

Innovations in Offshore Wind through R&D

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NOWITECH in brief

- ▶ A joint pre-competitive research effort
- ▶ Focus on deep offshore wind technology (+30 m)
- ▶ Budget (2009-2017) EUR 40 millions
- ▶ Co-financed by the Research Council of Norway, industry and research partners
- ▶ 25 PhD/post doc grants
- ▶ **Key target: innovations reducing cost of energy from offshore wind**
- ▶ **Vision:**
 - large scale deployment
 - internationally leading

Research partners:

- ▶ SINTEF ER (host)
- ▶ IFE
- ▶ NTNU
- ▶ MARINTEK
- ▶ SINTEF ICT
- ▶ SINTEF MC

Industry partners:

- ▶ CD-adapco
- ▶ DNV GL
- ▶ DONG Energy
- ▶ EDF
- ▶ Fedem Technology
- ▶ Fugro OCEANOR (TBC)
- ▶ Kongsberg Maritime
- ▶ Rolls Royce SmartMotor
- ▶ Statkraft
- ▶ Statnett
- ▶ Statoil

Associated research partners:

- ▶ DTU Wind Energy
- ▶ Michigan Tech Uni.
- ▶ MIT
- ▶ NREL
- ▶ Fraunhofer IWES
- ▶ Uni. Strathclyde
- ▶ TU Delft
- ▶ Nanyang TU

Associated industry partners:

- ▶ Devold AMT AS
- ▶ Energy Norway
- ▶ Enova
- ▶ Innovation Norway
- ▶ NCEI
- ▶ NORWEA
- ▶ NVE
- ▶ Wind Cluster Mid-Norway

A large growing global market for offshore wind

- ▶ Battle climate change
- ▶ Security of supply
- ▶ Industry value creation

Stern Review (2006):
..strong, early action on climate change far outweigh the costs of not acting.

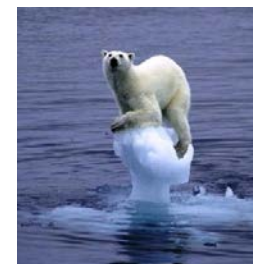
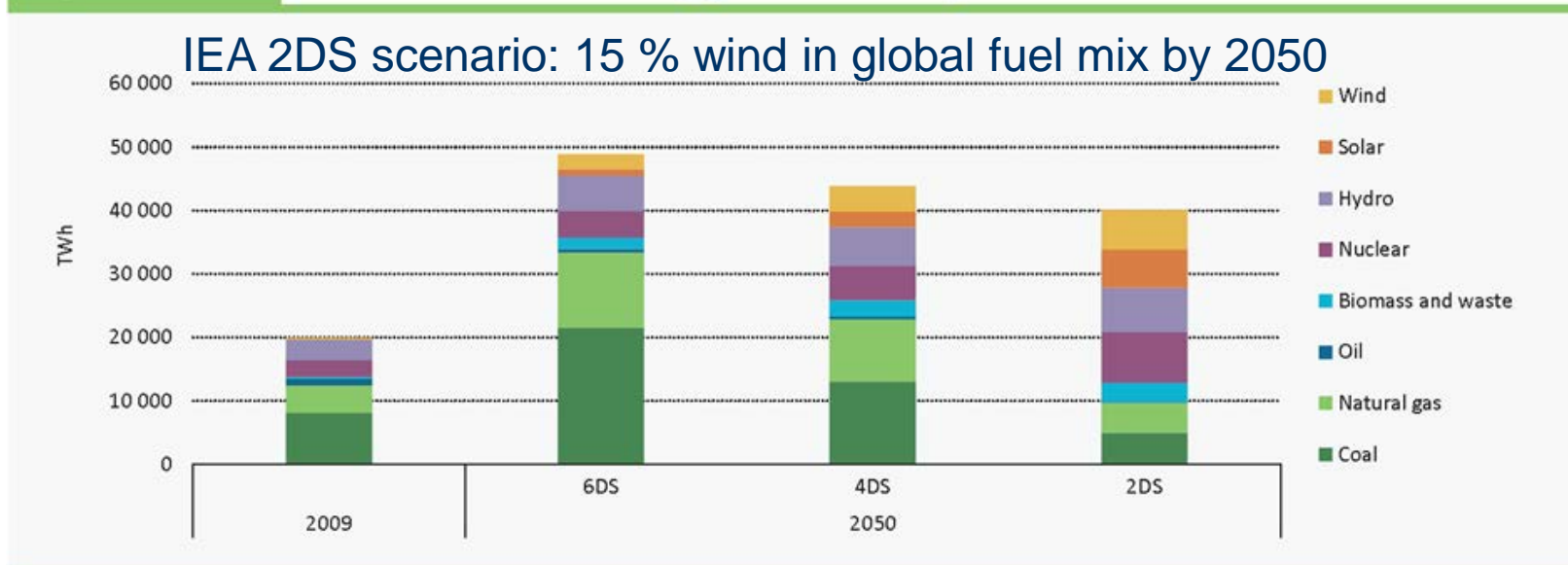


Figure 1.10 Fuel mix in electricity generation, by scenario



Key point *Diversification of fuels and increased use of low-carbon sources in the 2DS achieves a high degree of decarbonisation in electricity generation by 2050.*

Copy from IEA Energy Technology Perspectives 2012

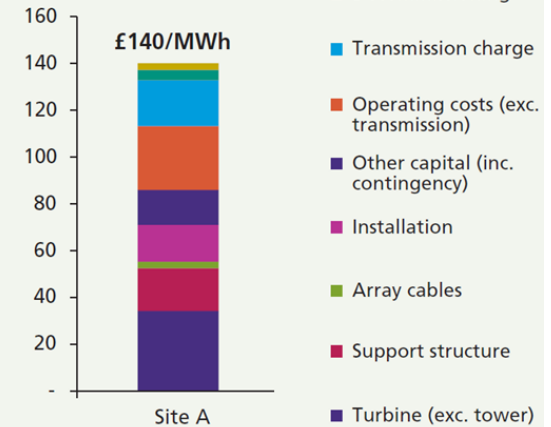
2012 installed wind:
 Total 282 GW incl 5 GW offshore
2050 2DS wind:
 6000 TWh/3000 h = 2000 GW
Required annual installations to reach 2DS goal for wind:
 2000 GW / 40 y = 50 GW/y
 + end of lifetime replacements

Main challenge: Reduce Cost of Energy

Offshore wind farm capital cost (2011£m/MW)

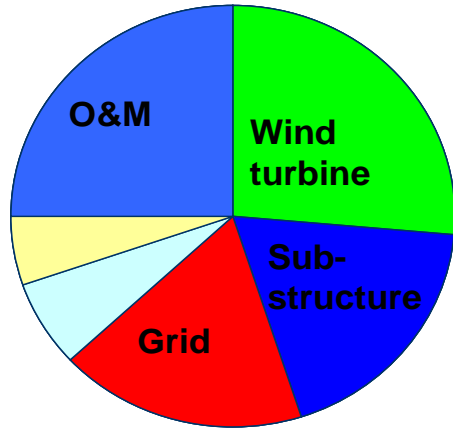


Levelised Cost of Energy (£/MWh)

