- Background
- DNV GL certification of floating wind turbines
- Numerical modelling of the Pelastar TLP model tests
- Simulation results
- Conclusions

Background

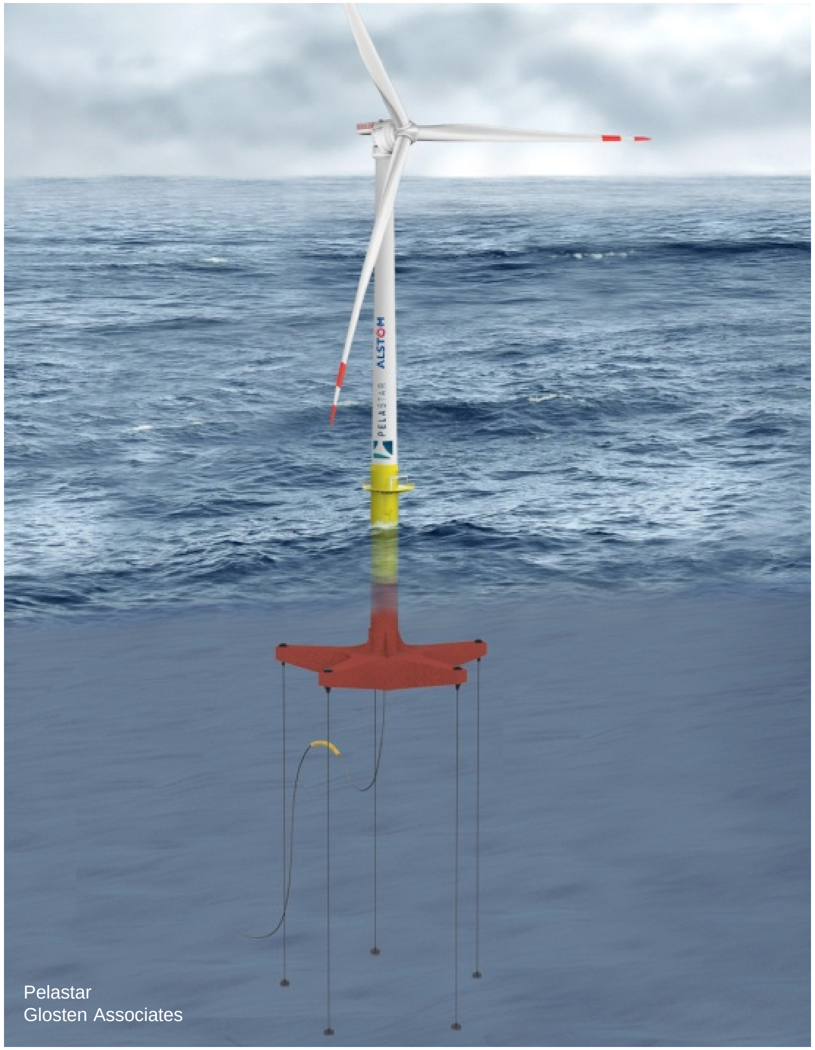
- DNV GL performs independent analysis as a part of the Project Certification process for offshore wind farms.
- Design of floating wind turbines require analysis of coupled response to wind and wave action.
- Two types of software is used in the industry/research:
  - Onshore WT software
  - Offshore O&G software
- Simplified modelling is sometimes necessary




Certification of the Pelastar demonstration project

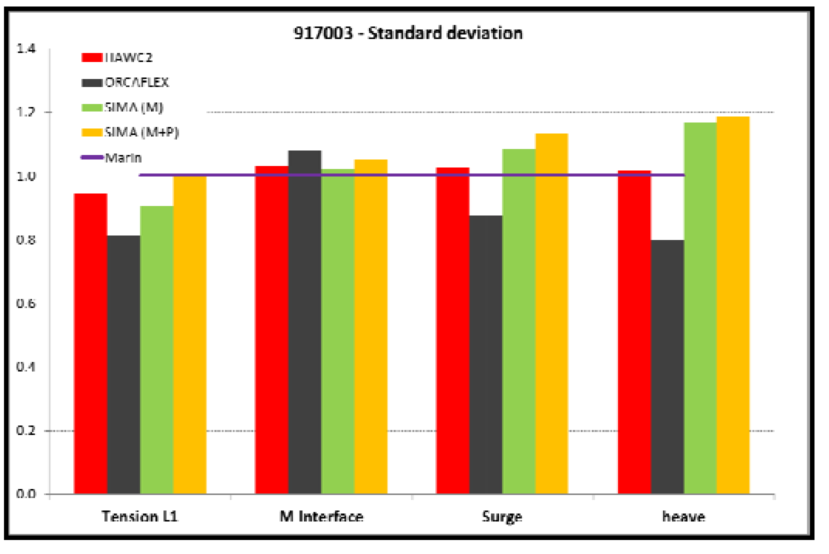
Application of DNV-OS-J103: Pelastar TLP demonstration project

- Floating wind turbine demonstration project in UK
- Funded by Energy Technology Institute (ETI)
- Glosten Associates’ Pelastar TLP design
- Supporting Alstom’s 6 MW Haliade turbine
- DNV GL performs certification of the design against DNV-OS-J103
- The project is currently in Front End Engineering Design (FEED) phase



