Mid Term UpWind Workshop

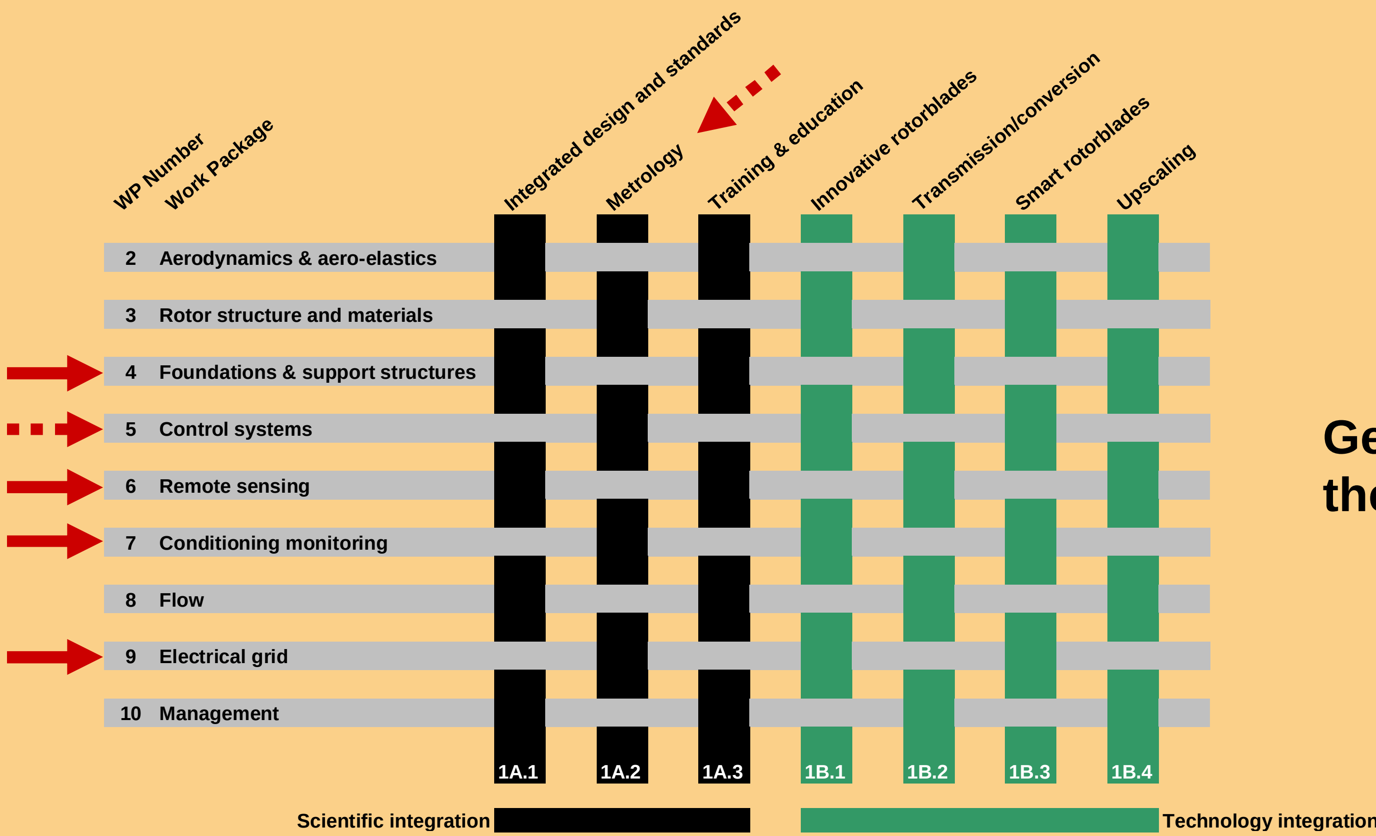
Brussels, October 9, 2008

Some conclusions from Periodic Activity Report Year 2

Jos Beurskens

SIXTH FRAMEWORK PROGRAMME

This presentation



General remarks on the UpWind project

General remarks (1)

- Many issues which are identified as priority topics in TPWind’s WG’s 1, 2, 3 and 4 are being addressed in UpWind, however:
- Many UpWind’s activities are initial phase actions (metrology, distributed aerodynamic rotor control,) or
- Continuation of high priority research with specific deliverables but not being the final phase (rotor structure and materials, conditioning monitoring)
- Overall progress is very satisfactory

General remarks (2)

Upwind s unique features:

- Metrology (See website for most critical parameters)
- Integrates the scientific and technical disciplines, the sector needs for the entire development chain of wind turbine technology
- Integral design methodology
- Incorporation of Education aspects

WG 2 Foundations and support structures

WG 2 Foundations and support structures

WP 4.1 Integration of support structure and turbine design

- Integrated design and WT control for mitigation of aerodynamic and hydrodynamic loading
- Compensation of site and structural variability