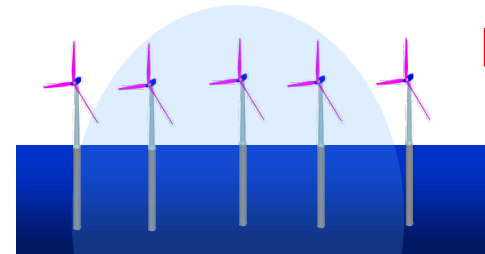


Graphics from: The Crown Estate (2012) Offshore wind cost reduction pathways study

From R&D to innovations to cost reductions



NOWITECH focus area



Market impact

Pilot implementation



Prototype



Lab testing



Knowledge



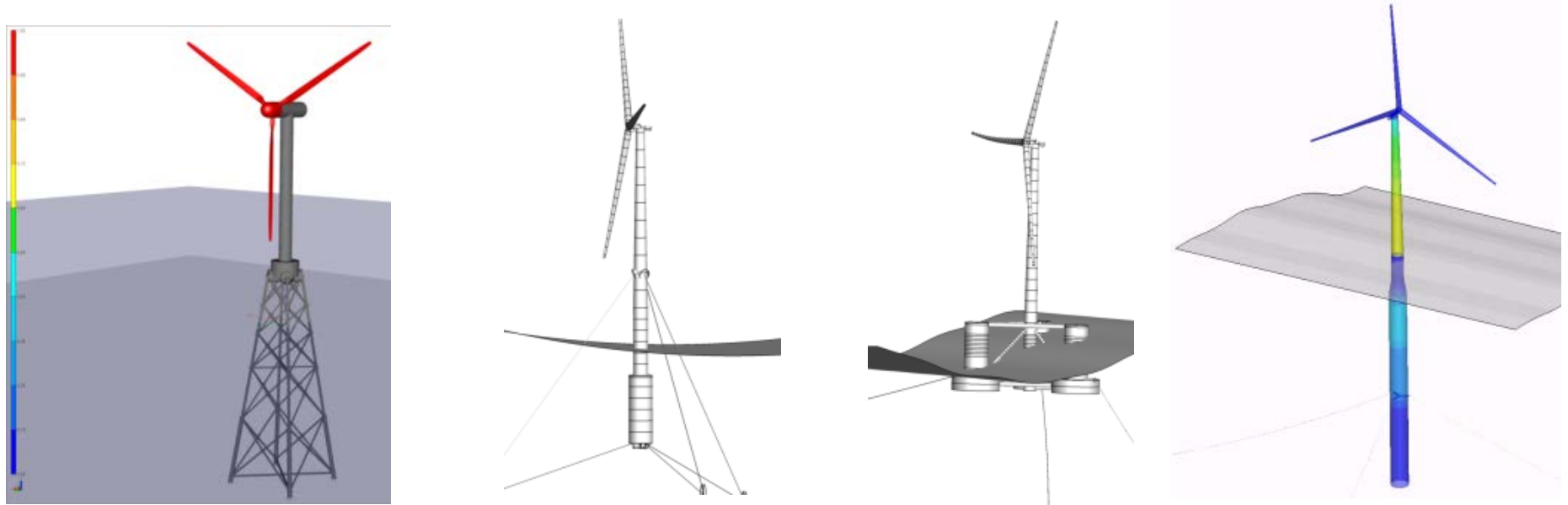
Idea

Industry driven development

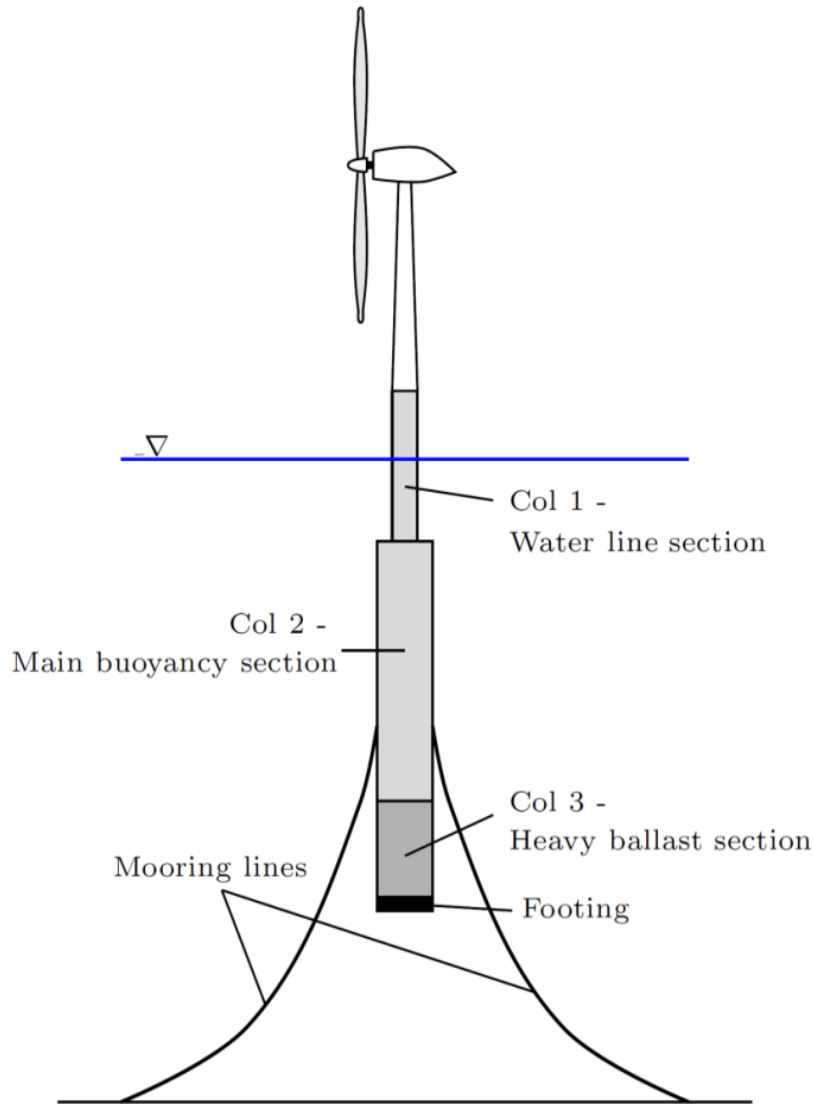
0 ————— 4 ————— 10 → TRL

Reducing uncertainties by better models

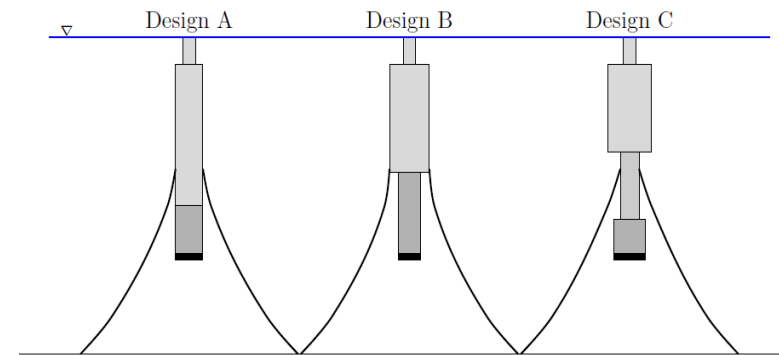