DNV GL code comparison

- SIMA (SIMO/RIFLEX) – HAWC2 – BLADED - ORCAFLEX
- Collaboration:
  - DNV GL in Copenhagen – Hamburg – Høvik
  - Glosten Associates
- To be presented at OMAE 2015 in St. Johns, Canada

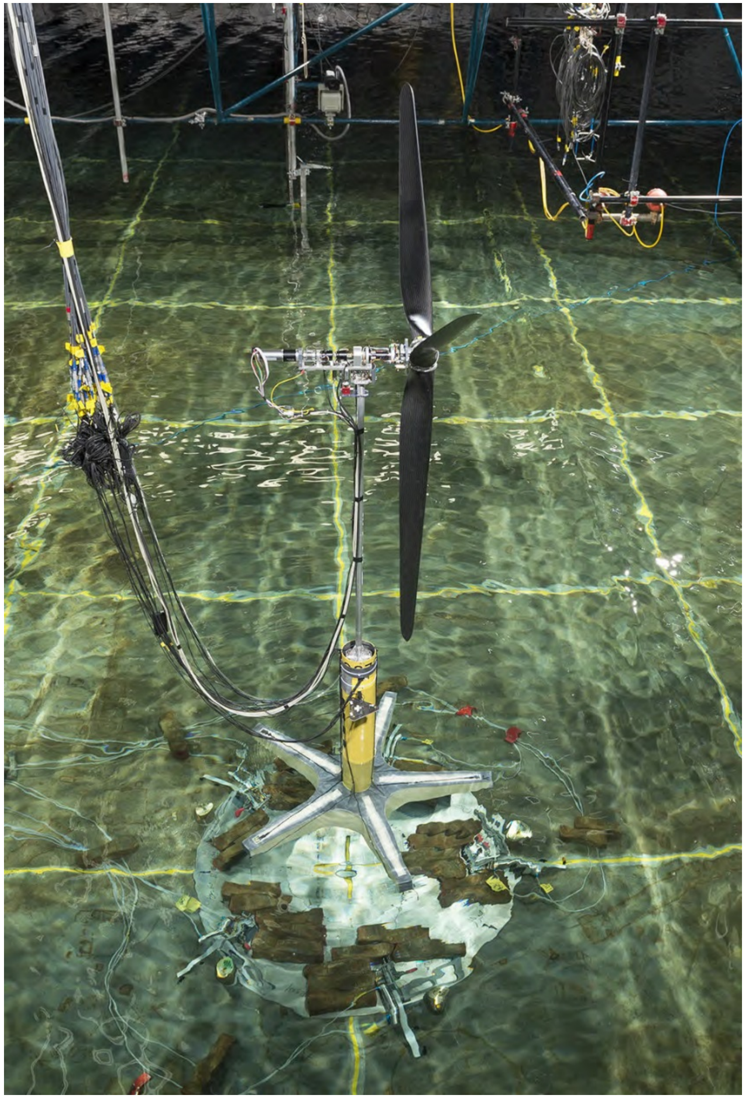



Numerical
modelling of
model test

Model tests: MARIN ocean basin

- 1:50 scale model tests

- MARIN stock wind-turbine:
  - Froude scaled wind to represent the mean thrust, RPM and TSR of the full scale NREL 5 MW turbine
  - Torque matched only in idling conditions
  - Fixed blade pitch to obtain correct thrust (not same as NREL controller)