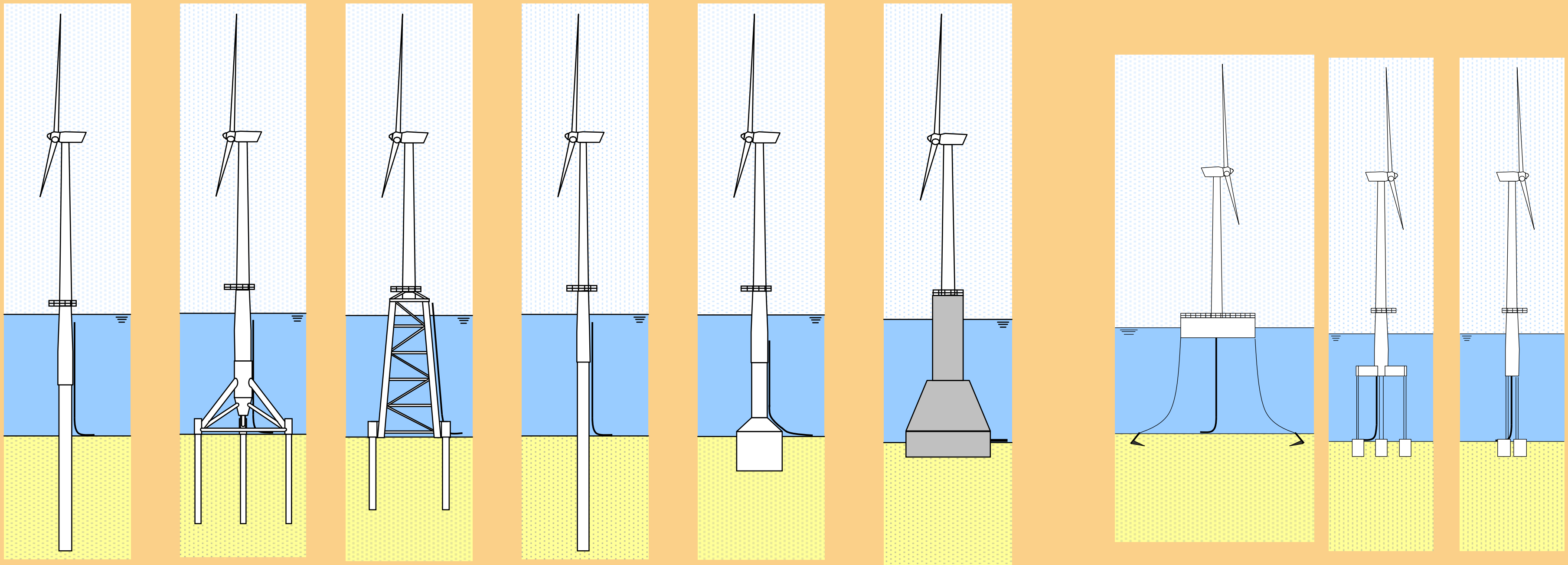
WP 4.2 Concepts for deep water sites

- Innovative bottom-mounted structures e.g. truss-type
- Very soft structures: monopile-type or braced-type
- Floating structures

WP 4.3 Enhancement of design methods and standards

- e.g. non-linear sea states, multi-member support structures, large number of similar designs, floating designs
- Support 1st revision of IEC 61400-3

WG 2 Foundations and support structures



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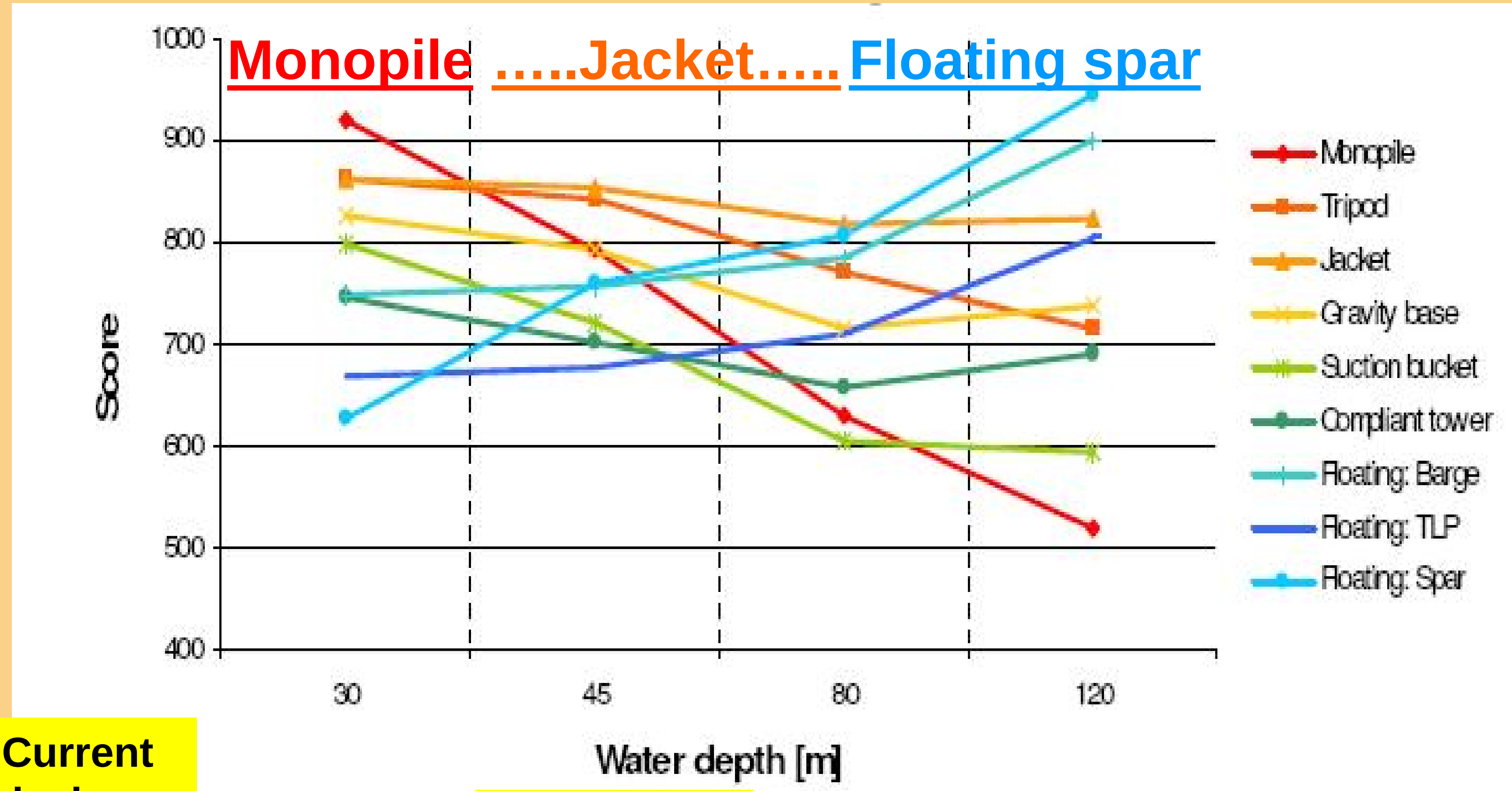
WG 2 Foundations and support structures



Current designs (< 20 m): Monopile

Current design: 1st Jacket

WG 2 Foundations and support structures

NREL

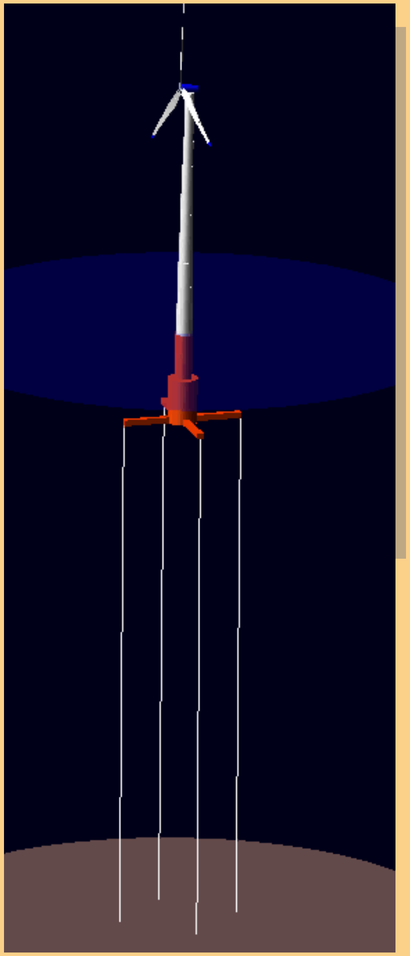
- Benchmark of design tools (IEA Wind Annex 23)
- Design tool for floating turbines (3rd & 4th year)
- Design of floating wind turbines (5th year)

