Welcome

WIND. ASSURING CONFIDENCE
THROUGH COMPETENCE

LVRT Testing on DyNaLab

Electrical certification of Windturbines on Test Benches?

Torben Jersch

1st International Workshop on Grid Simulator Testing of Wind Turbine Drivetrains

Fraunhofer IWES

Contents of Presentation

- Short Introduction
- General overview of DyNaLab test bench and objectives
- Electrical certification of wind turbines – LVRT Testing
- Derive of electrical requirements for DyNaLab test bench
- Derive of mechanical requirements for DyNaLab test bench
- Summary




Short profile Fraunhofer IWES Northwest

Direction:	Prof. Dr. Andreas Reuter
Research Spectrum:	Wind energy from material development to grid integration
Overall Budget 2012:	around 11 million €
Personell:	130 employees
Previous investments in the establishment of the institute:	50 million €

Research Alliance Wind Energy

Strategic Association with ForWind and German Aerospace Center (DLR)

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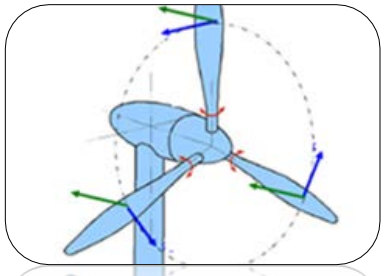
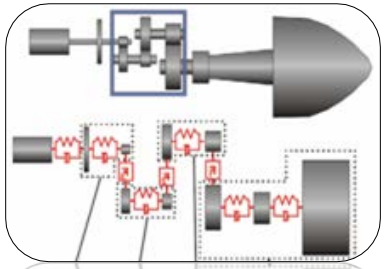
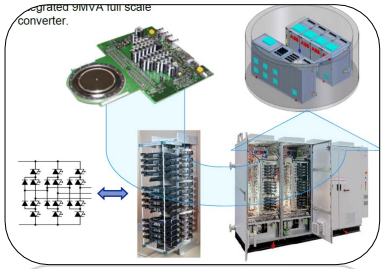
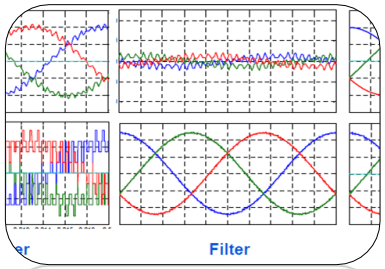
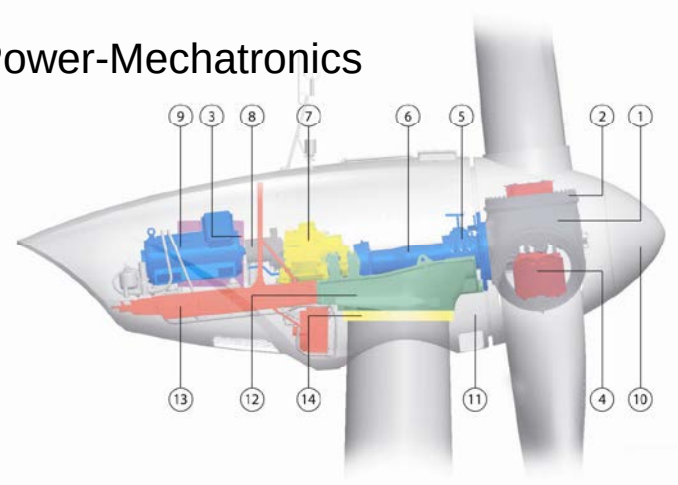






Short profile dept. Drive and System Technology

Head of Dept.:	Prof. Dr. Jan Wenske
Research Spectrum:	Key - Understanding of Power-Mechatronics Test Bench DyNaLab
Personell:	18 employees 9 mechanical engineers 5 electrical engineers 4 control engineers
Research Network:	Universities of Bochum, Freiberg, Saarbrücken, Bremen



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Personal Information

Name : Torben Jersch
Age: 32 years

Status: Married
1 Child

Degree of electrical Engineer 2007
Diploma Thesis: Design and control of a grid-forming inverter (100 kVA)

Working as power electrical engineer 3,5 years
Dimensioning of power electronics and control of inverters and drive trains

Since 2011 Fraunhofer IWES dept Drive and System Technology
Sensorless control of drive train, DyNaLab: Test bench control system