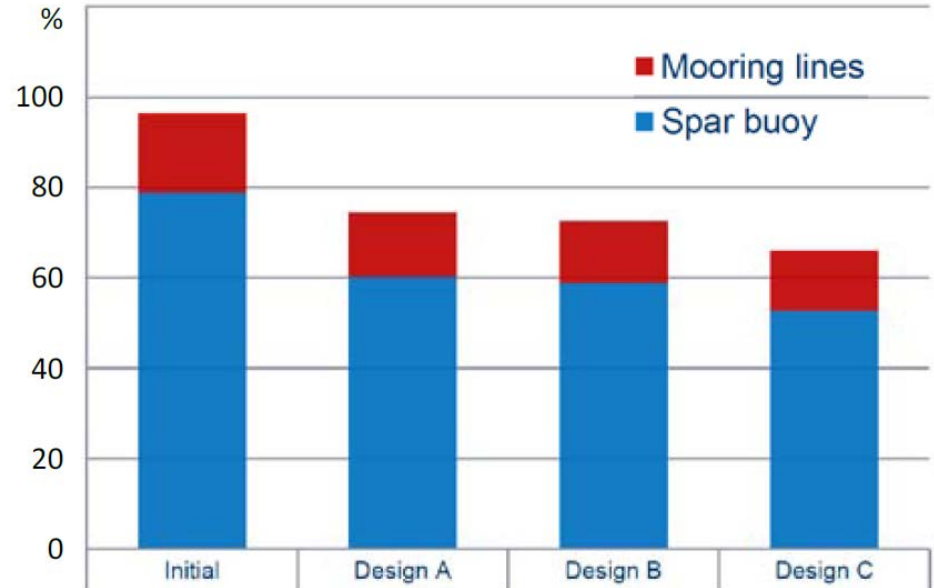
- Integrated models simulate the behavior of the complete turbine with substructure in the marine environment: SIMO-RIFLEX (MARINTEK) and 3DFloat (IFE)
- Model capability includes bottom fixed and floating concepts
- Code to code comparison in IEA Wind OC3 and OC4
- Model to measurements comparison in progress



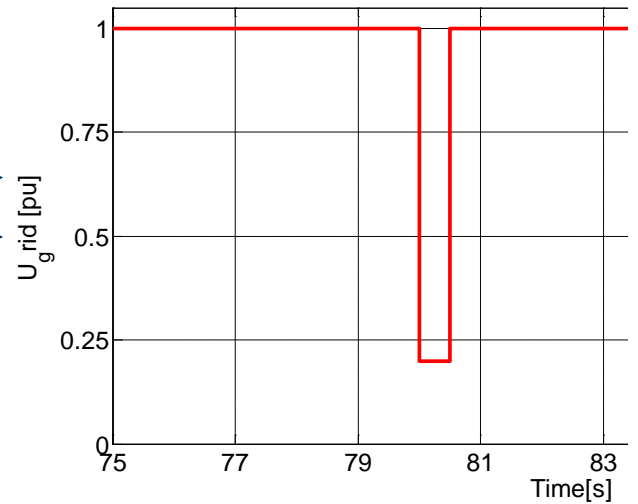
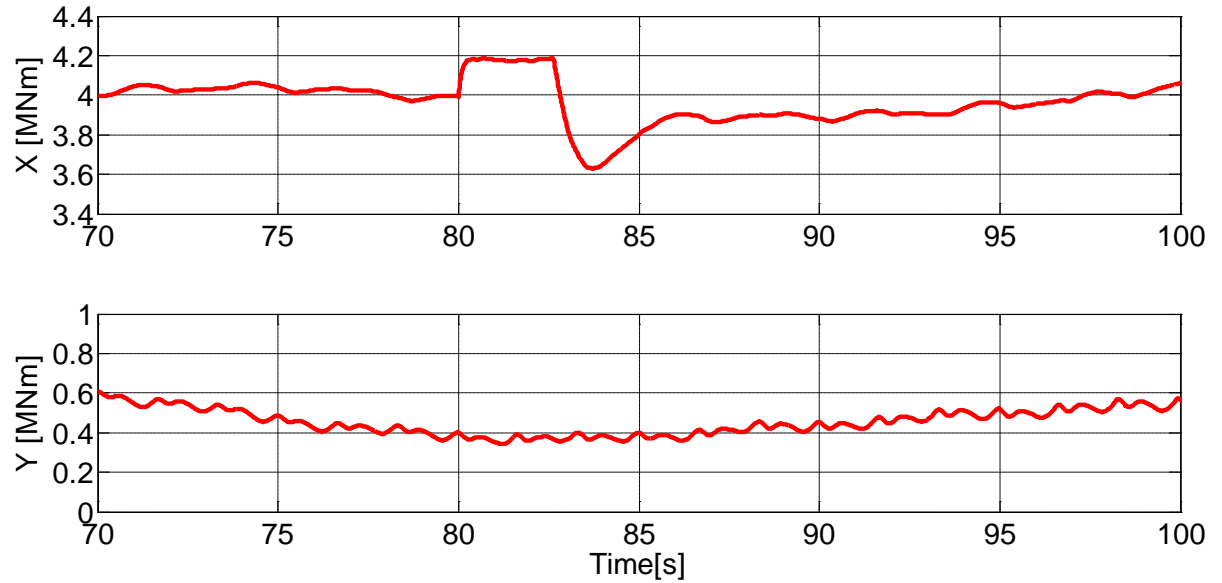
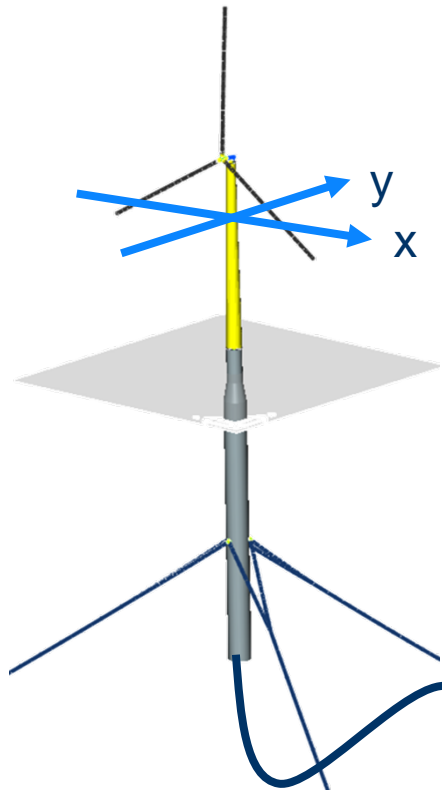
Cost savings by optimising spar buoy design



