Reliability-Based Optimisation of Floating Wind Turbine Support Structures

1. Motivation

Floating offshore wind turbines can overcome the challenge of deploying promising sites for offshore wind energy located in deep water. However, coupled motions, complex system dynamics, wave and current loads, as well as additional components for example for station-keeping, place high demands on the structure and entire floating system. This is reinforced by the quite harsh offshore environment which only leaves certain limited weather windows for maintenance and repair work. Thus, any failure of the floating wind turbine system could cause long production downtimes and economic losses. For this reason, reliability-based design methods and optimisation processes can be of great benefit for floating wind turbine systems.

2. Methodology

1. Literature Review

Reliability Methods

- Reliability-based methods for risk analysis and their application in offshore and marine renewable energy industry
- Classification of reliability methods: qualitative, semi-quantitative, and quantitative approaches
- Discussion on challenges and existing trends

Floating Wind Turbine Systems

- Floating support structures for offshore wind turbines
- Classification and analysis of existing concepts with respect to their benefits and drawbacks
- Analysis of recent and innovative concepts, and elaboration of promising design solutions

2. Modelling of Floating Wind Turbines

Environment

- Modelling of environmental conditions: hydrodynamics and aerodynamics
- Focus on wave theories, currents, diffraction/radiation effects

Structure

- FEM modelling
- Structural analysis, load calculation and stress analysis
- Consideration of global and local effects

3. Reliability-Based Design Optimisation

Reliability Criteria

- Limit state functions and target safety levels
- Global and local criteria
- Sensitivity analysis on impact of constraints on overall design

Optimisation Process

- Definition of design parameters and boundary conditions
- Utilisation of different optimisation approaches (linear approximation, Particle Swarm theory, evolutionary algorithm)

4. Outlook and Related Topics

- Controlled Reliability
- Damping Systems for Floaters
- Floating Wind Farm Simulation and Analysis

3. Current Status and Conclusions

A review of reliability-based methods for risk analysis and their application in offshore and marine renewable energy industries is finished. As starting point for the optimisation procedure, a simple tool is under development, which aims to optimise a floating concept by utilising global limit states. This tool should serve as basis for determining what is required to build a more detailed and advanced model for reliability-based design optimisation of floating wind turbine support structures, including local characteristics. A pending study on floater concepts is expected to help elaborating a design basis, as well as setting the design parameters and boundaries for the optimisation.

Mareike Leimeister (Mareike.Leimeister@cranfield.ac.uk;
mareike.leimeister@iwes.fraunhofer.de)

Academic Supervisor: Dr Athanasios Kolios

Industrial Supervisor: Philipp Thomas

www.cranfield.ac.uk

REMS RENEWABLE ENERGY MARINE STRUCTURES

EPSRC Engineering and Physical Sciences Research Council

Fraunhofer IWES