Since 2013 Group manager Systems and Control

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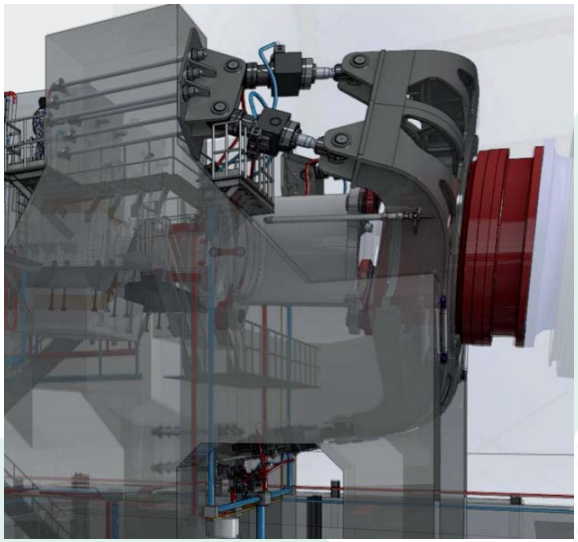
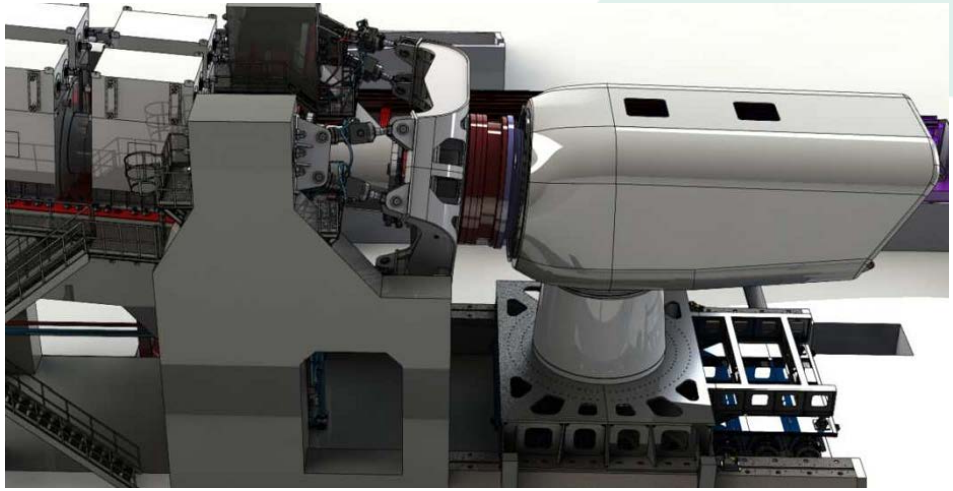
Overview of Fraunhofer IWES DyNaLab

Multifunctional

- 10MW / 8.6 MNm EESM Prime Move
- 44MVA-MV- Artificial Grid
- Hardware in the loop Test-Environment
- Optimized DUT rigging/handling solution
- Test range of specimen 2-7,5MW





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X – degrees of freedom

- Dyn. bending moments (20MNm)
- Dyn. thrust forces (2MN)
- Dyn. radial forces
- High dyn. torsional moments (16Hz)
- 100% 3-phase dyn. MV-Grid control
- RT aeroelastic Rotorsimulation

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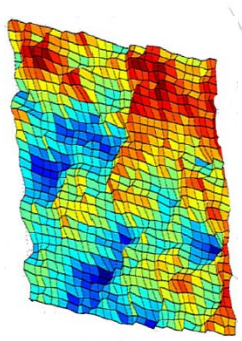
HIL Testing on DyNaLab