Relative cost of spar and mooring



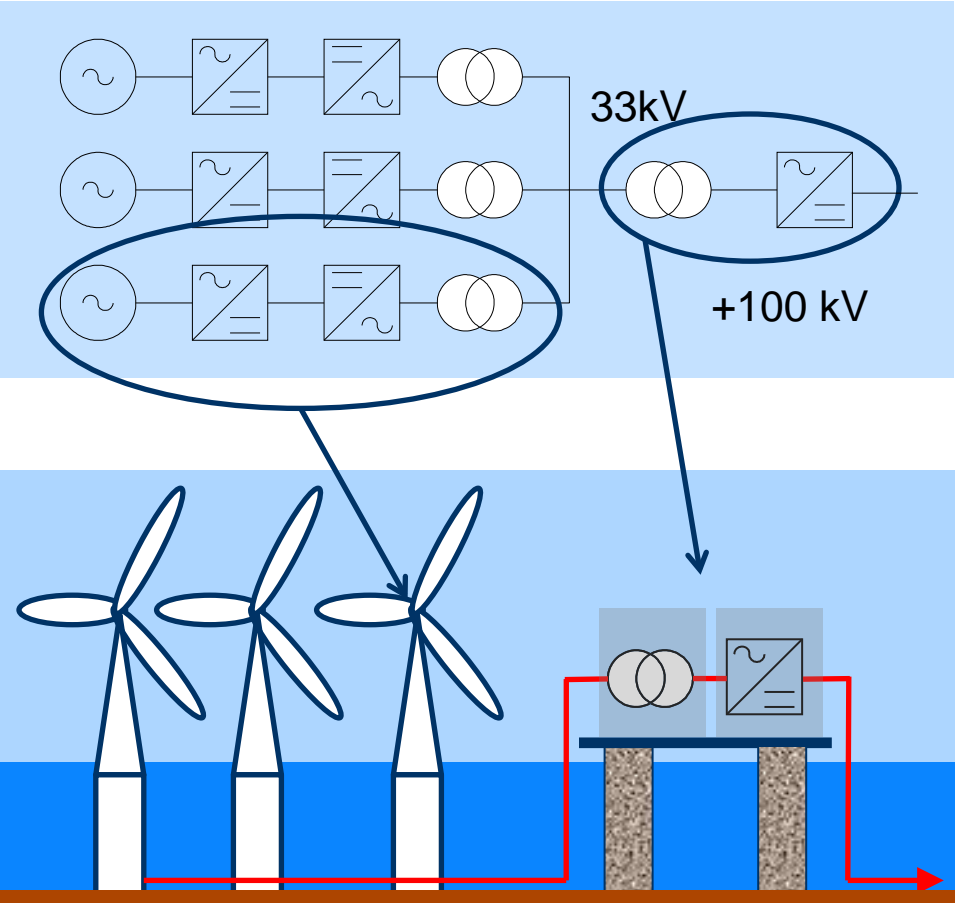
Integrating structural dynamics, control and electric model