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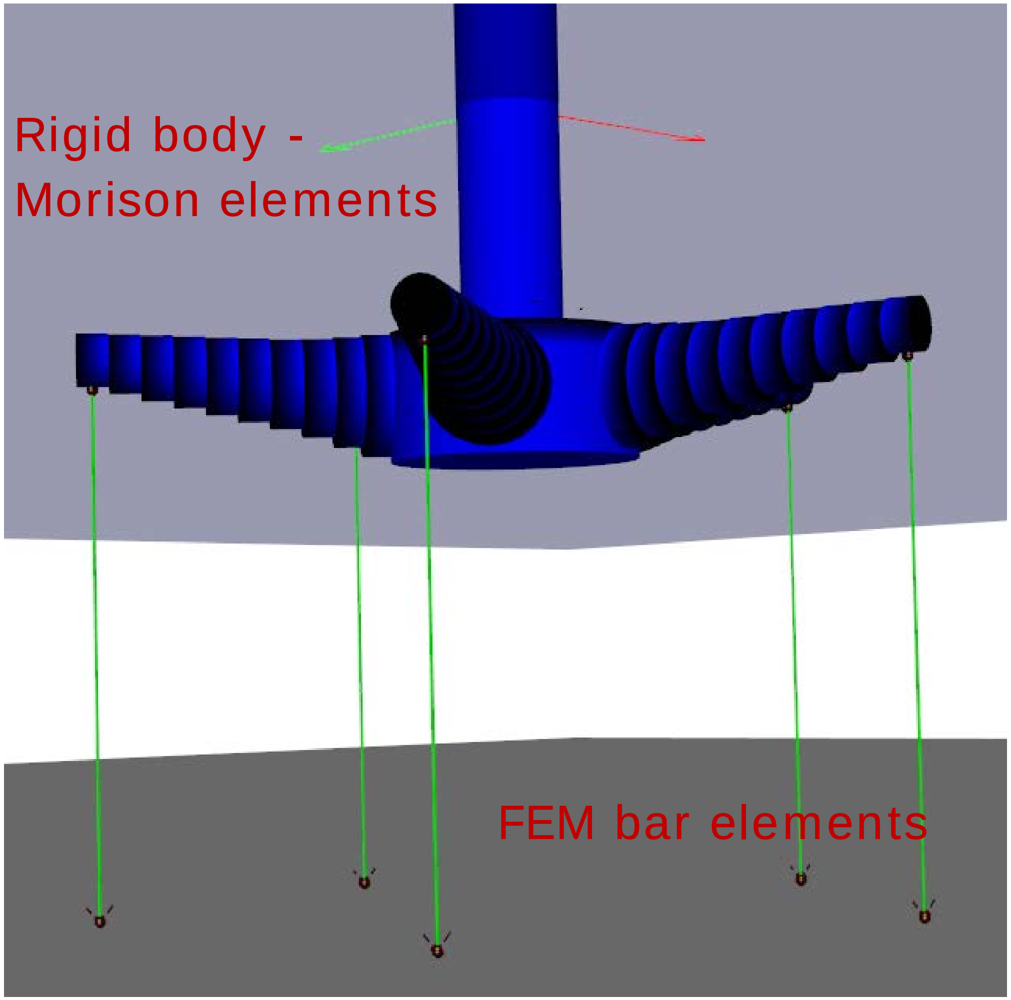
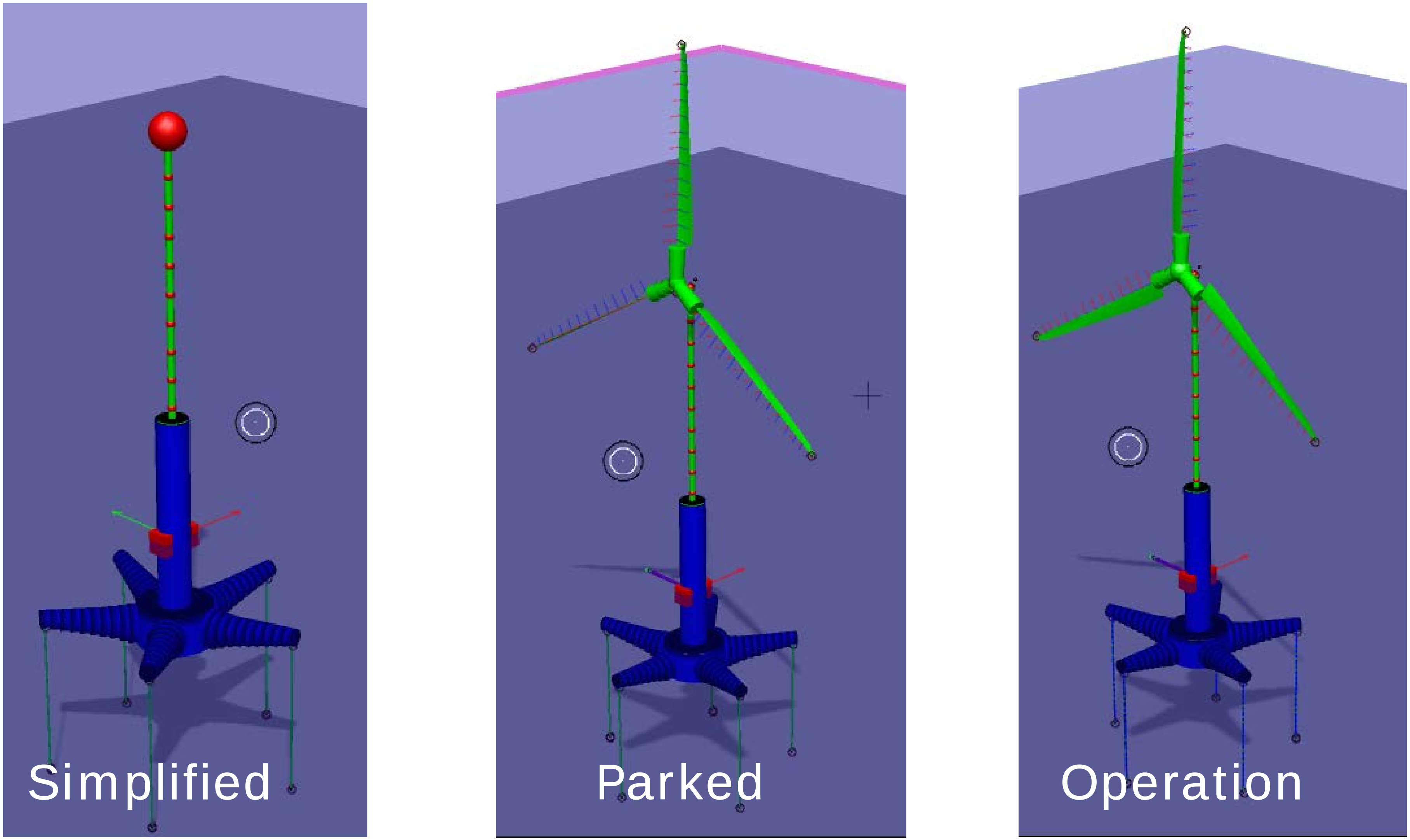
SIMO/RIFLEX: Substructure model