Online-Wind &
WEC Simulation

Load Model

- Wind (Aerodynamic)
- Swell
- Foundation & Ground Interactions

Development environment & Post processing

Real-time Hardware:
Data Acquisition
Test bench model
WEC-Model

WEA-HIL-Subsystem

Test bench & DUT & Grid

Rotor

WEA-Regelung

Tower

Fundation

WEC-Modell

DyNaLab
Test Bench Control

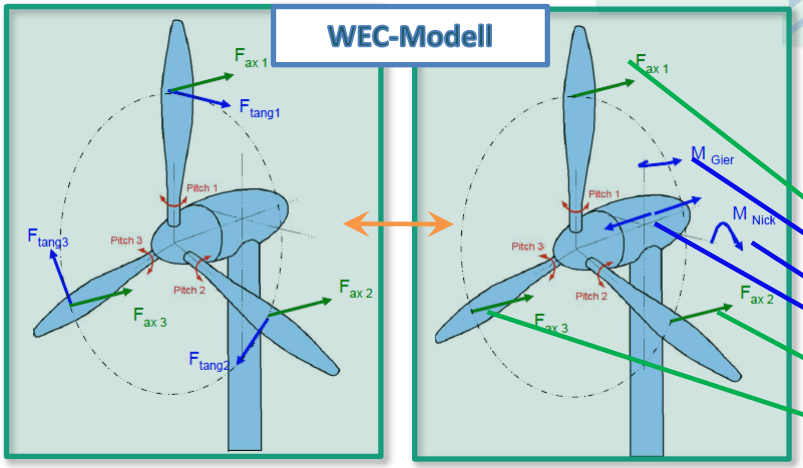
Profibus,
ProfiNet
EtherCat

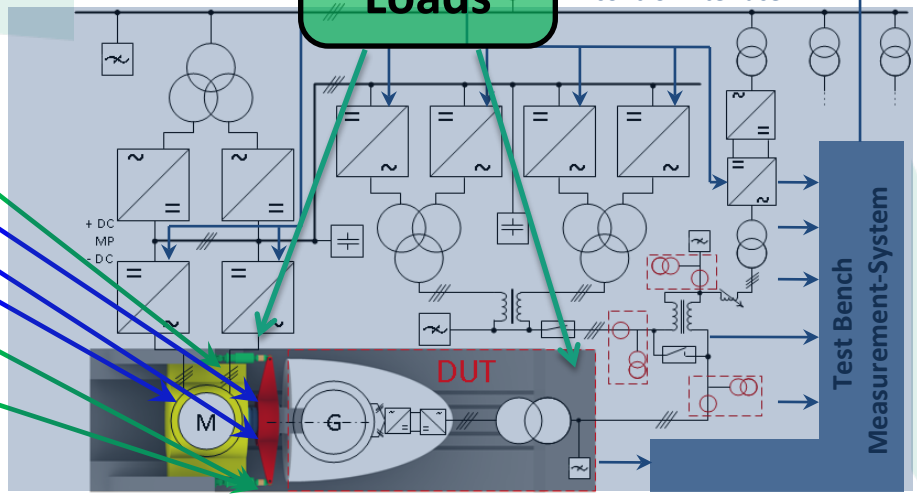
Real Time
control-Interface

Real Time
data -Interface

Applying Loads

WEC-Modell





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Scope of nacelle testing on test rigs

- ✓ Development testing / optimization
- ✓ Design verification / analysis / model validation
- ✓ „End of Line“ Tests / production conformity testing
- ? Accelerated lifetime tests / reliability testing
- ✗ Full lifetime and fatigue testing
- ? Partly wind turbine certification / support (savings at field tests)
  - ✓ Electrical certification of wind turbines — Big Benefit
- ✗ Complete Wind turbine certification testing

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Testing of LVRT of Wind turbines on Test benches

- For electrical certification fulfill

  IEC 61400-21

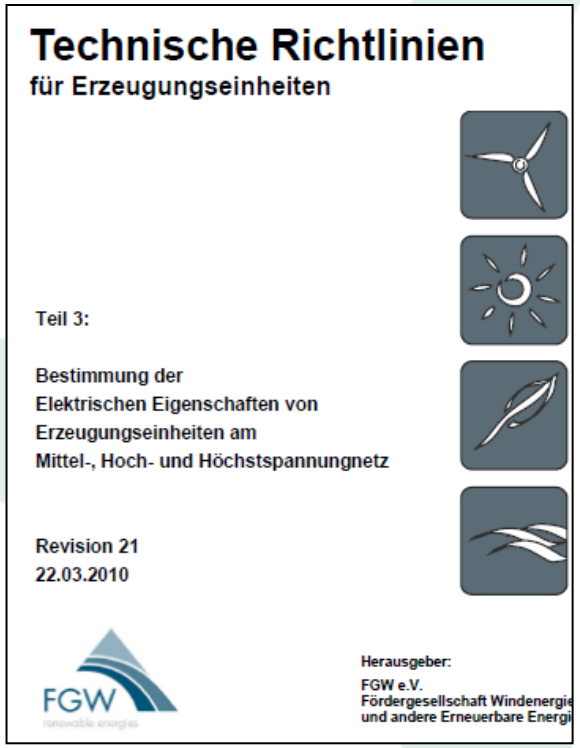
- Key features for LVRT testing
- Technical guideline for power supply units
- Requirements of test benches for testing LVRT

  Voltage, Current, Inertia

- Short circuit current of WEC connected to grid

  Inverter $I_K = 2.2 \times I_{RATED}$

  Synchronous & DFIG $I_K = 7 \times I_{RATED}$



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Testing of LVRT of Wind turbines on Test benches

- Inverter based grid simulation
- Voltage control down to 0V
- Dynamics of voltage change