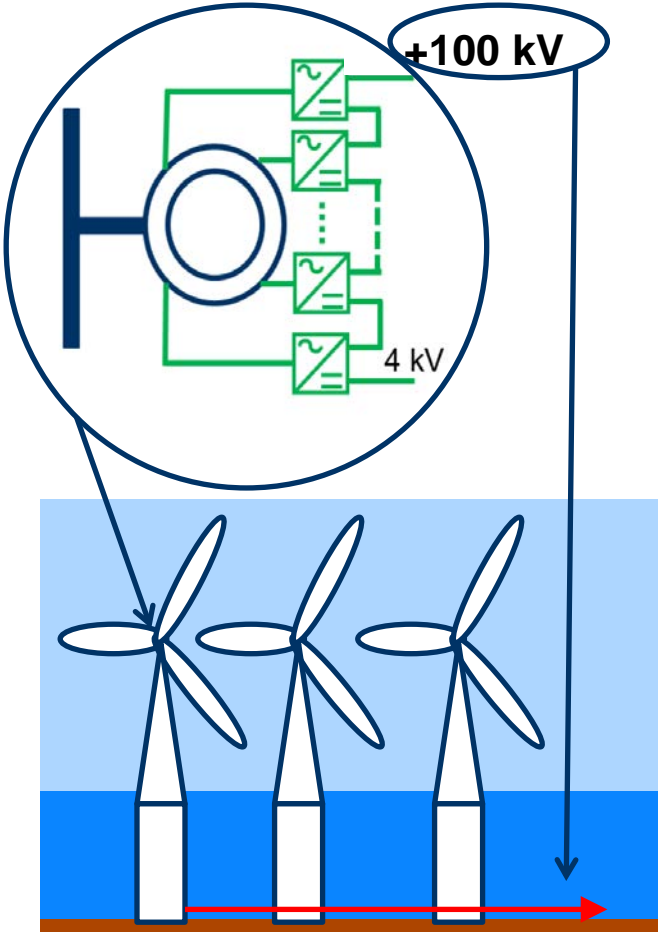
Best poster at EOW 2011

HVDC generator avoiding need for large sub-station

Conventional system



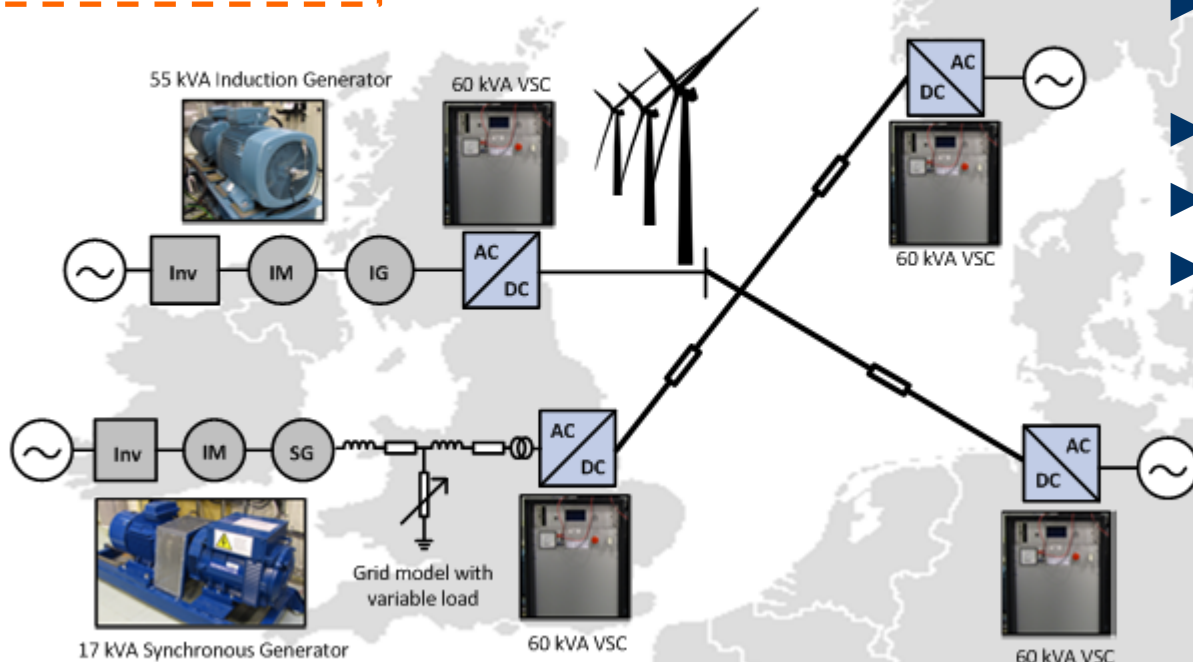
Innovative system



Lab-scale implementation of multi-terminal HVDC grid connecting offshore wind farm

VSC-HVDC model:

In-house built laboratory VSC converters with FPGA-control

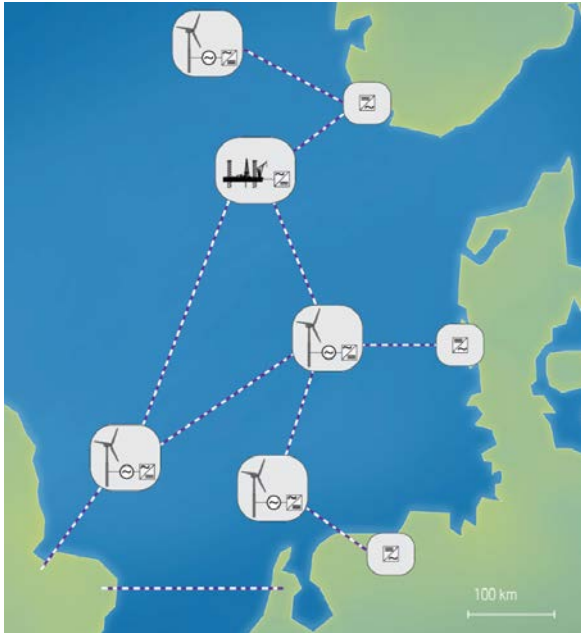


R&D topics:

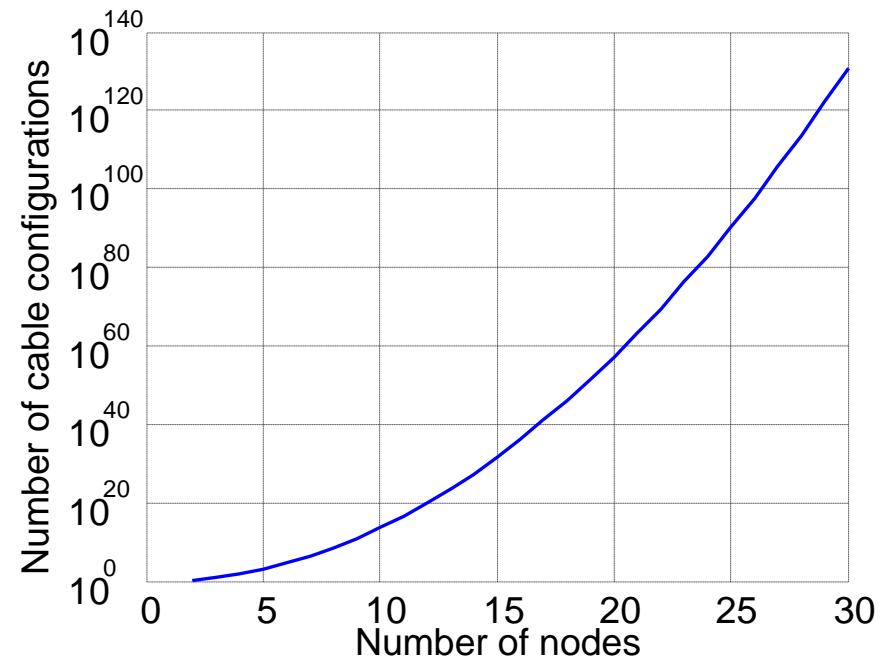
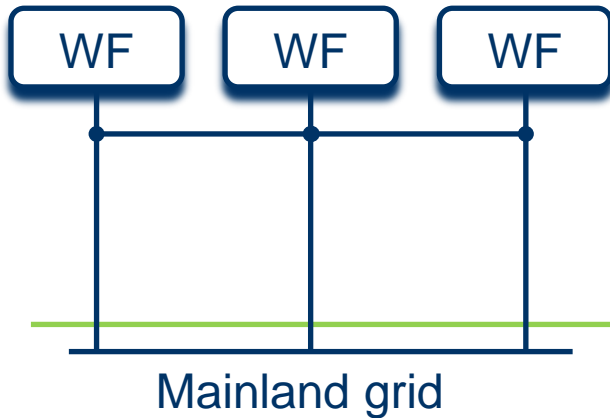
- ▶ Operation and control
- ▶ Converter interoperability
- ▶ System stability
- ▶ Fault handling
- ▶ System services