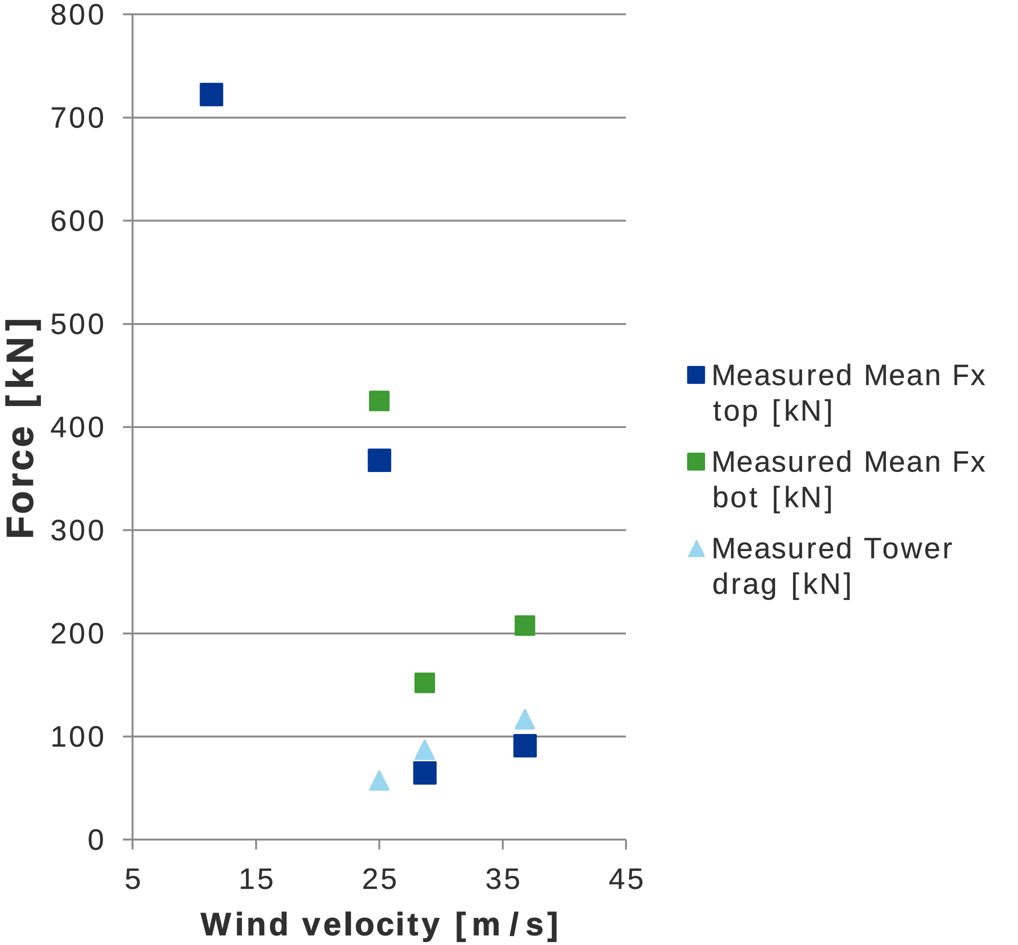
- Undisturbed wave kinematics
- Morison coefficients based on DNV-RP-C205
- Minor adjustments to match natural periods

SIMO/RIFLEX: Simplified vs. full rotor



Calibration of drag coefficient for simplified rotor

- Calibrated from measured tower top forces
- Includes tower drag
- Drag forces consider the relative velocity between wind and hub