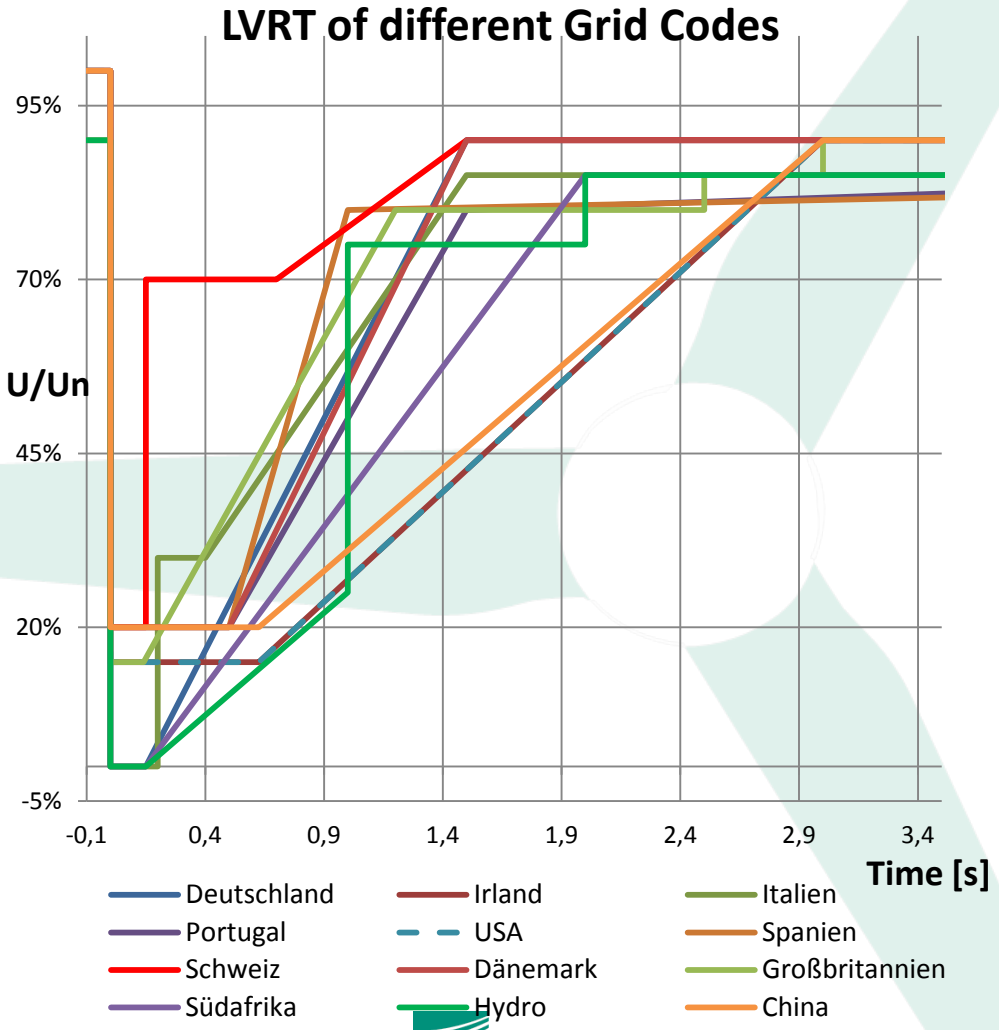
  Rise and Fall
- Low leakage impendence of

  Transformers
- Future of grid codes:

  Multi dips

  Unbalanced voltages

  Changing phase angle



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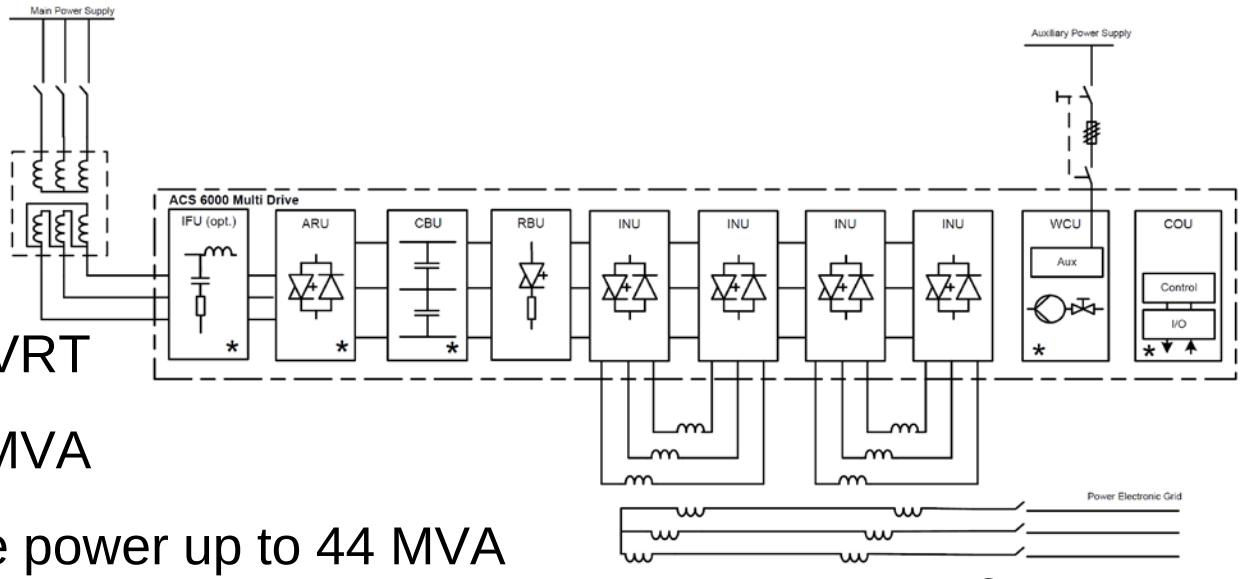
Specification and concept of Grid Simulation

- Rated voltage

  0-36 kV

  up to 47 kV for HVRT
- Rated power 15 MVA
- Transient reactive power up to 44 MVA
- High dynamic for voltage control
- Independent control of voltage and phase angel of each phase
- Voltage THD < 2% overall
- Controllable grid impedance
- Frequency 45 – 65 Hz