Centre for Wind Energy & Marine Technology (CWMT)

- Sub-structuring of joints in braced support structures => UpWind reference design (4th year)
- Adaptive design of large number of support structures at varying site conditions (5th year)

Casted joint

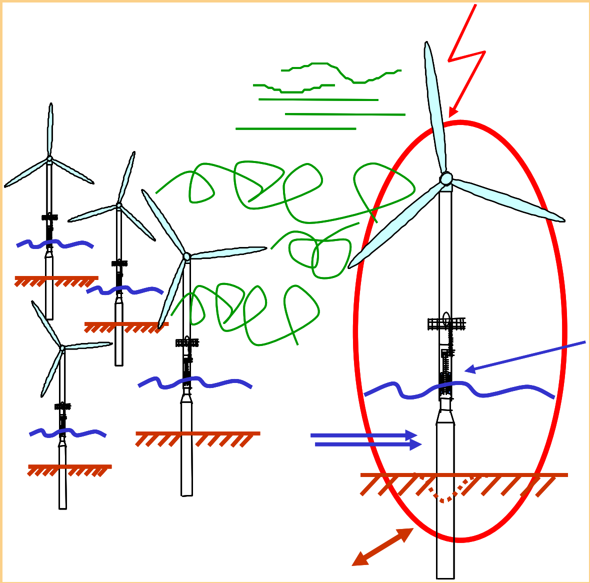
Fraunhofer Center Windenergie und Meerestechnik



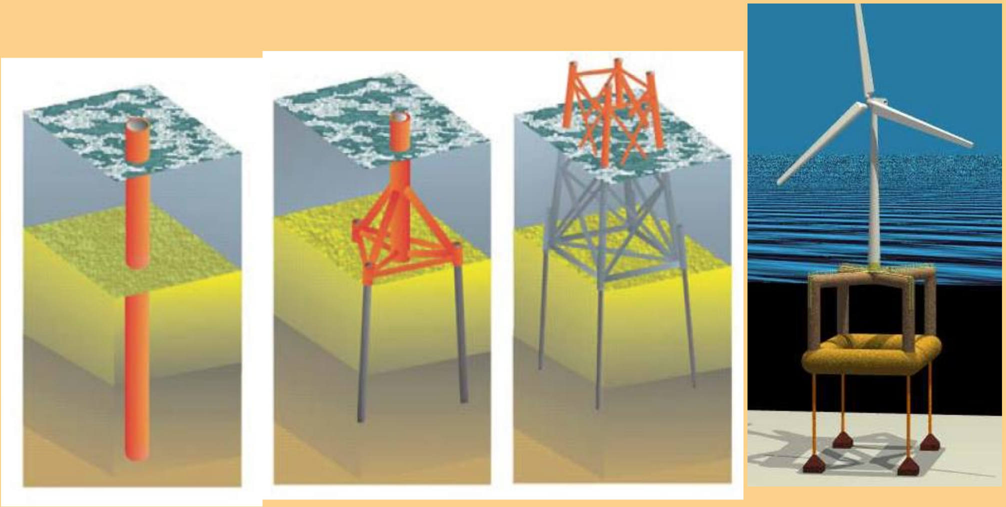
NREL National Renewable Energy Laboratory

WG 2 Foundations and support structures

Cost reduction through
integrated design & design methods



Cost reduction through
weight reduction & standards



Cost reduction through
site-insensitivity & series production

WG 6 Remote sensing

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THE UNIVERSITY OF SALFORD

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centro nacional de energías renovables
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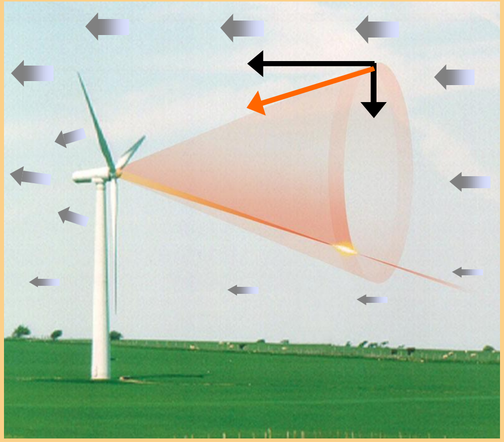
Vestas®

QinetiQ

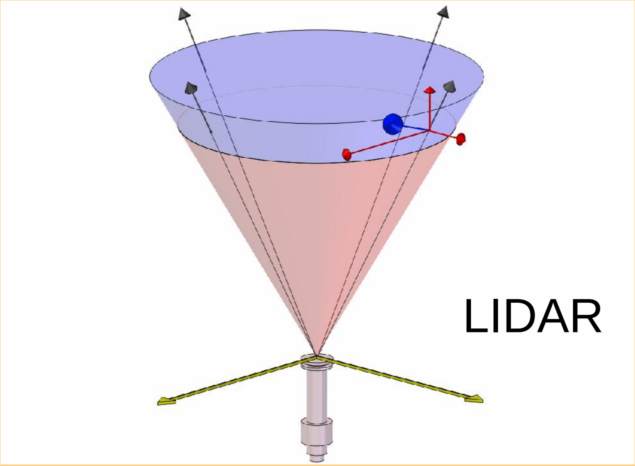
WG 6 Remote sensing

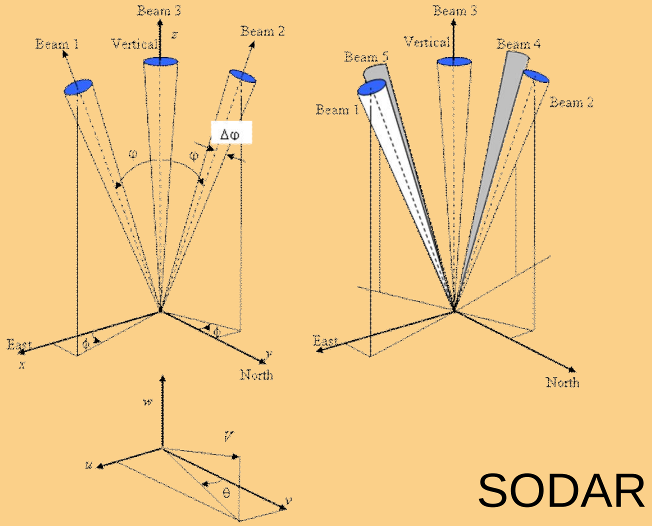
WP 4.1 Cheaper faster dynamic measurements of wind velocity