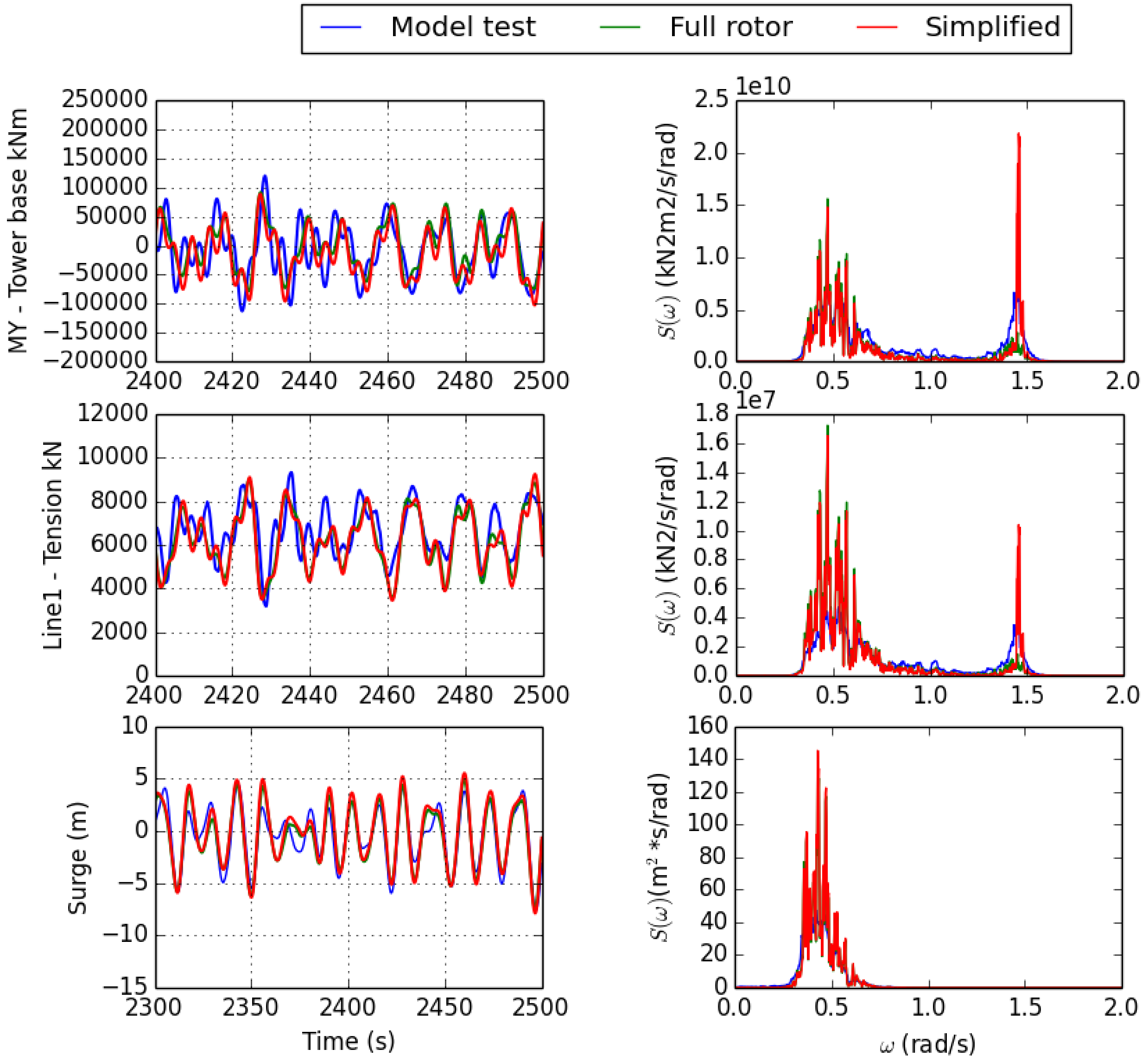


Results:

- Model tests
- Full rotor
- Simplified rotor

Simulation results: Parked turbine

- Wsp = 25.6 m/s
- Hs = 6.6 m
- Tp = 13.5 s

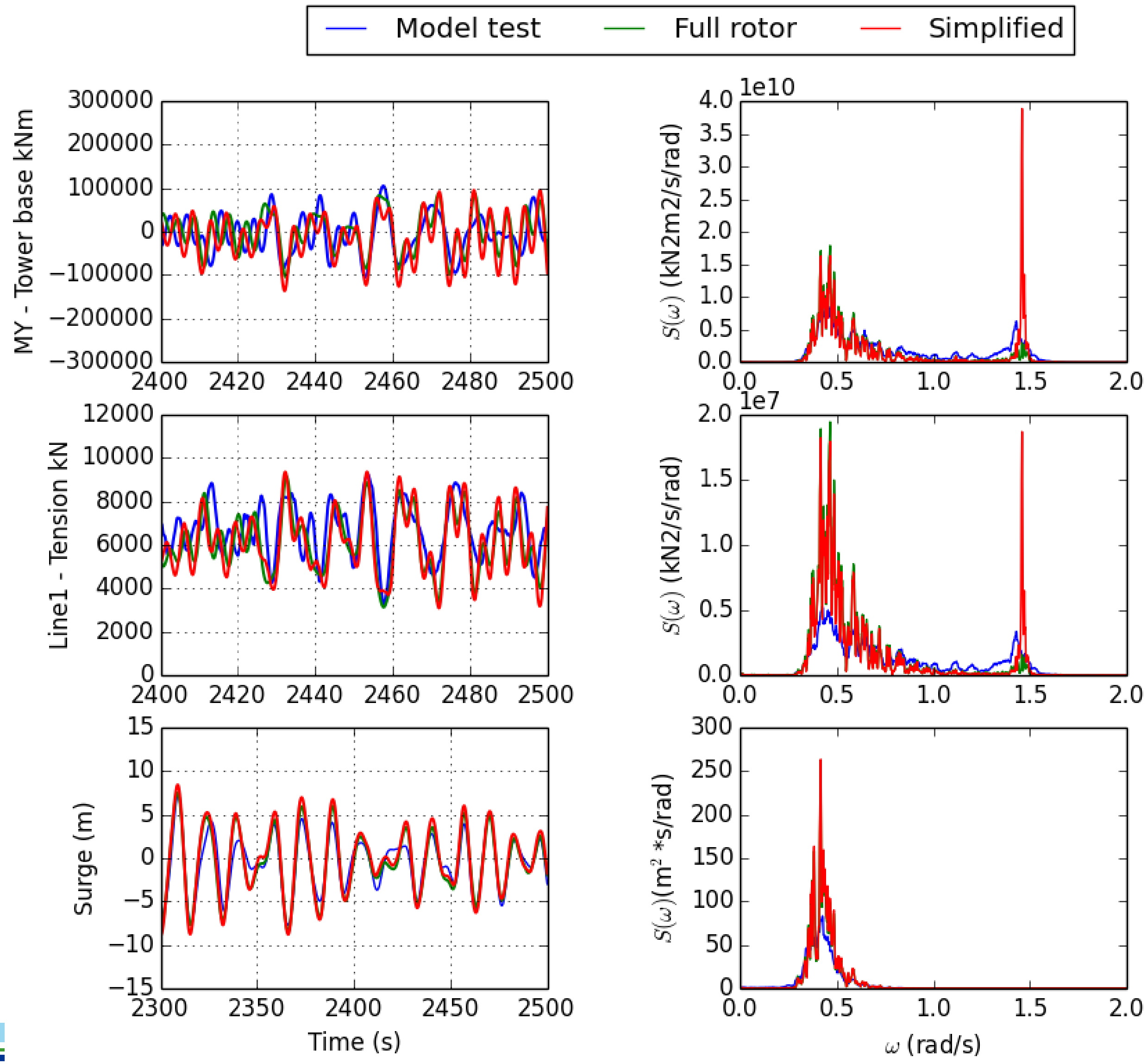


- Simplified and full rotor model give similar results
- Both models compare well to model tests
- Differences in excitation of pitch-bend frequency

Simulation results: Parked turbine

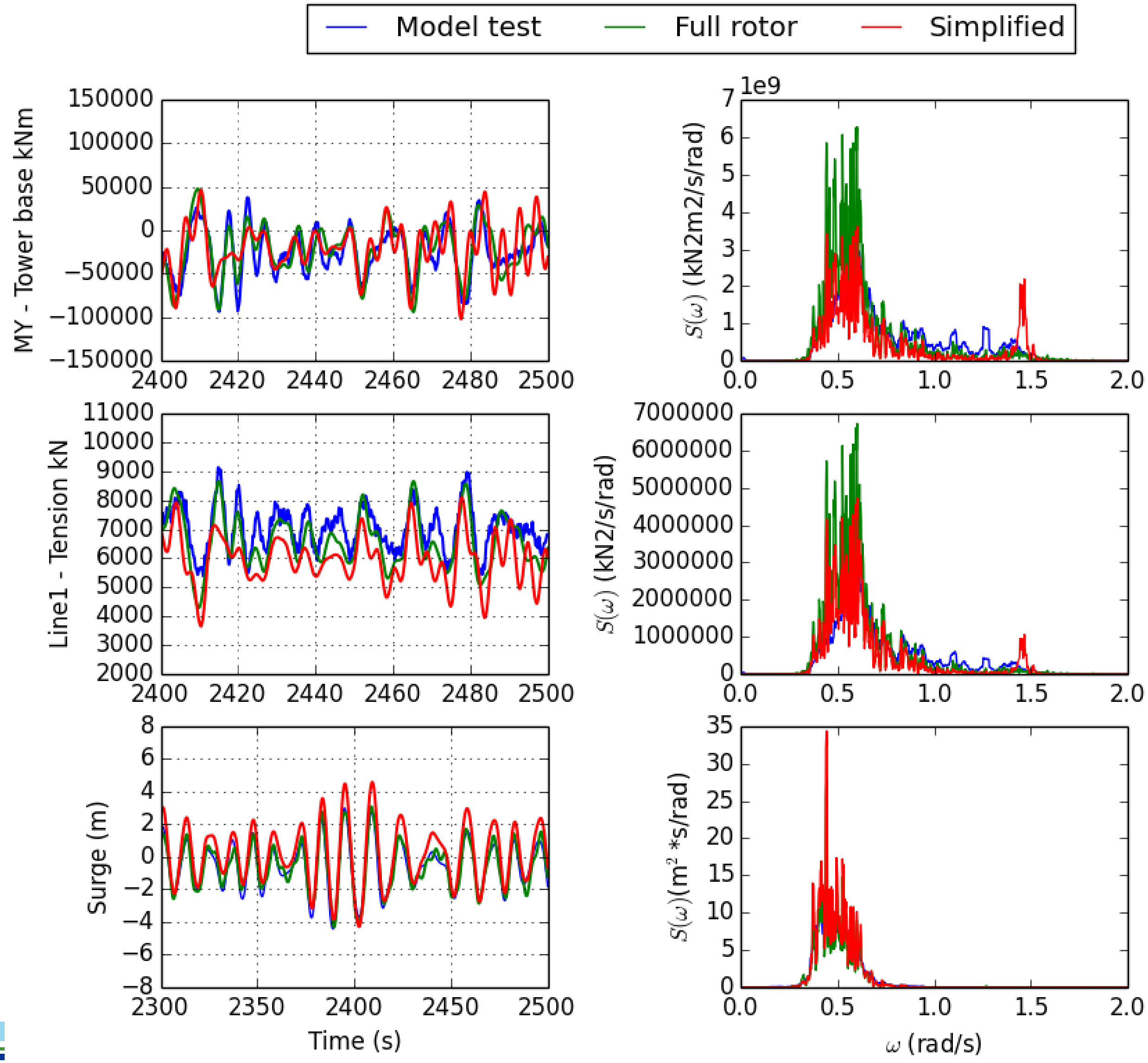
- Wsp = 29.7 m/s
- Hs = 8.2 m
- Tp = 14.4 s

- Simplified and full rotor model give similar results
- Both models compare well to model tests
- Differences in excitation of pitch-bend frequency