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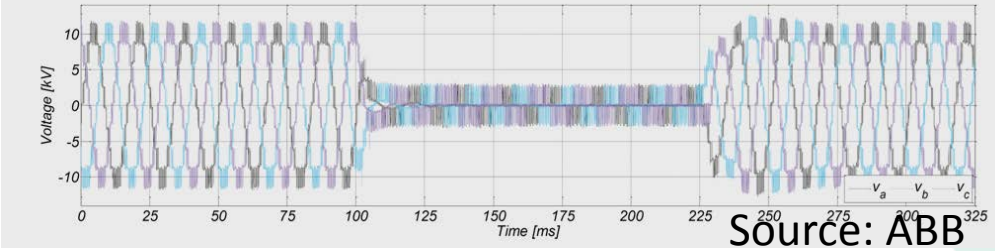

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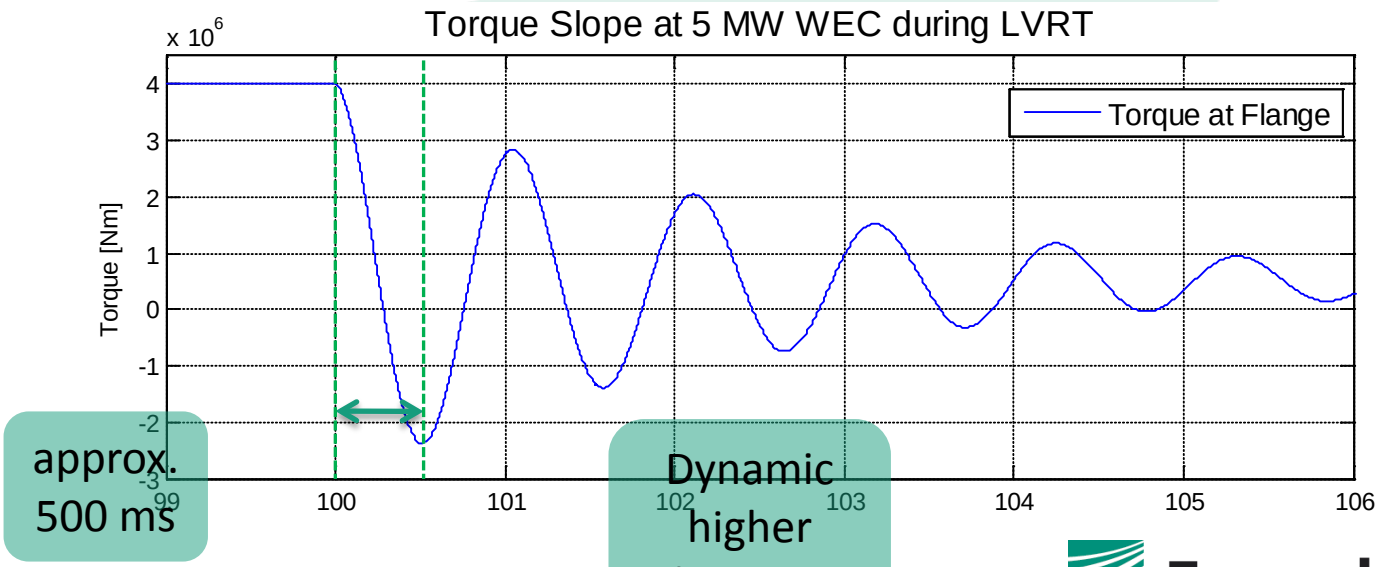
Artificial Simulation of Rotor Inertia

- Necessity of rotor inertia simulation
- Estimation of torque curve at flange between hub and shaft during LVRT event
- Simulating 5 MW WEC with gearbox