- Vertical profiles
- Offshore
- Complex terain chracterisation
- Wind field of large rotors
- Flow in wind farms



WG 6 Remote sensing





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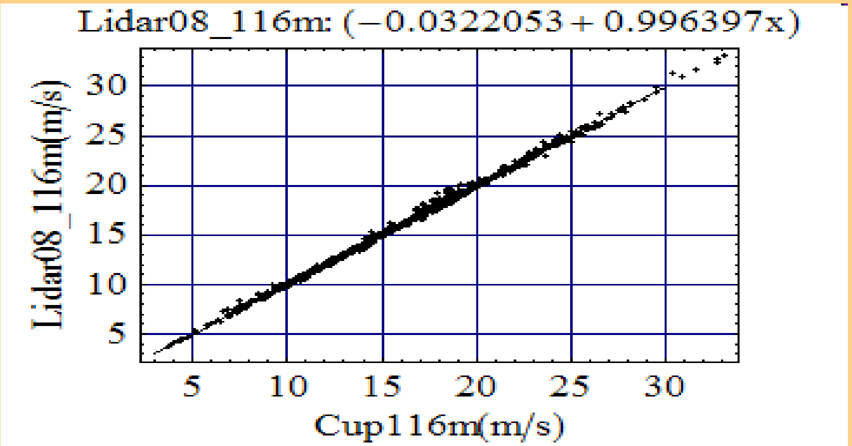
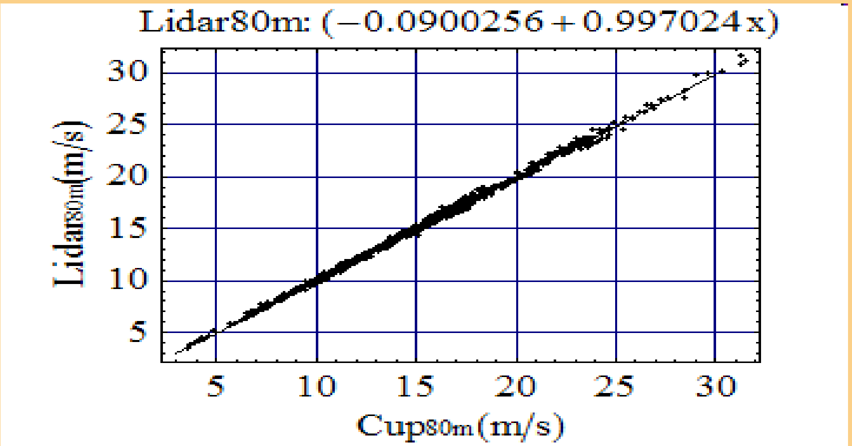
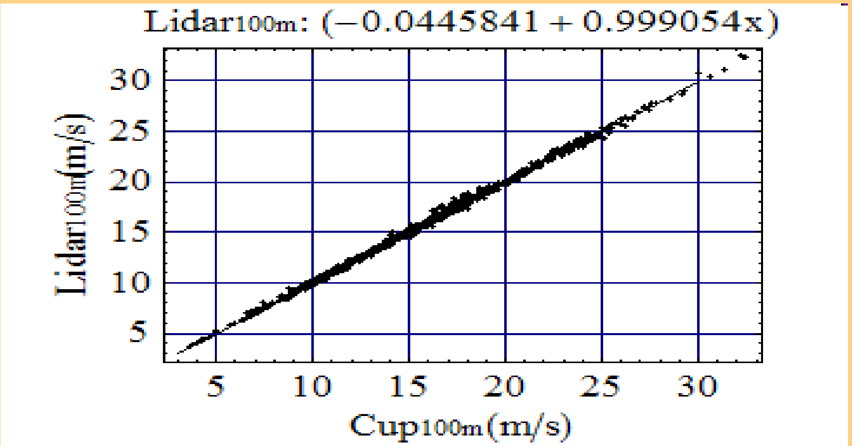
WG 6 Remote sensing







Slope very close to unity.

High degree of correlation.

Lidar-Cup slope (dry weather data)

WG 6 Remote sensing

Experimental research more difficult to manage than desk work !

- Teething problems for the lidars and the sodars.
- CENER lidar defect needed to be returned, measurements expected resumed soon.
- CRES sodar destroyed, measurements expected resumed soon.

- Annoying but NOT (yet) CRITICAL DELAYS

WG 6 Remote sensing

- UpWind accelerated development of LIDAR
- More manufacturers
- Measurements create confedence in this novel technique
- New applications came into reach (e.g. rotor control)

WG 7 Condition monitoring

Participants: ISET (D),
ECN (NL),
Risø-DTU (DK)
SmartFibres (GB)

WG 7 Condition monitoring

Subtasks:

7.1 Next Generation CMS for use in multi MW turbines

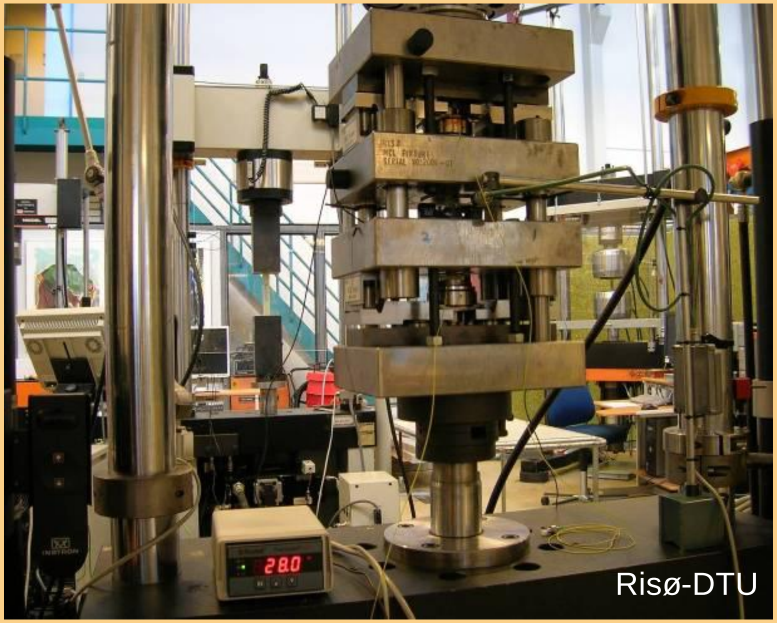
7.2 Flight Leader Turbine concept for cost optimised O&M on offshore wind farm WTs