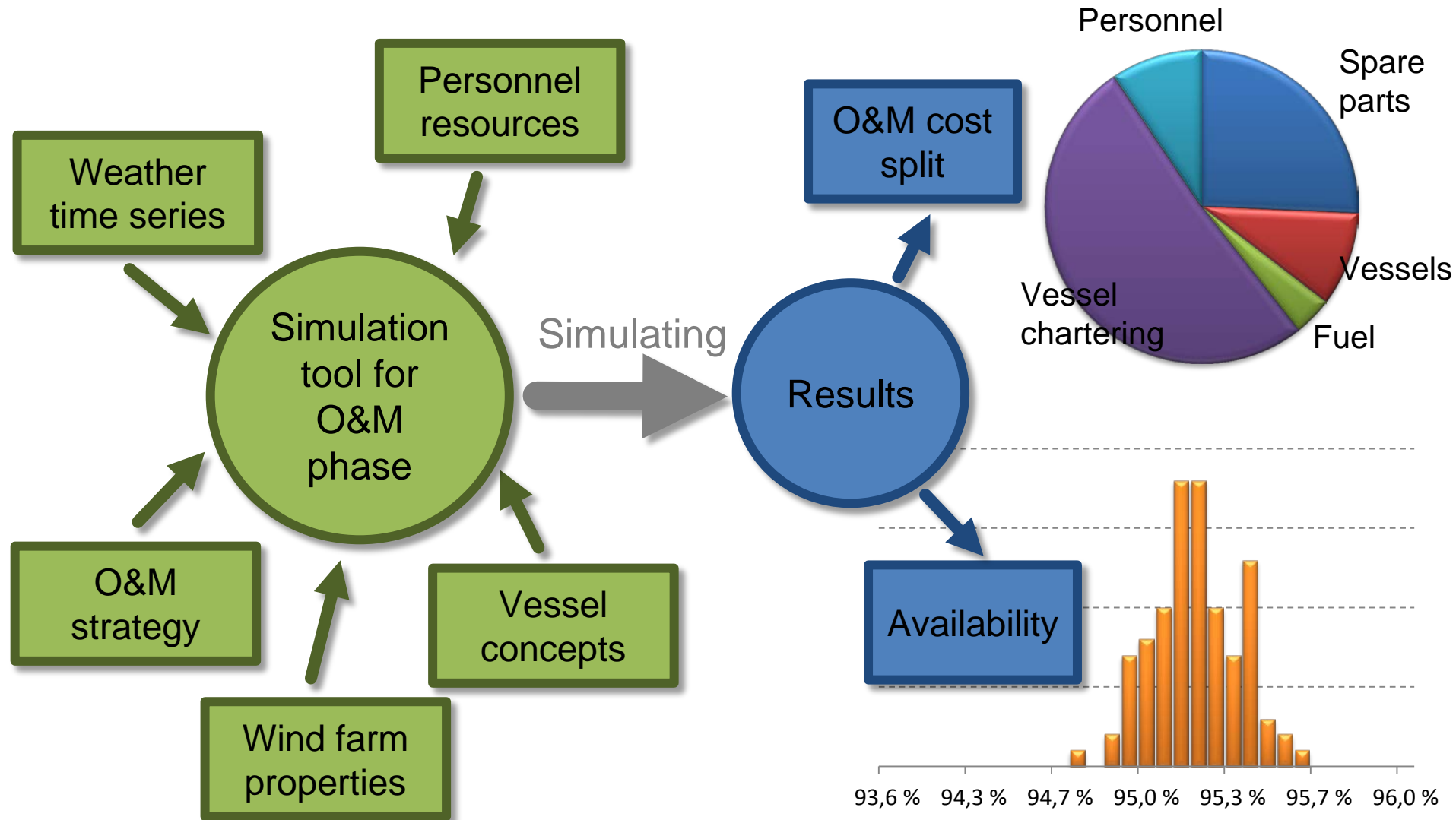
Optimization of the offshore grid



- ▶ Inside and between wind farms
- ▶ New market solutions are required
- ▶ New technology (HVDC VSC, multi-terminal, hybrid HVDC/HVAC, ..)
- ▶ Protection, Fault handling, Operation, Control, Cost, Security of Supply