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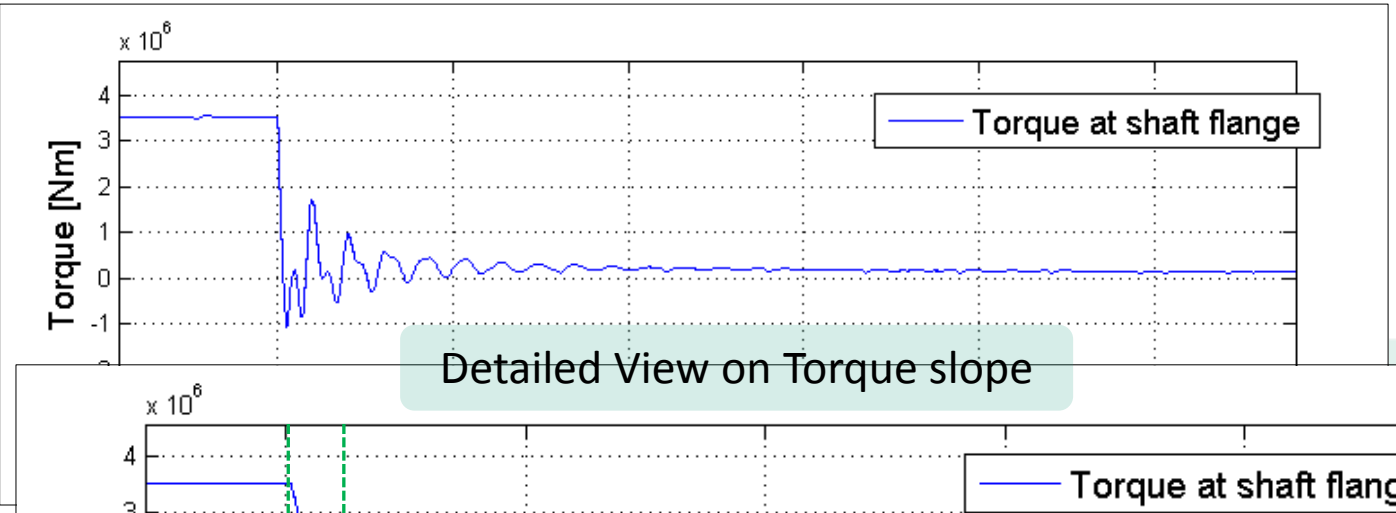
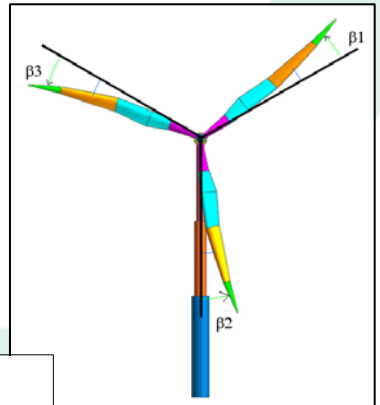
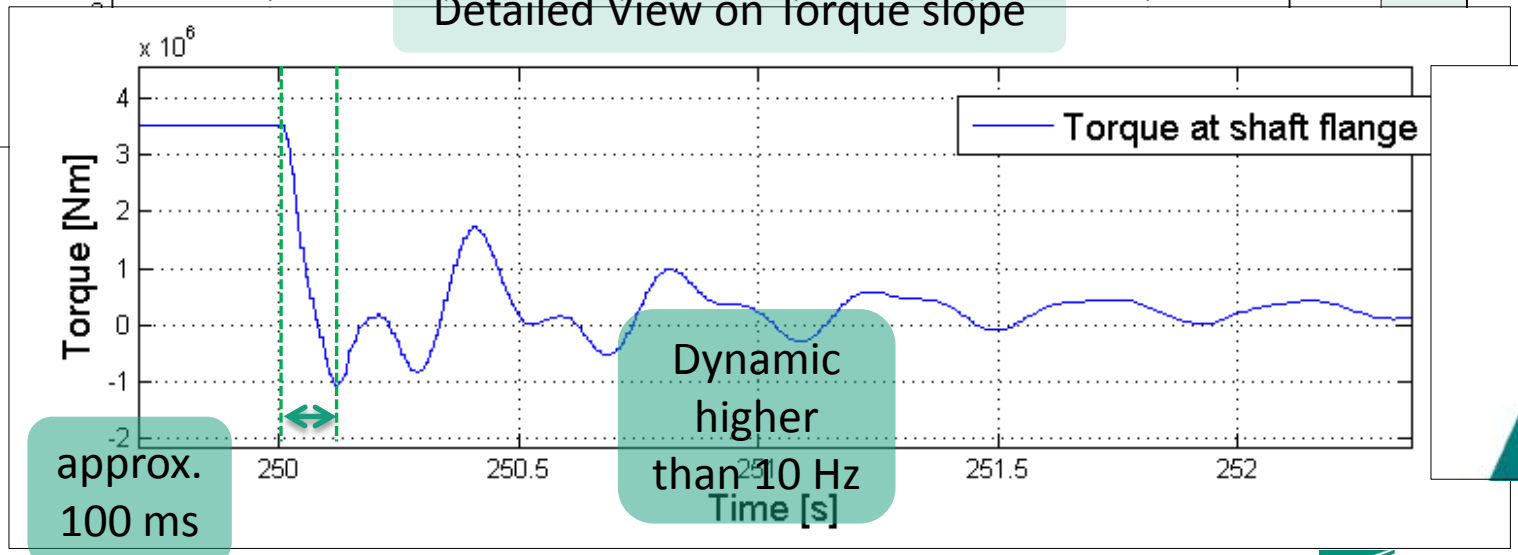
Artificial Simulation of Rotor Inertia