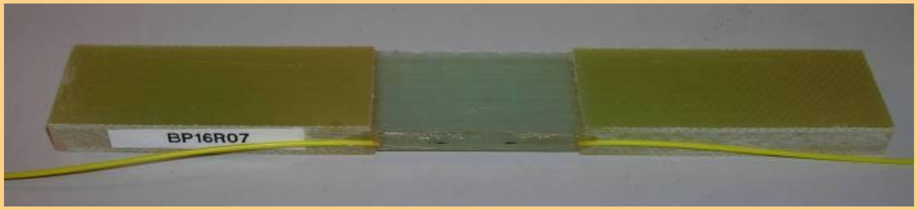
7.3 Fault statistics to identify fault critical components of WTs

7.4 Integration of WP7 results into international standards and technical guidelines

WG 7 Condition monitoring

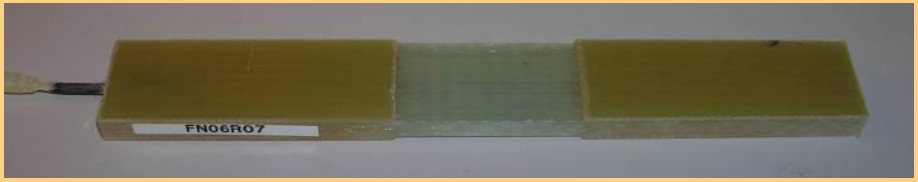
CMS for use in multi MW turbines; material properties





Before test

After test



Embedded sensor.

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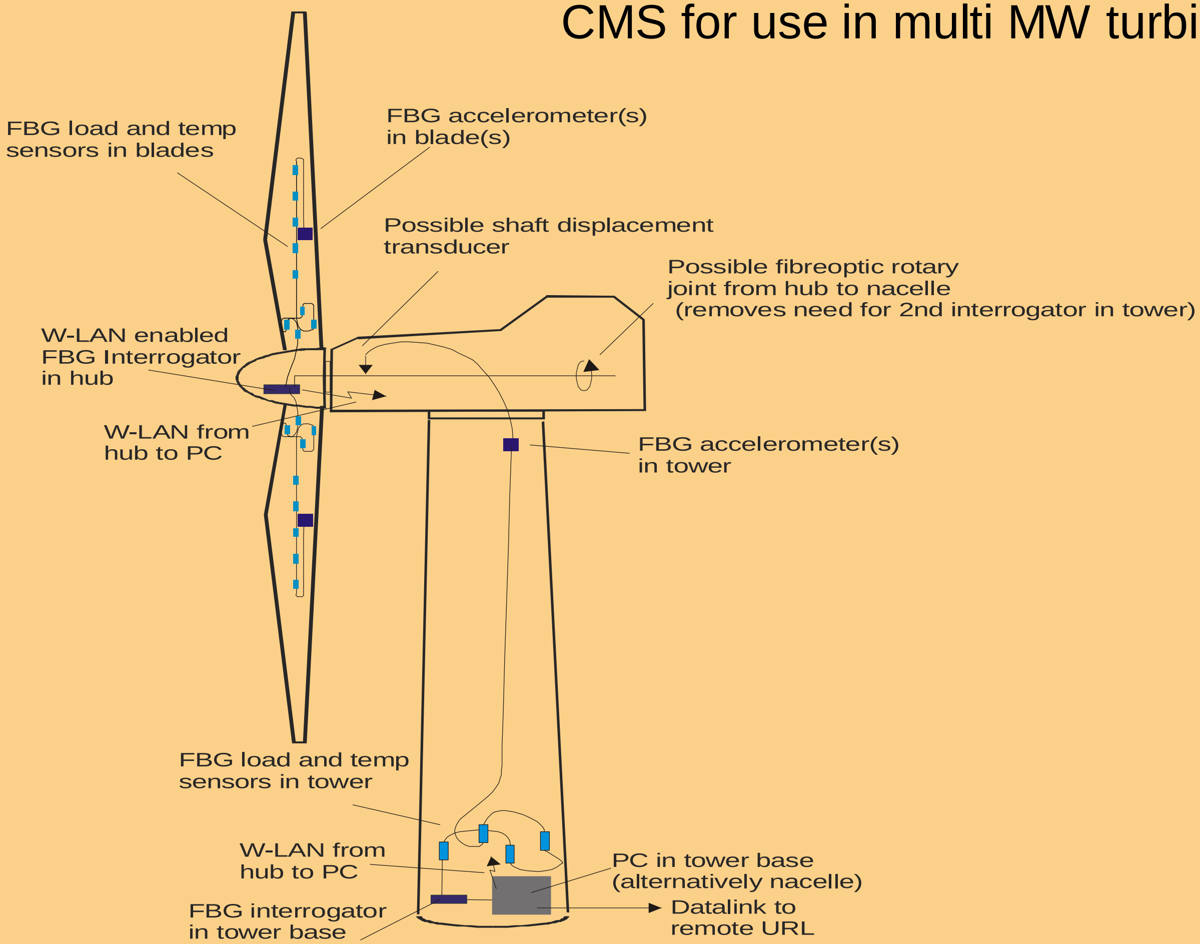
WG 7 Condition monitoring