Simulation results: Turbine in operation

- Wsp = 22.3 m/s
- Hs = 4.5 m
- Tp = 11.8 s

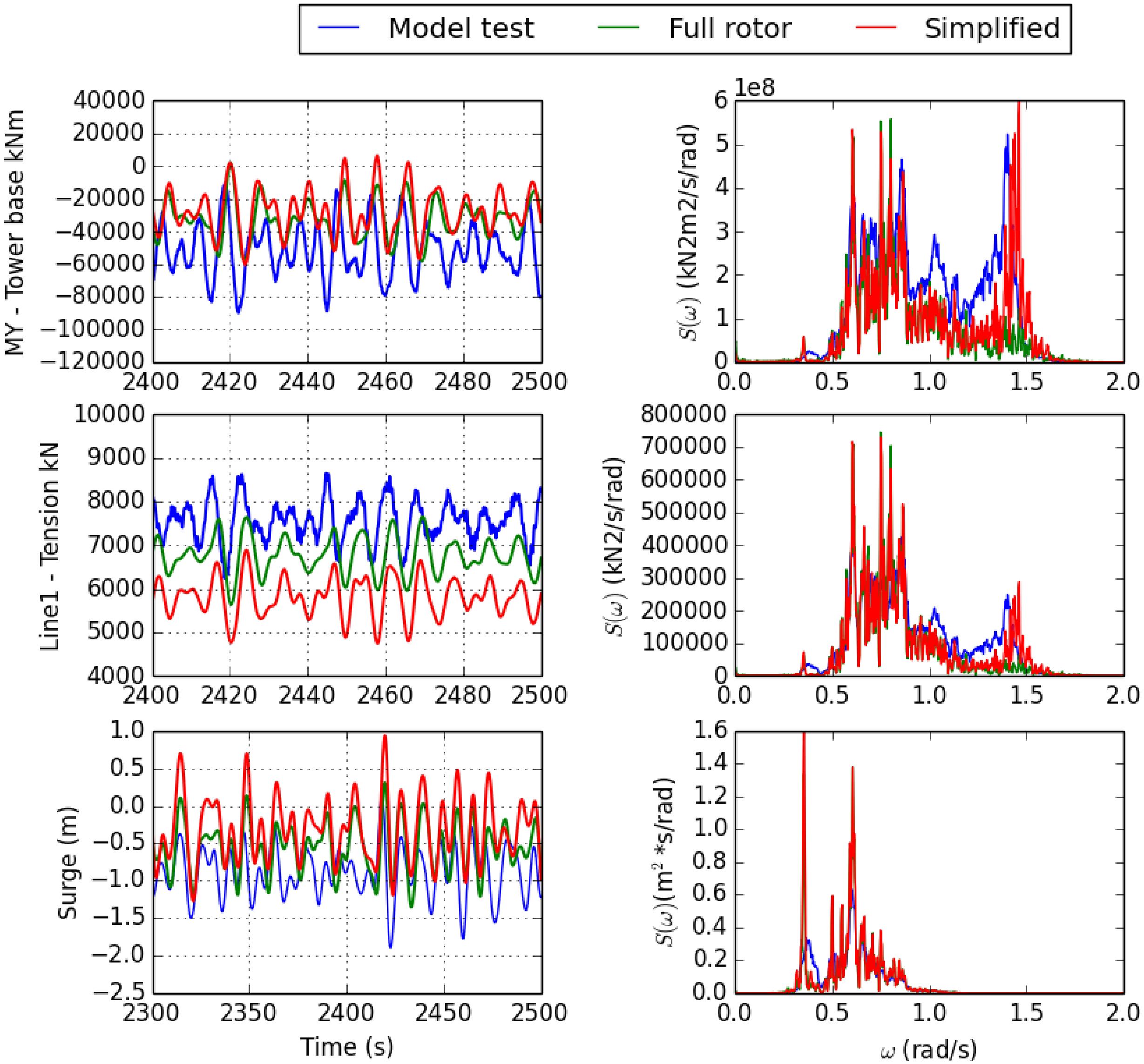


- Surge motion: Full rotor compares better to model tests
- Simplified model overestimates forward surge motion