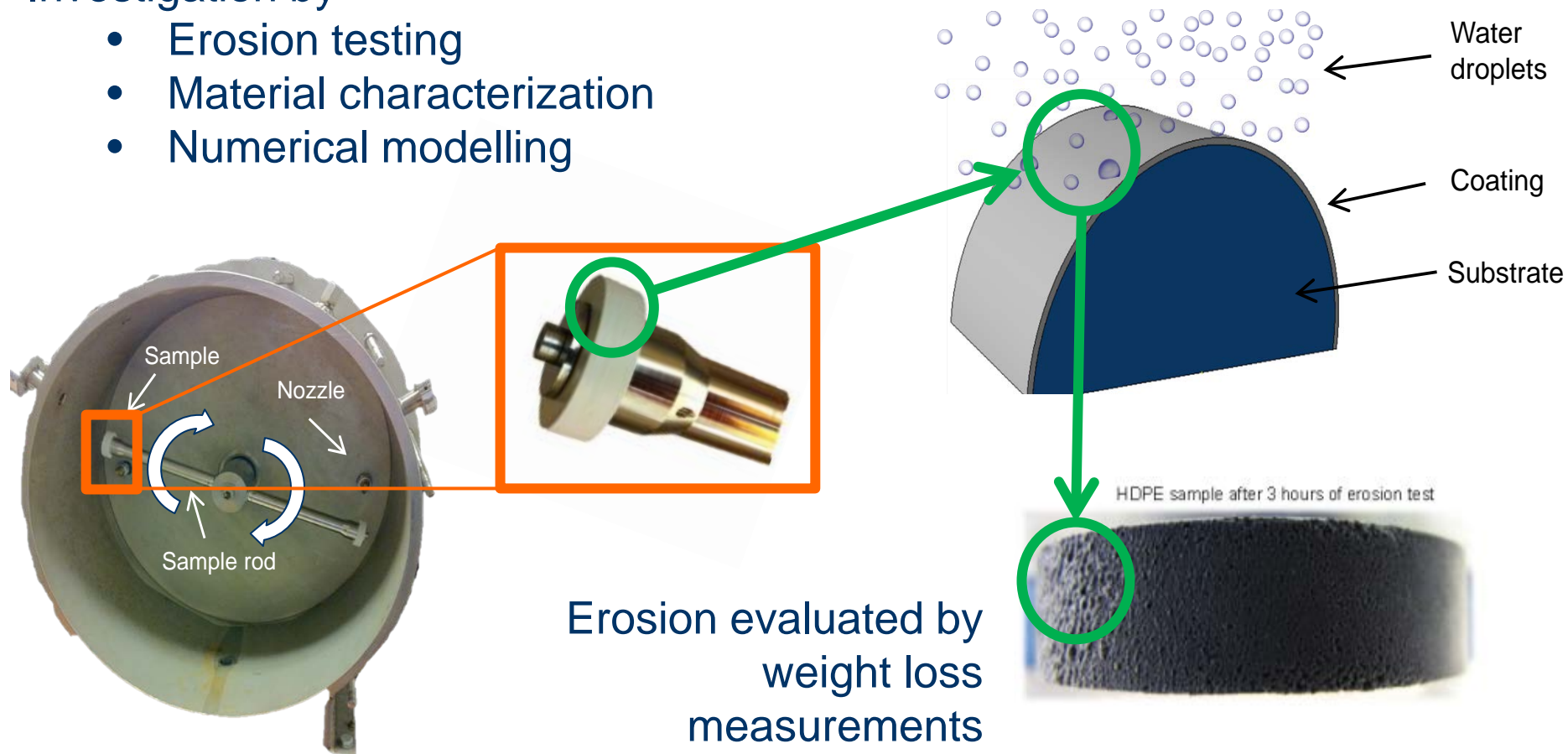
O&M and logistics cost analysis



Coatings for offshore wind turbine blades - Protection against rain droplet

Investigation by

- Erosion testing
- Material characterization
- Numerical modelling

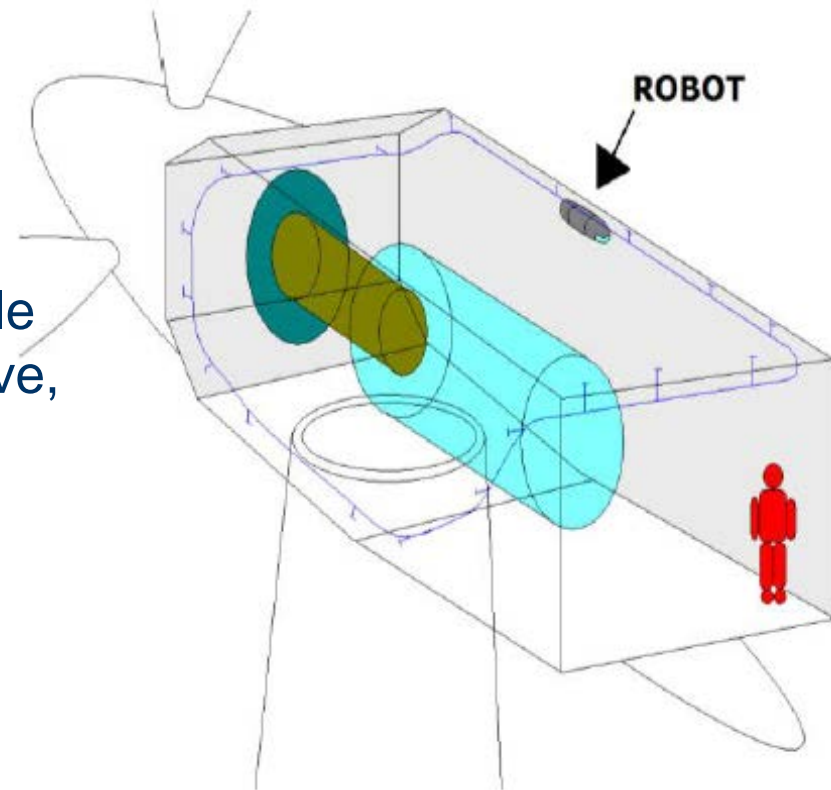


Remote presence reduce O&M costs

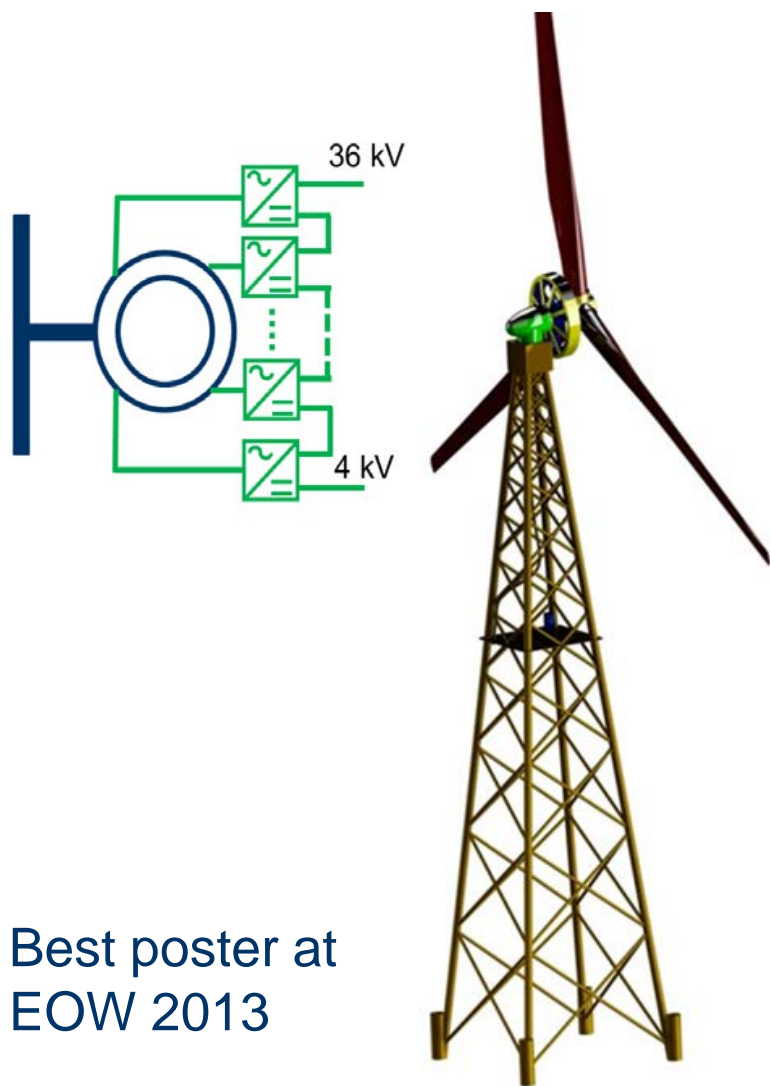
- ▶ It is costly and sometimes impossible to have maintenance staff visiting offshore turbines



- ▶ Remote presence:
 - Remote inspection through a small robot on a track in the nacelle equipped with camera / heat sensitive, various probes, microphone etc.
 - Remote maintenance through robotized maintenance actions