- Simulating 5 MW WEC with direct drive and flexible rotor



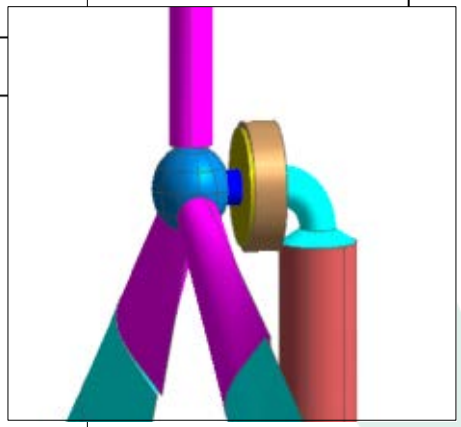


Detailed View on Torque slope



approx. 100 ms

Dynamic higher than 10 Hz



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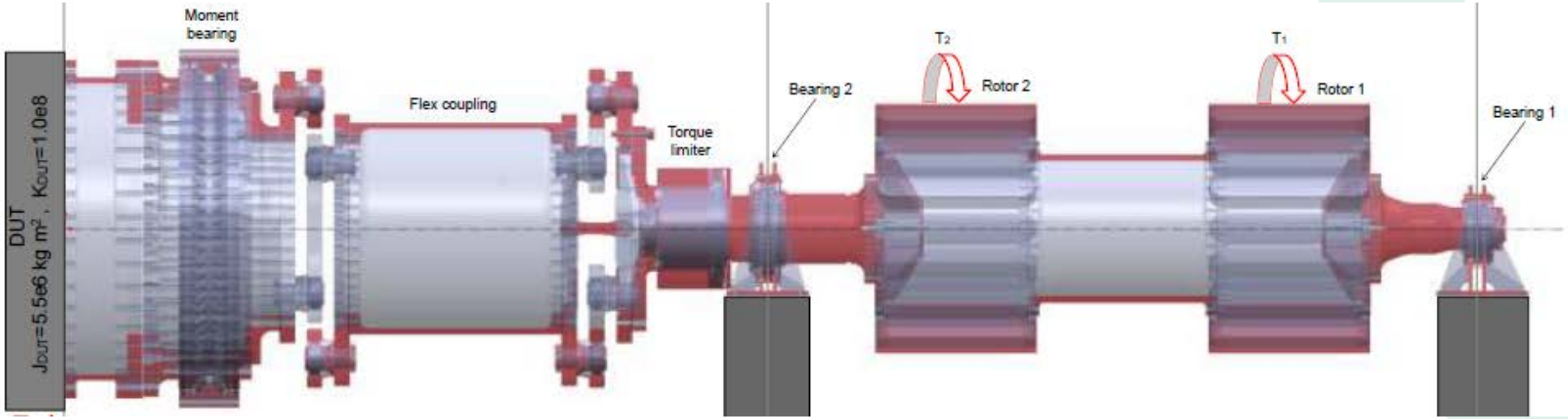
Derive of mechanical Requirements

- High dynamic at the flange between test bench and nacelle for simulation of rotor and hub inertia
- Reducing mass of the shaft and increase stiffness of the drive train



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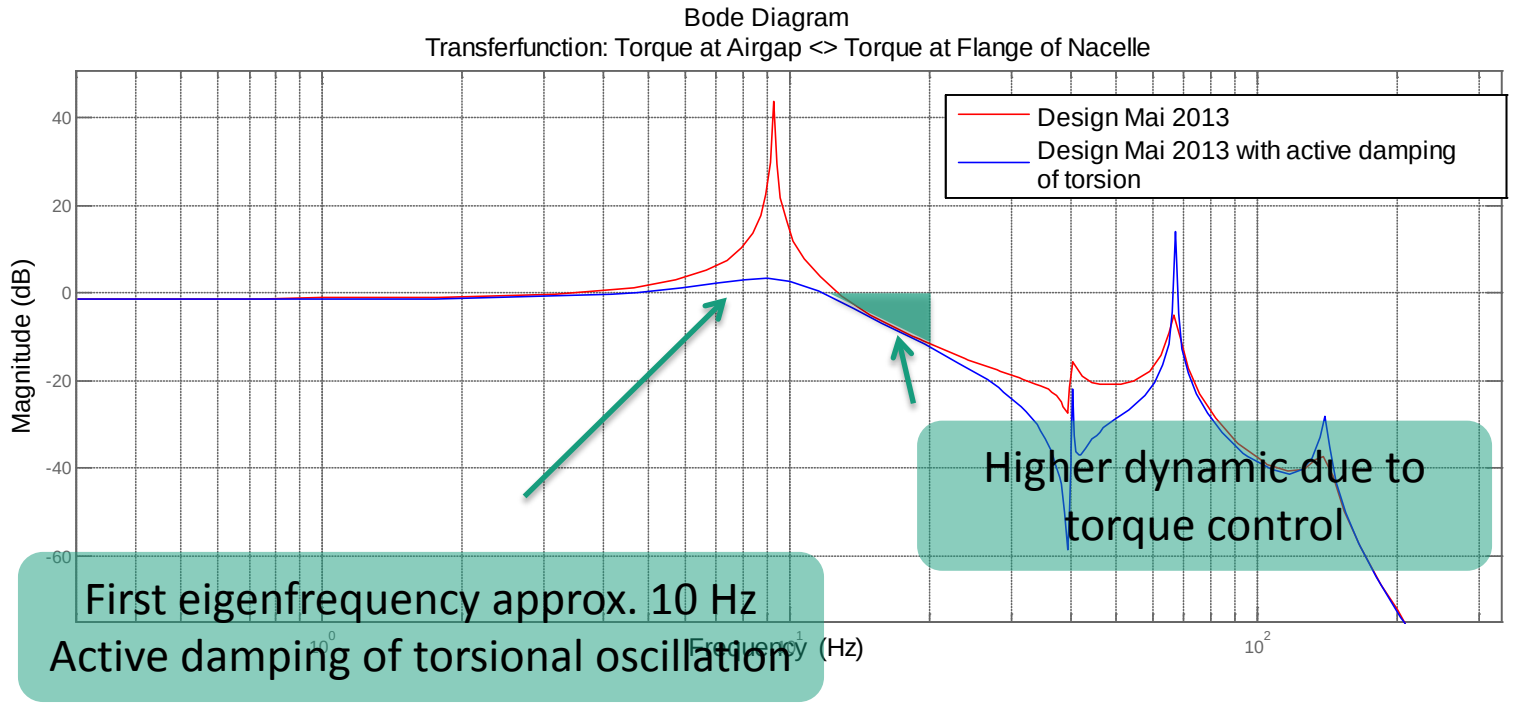