CMS for use in multi MW turbines; operational verification

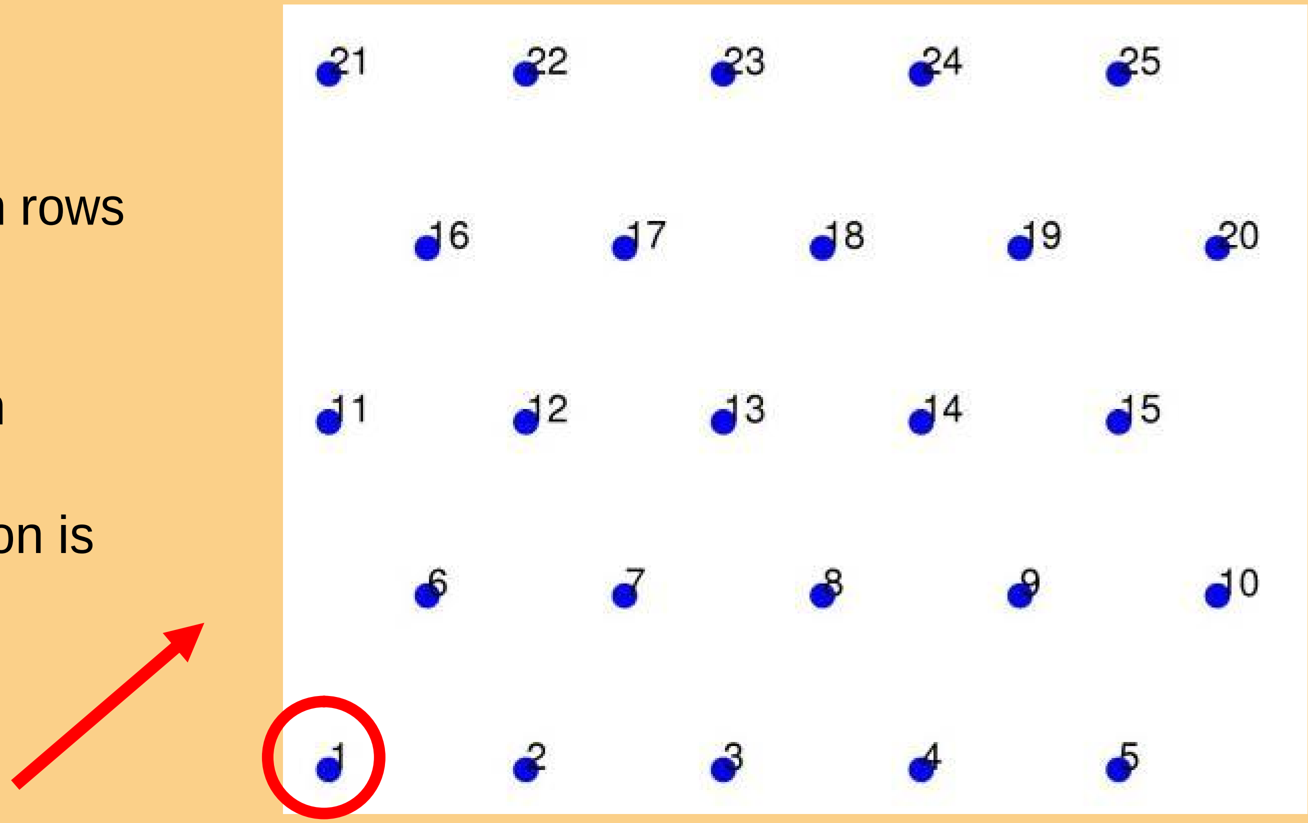


WG 7 Condition monitoring

Flight Leader concept

<u>Model wind farm:</u>

- Distance between rows is 8.3 D_R
- Distance between turbines is 7 D_R
- Main wind direction is roughly SW

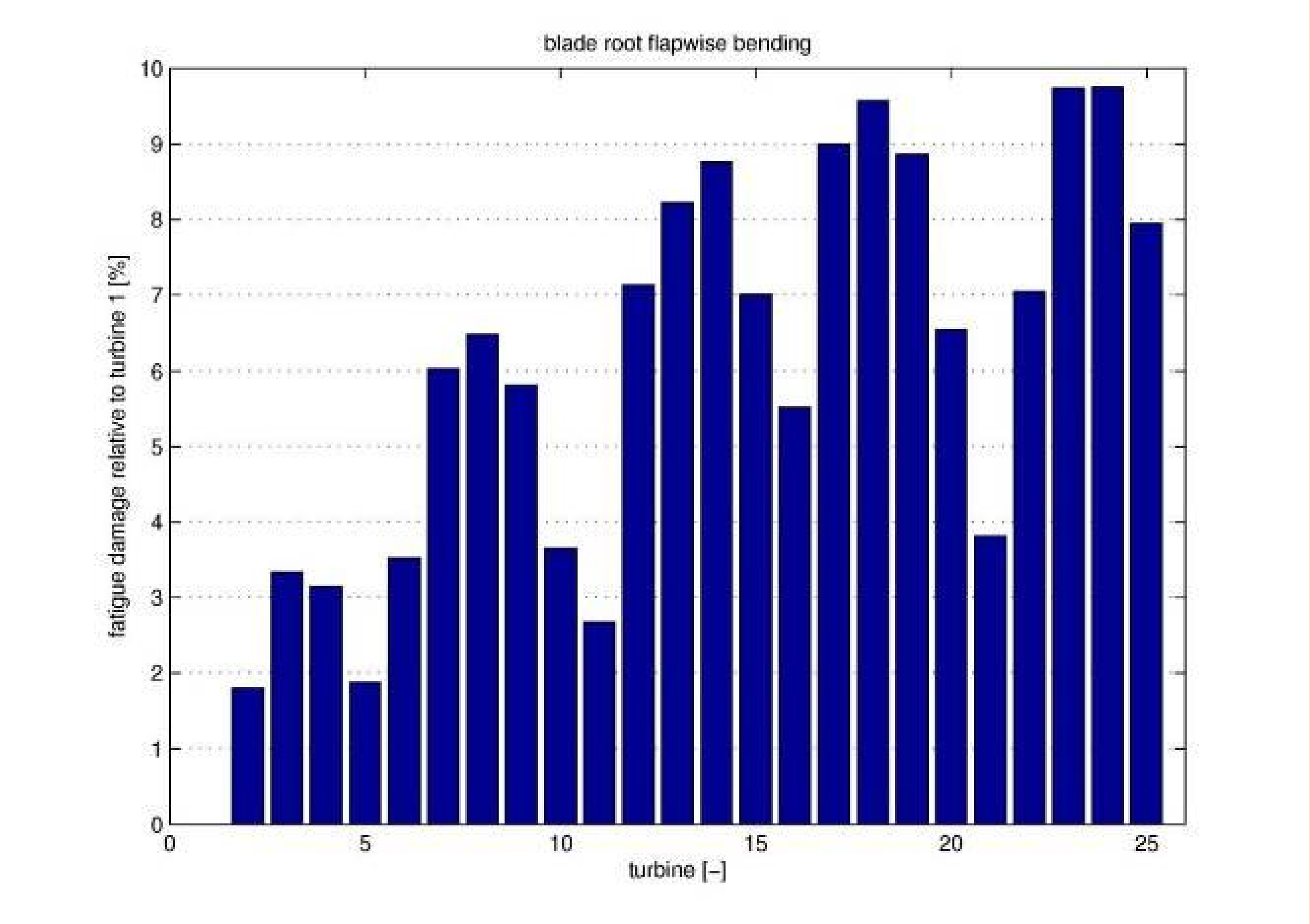


WG 7 Condition monitoring

Flight Leader concept

Simulation results:

- There is a significant difference in the load exposure to WTs in wind farm



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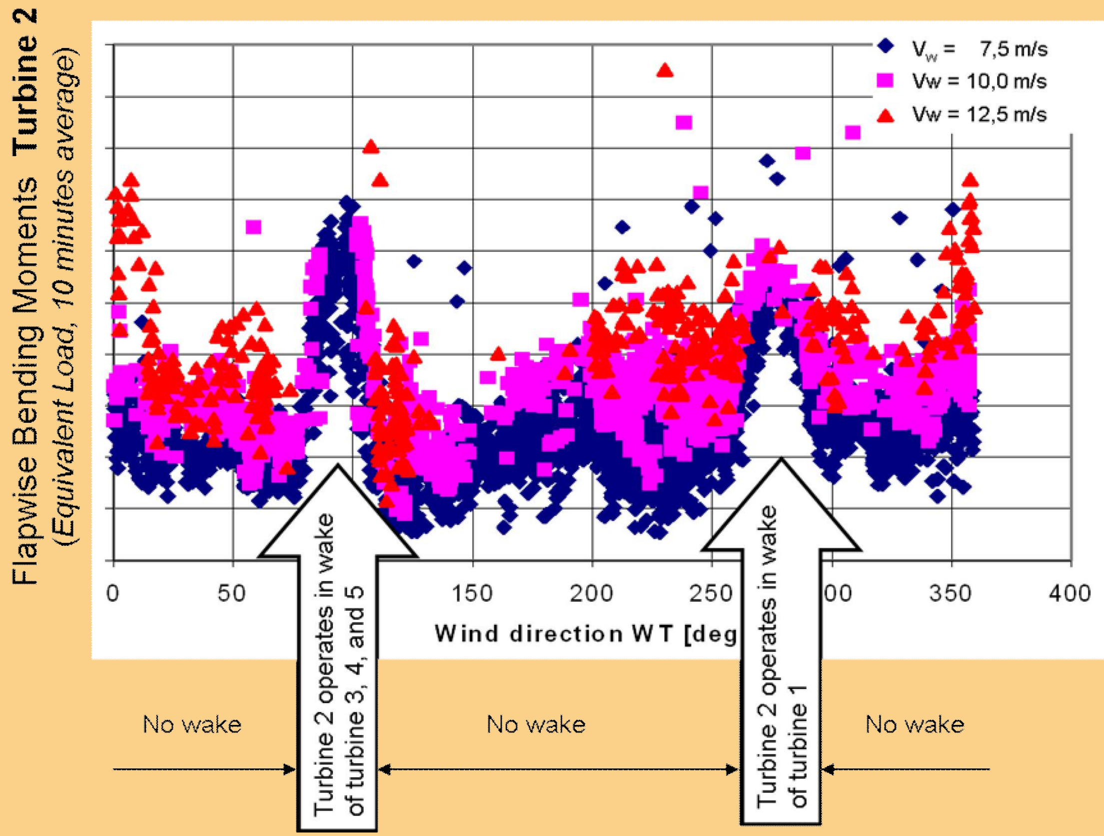
WG 7 Condition monitoring

Flight Leader concept

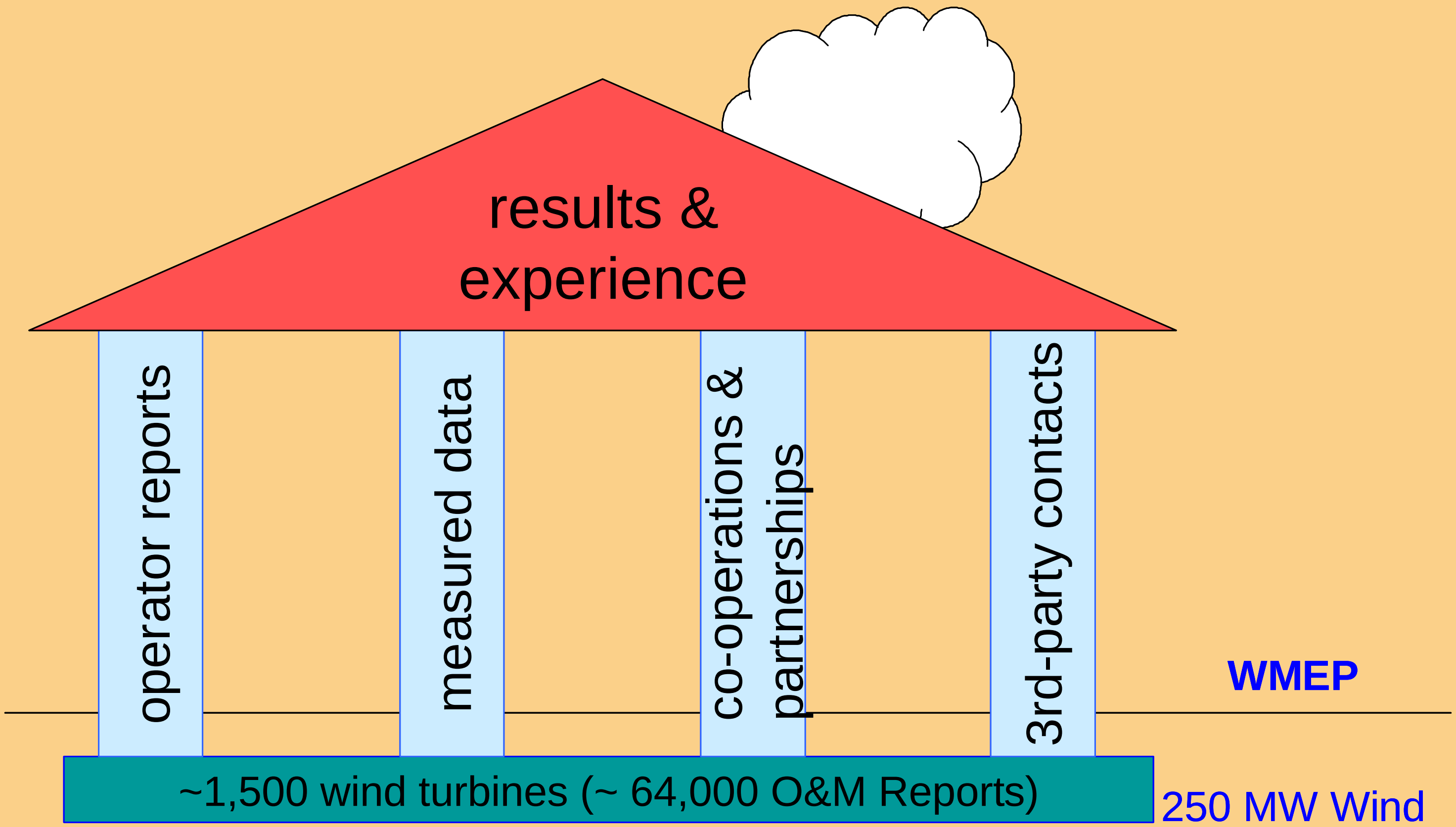
Higher loads when turbine 2 is in wake of other turbines