NOWITECH 10 MW reference turbine



Best poster at
EOW 2013

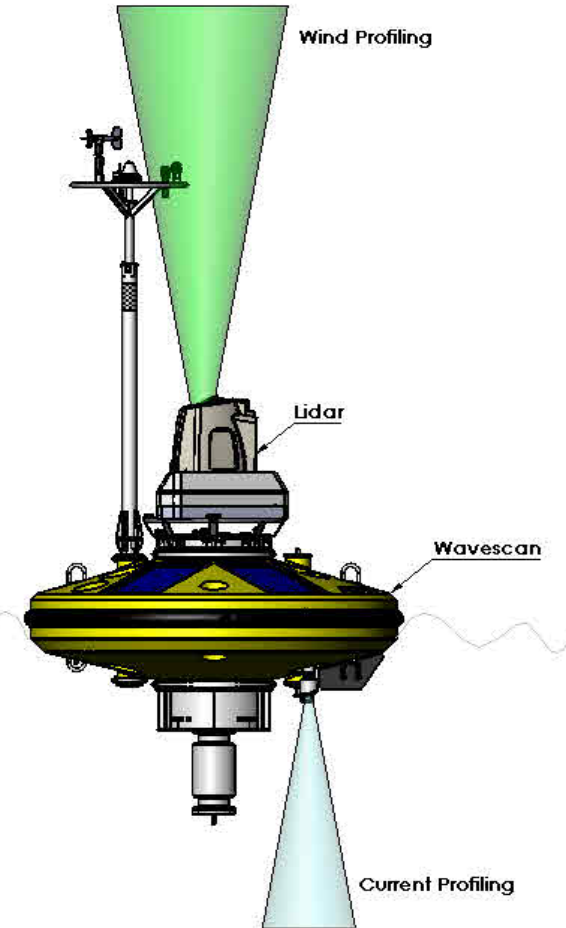
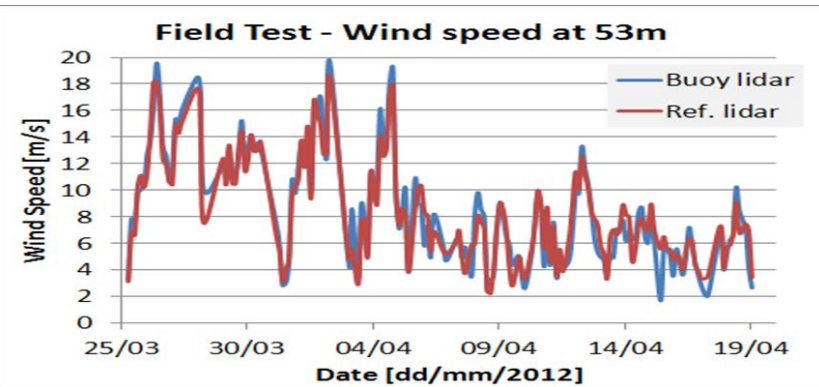
Initial design parameters

- Nominal power output 10.0 MW
- Design wind velocity 13.0 m/s
- Tip speed ratio 7.7
- Hub height 93.5 m
- Turbine diameter 141.0 m
- Design water depth 60.0 m
- Wind & waves ala Doggerbank
- **(work in progress!)**

The NOWITECH 10 MW reference turbine introduces a new generator and support structure concept

SEAWATCH Wind Lidar Buoy

- ▶ Cost efficient and flexible compared to offshore met mast
- ▶ Measure wind profiles (300 m), wave height and direction, ocean current profiles, met-ocean parameters
- ▶ Result of NOWITECH "spin-off" joint industry project by Fugro OCEANOR with Norwegian universities, research institutes and Statoil.



Relevant labs on campus



Ocean basin 80x50x10 m

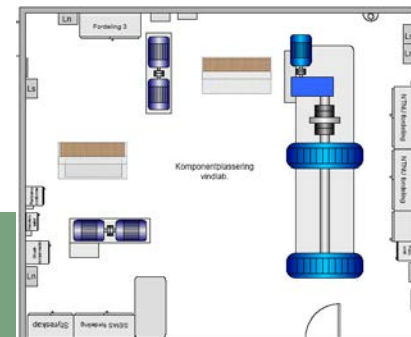
Wind tunnel
11x3x2 m



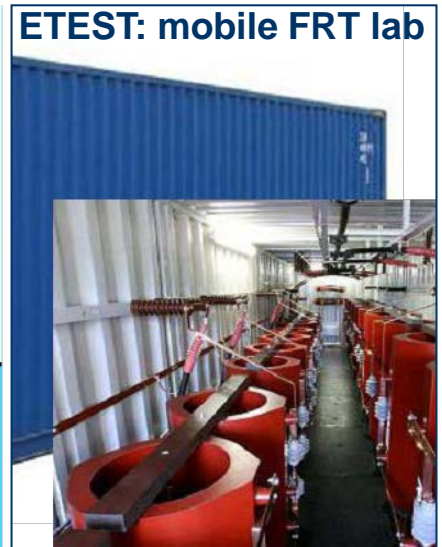
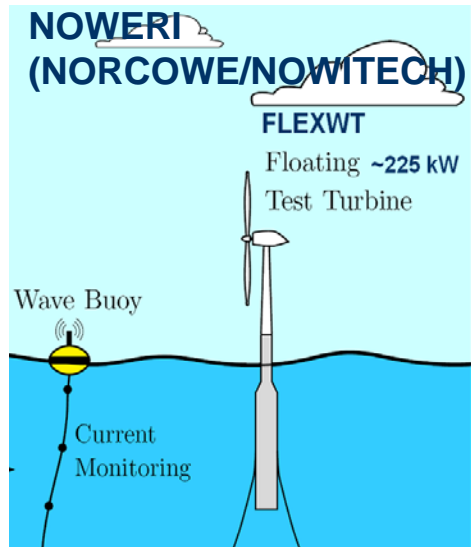
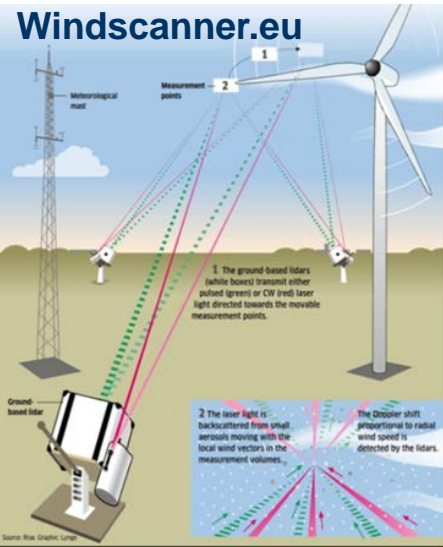
Material testing



SmartGrids lab



Strong field facilities for R&D in development



Recruitment and education

- ▶ 25 PhD and post doc students are granted by NOWITECH to be finished in 2014-2015
- ▶ Some +30 PhD students are funded through other projects and some hundred MSc have specialized within wind energy
- ▶ The Erasmus Mundus European Wind Energy Master (EWEM) programme gives further weight to the wind education at NTNU and NOWITECH



NOWITECH achievements

- ▶ **NOWITECH is about education, competence building and innovations reducing cost of energy from offshore wind**
- ▶ Significant budget and duration: EUR 40 millions (2009-2017)
- ▶ Strong consortium with leading research and industry parties
- ▶ Excellent master and PhD programme: 25 PhD & post doc grants
- ▶ Strong scientific results: good number of peer-reviewed publications
- ▶ R&D results give value creation and cost reductions
- ▶ Innovation process is enhanced through TRL
- ▶ Two new business developments (Remote Presence + SiC coatings)
- ▶ Strong infrastructure in development: NOWERI, WindScanner, ++
- ▶ A high number of spin-off projects: total volume EUR 125 millions
- ▶ **Vision: large scale deployment & internationally leading**

We make it possible

NOWITECH is a joint 40M€ research effort on offshore wind technology.

- Integrated numerical design tools
- New materials for blades and generators.
- Novel substructures (bottom-fixed and floaters)
- Grid connection and system integration
- Operation and maintenance
- Assessment of novel concepts

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