Simulation results: Turbine in operation

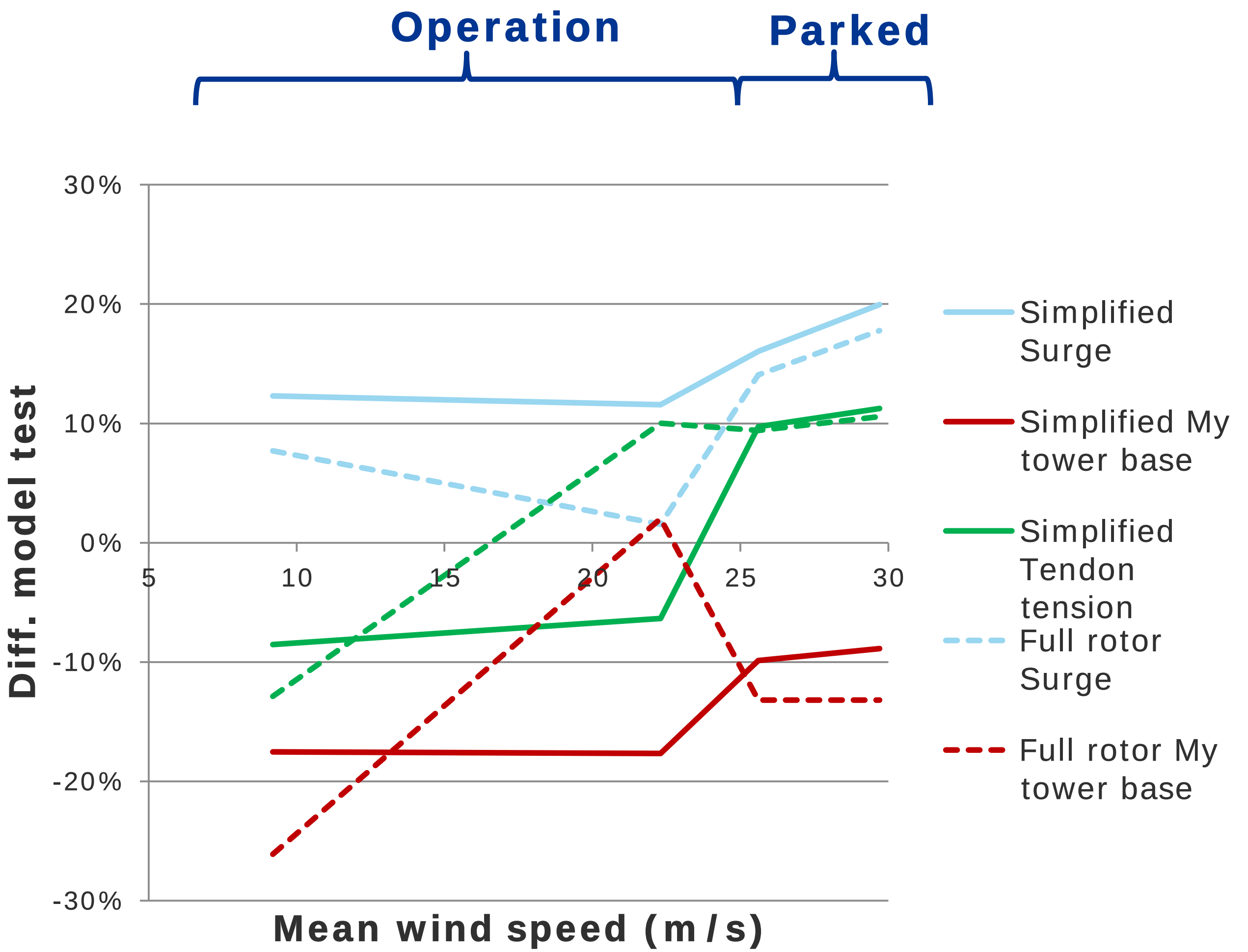
- Wsp = 9.2 m/s
- Hs = 1.7 m
- Tp = 8.7 s

- Uncertain wind input
- Simplified model overestimates forward surge motion



Simulation results: Standard deviations

- SURGE: Full rotor model closer to model tests in all cases
- Small differences between simplified model and full rotor in parked cases



Conclusions

- The analysis models captured significant responses seen in model tests
- Wave response captured with minor adjustments to analytical Morison coefficients
- Full rotor model gave the best reproduction of the surge motion in model tests
- Simplified modelling gave good representation for parked/survival cases
- Further testing with turbine in operation will give deeper insight

Thank you!

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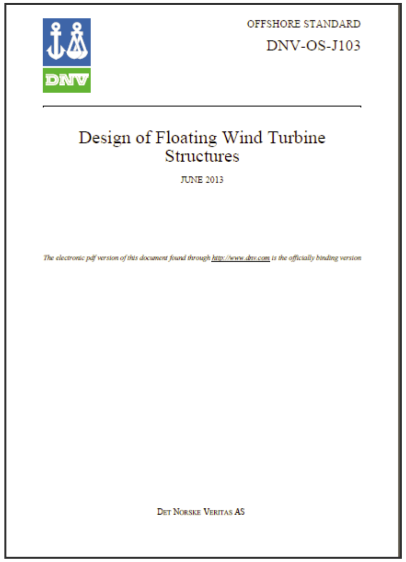
DNV GL Standards for floating wind turbines


OFFSHORE STANDARD
DNV-OS-J103

Design of Floating Wind Turbine Structures

JUNE 2013

The electronic pdf version of this document found through http://www.dnv.com is the officially binding version

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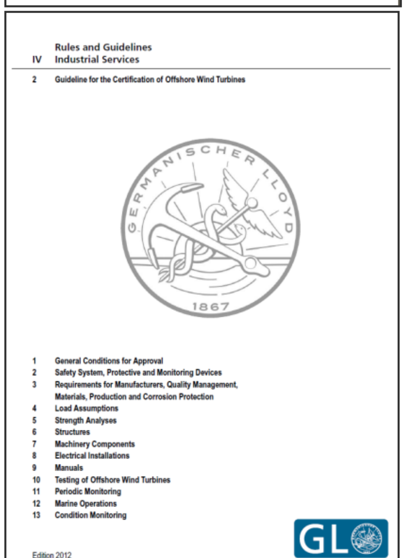
Rules and Guidelines
IV Industrial Services

2 Guideline for the Certification of Offshore Wind Turbines

Edition 2012

- DNV-OS-J103 *Design of Floating Wind Turbine* Structures was published in 2013
- Can be downloaded for free on **www.dnvgl.com**
- Developed through a Joint Industry Project (JIP) during 2011 – 2013
- GL-IV-2 *Guideline for the Certification of Offshore Wind Turbines* with extension for floating wind turbines published in 2012
- The two standards are to be merged in 2016