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IWES Nacelle Test rig - Summary

Being prepared for?	**LVRT Testing – Requirements for DyNaLab**		
✓	Voltage		
	0V up to 47 kV	High dynamic voltage control	Inverter controlled
✓	Current		
	7 x I_{RATED}	700 A_{rms} transient	Low impendence
✓	Inertia		
	Very stiff drive train	8.6 MNm rated 13 MNm < 360 s	Dynamic of torque control at flange > 16 Hz
	Prepared for HIL-Testing		
	Starting Construction of DyNaLab July 2013		

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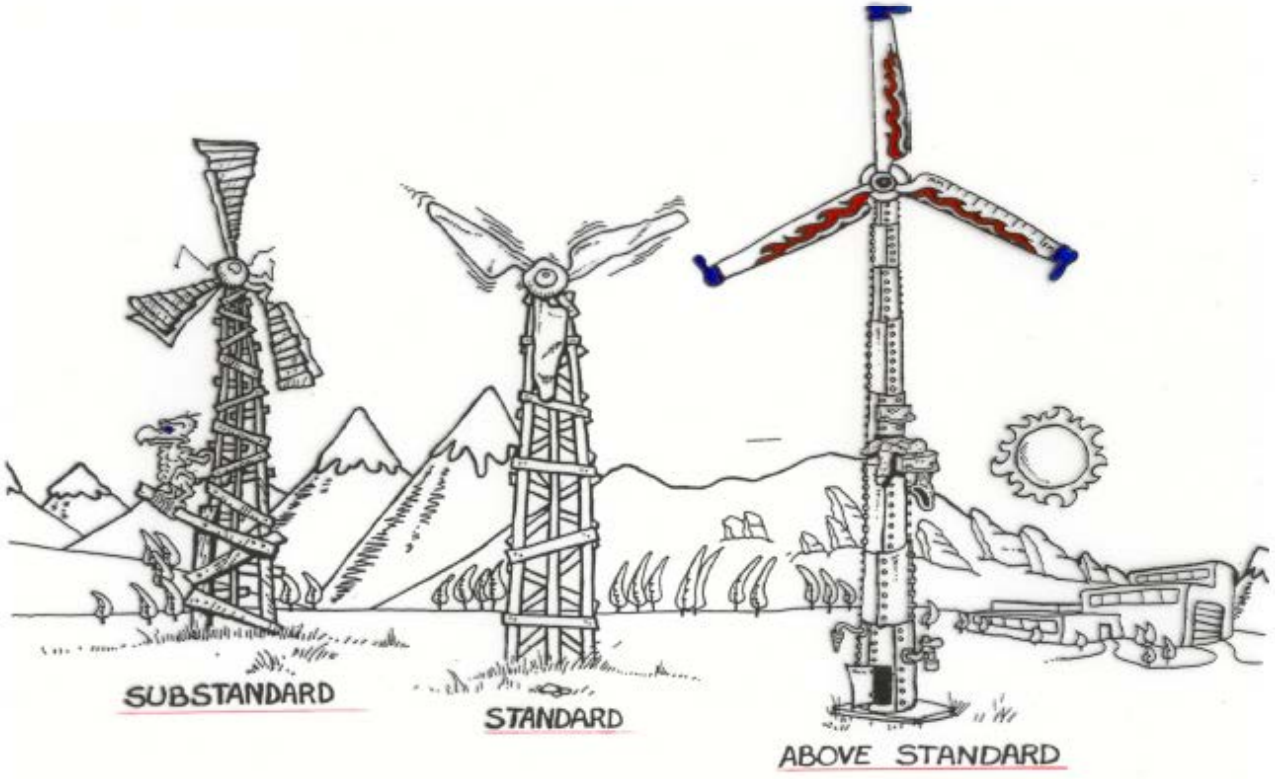
Questions ?

Thank you for your attention!



Wind turbines need intelligent solutions !

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