ECN$ test field in Wieringermeer, NL
5 Nordex N-80 turbines of 2 MW each



WG 7 Condition monitoring

Fault statistics to identify fault critical components of WT's

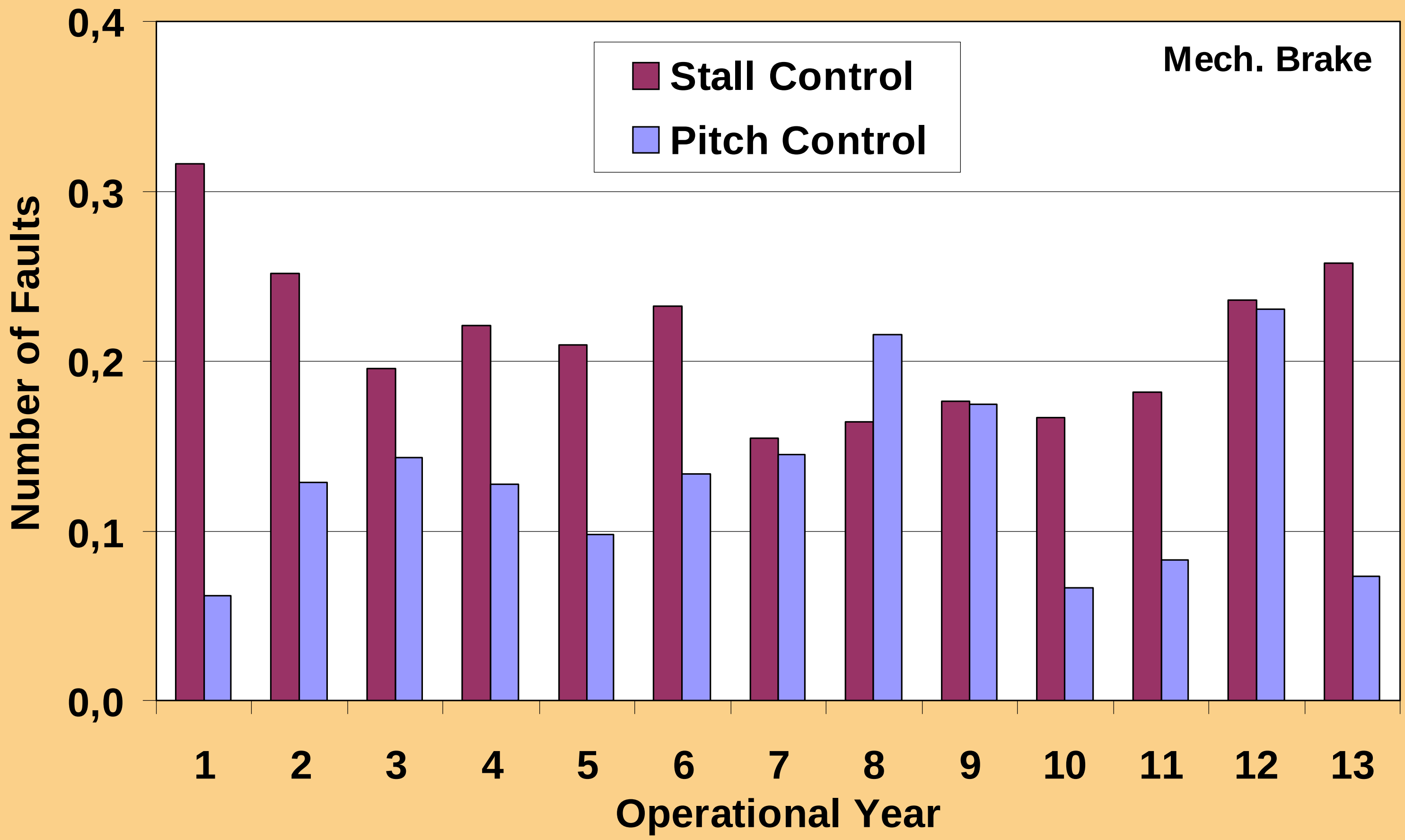


WG 7 Condition monitoring

Fault statistics to identify fault critical components of WT's

Higher rates for stall machines due to higher stress for brake system

Pitch control allows aerodynamic brake operation, i. e. reduced wear on mechanical brakes



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WG 8 Electrical grid

	Risø-DTU	DK
	Aalborg University	DK
	Energy research Centre of the Netherlands ECN	NL
	National Technical University of Athens	GR
	ISET/Universität Kassel e.V.	D
	DONG Energy (WP leader)	DK
	GE Global Research	D
	Garrad Hassan	GB
NEW	Vattenfall A/S Generation Nordic	DK

WG 8 Electrical grid

Expected results

- Improved reliability assessment
- Better integration in power system
- Electrical design requirements for future wind turbines

WG 8 Electrical grid

Status of work

- Survey of wind farm reliability (completed)
- Reliability database (complete)
- Investigation on power system requirements for high wind penetration (completed)
- Study of wind farm design (nearly completed)
- Evaluation of extreme wind and control (pending)
- Work on cost function (just started)

WG 8 Electrical grid

Cost modelling; reference turbines and wind farms

Wind turbine electrical power:	5MW	20MW
Rotor diameter D	126m	252m
Tip speed	80 m/s	80 m/s
Hub height H	90m	153m

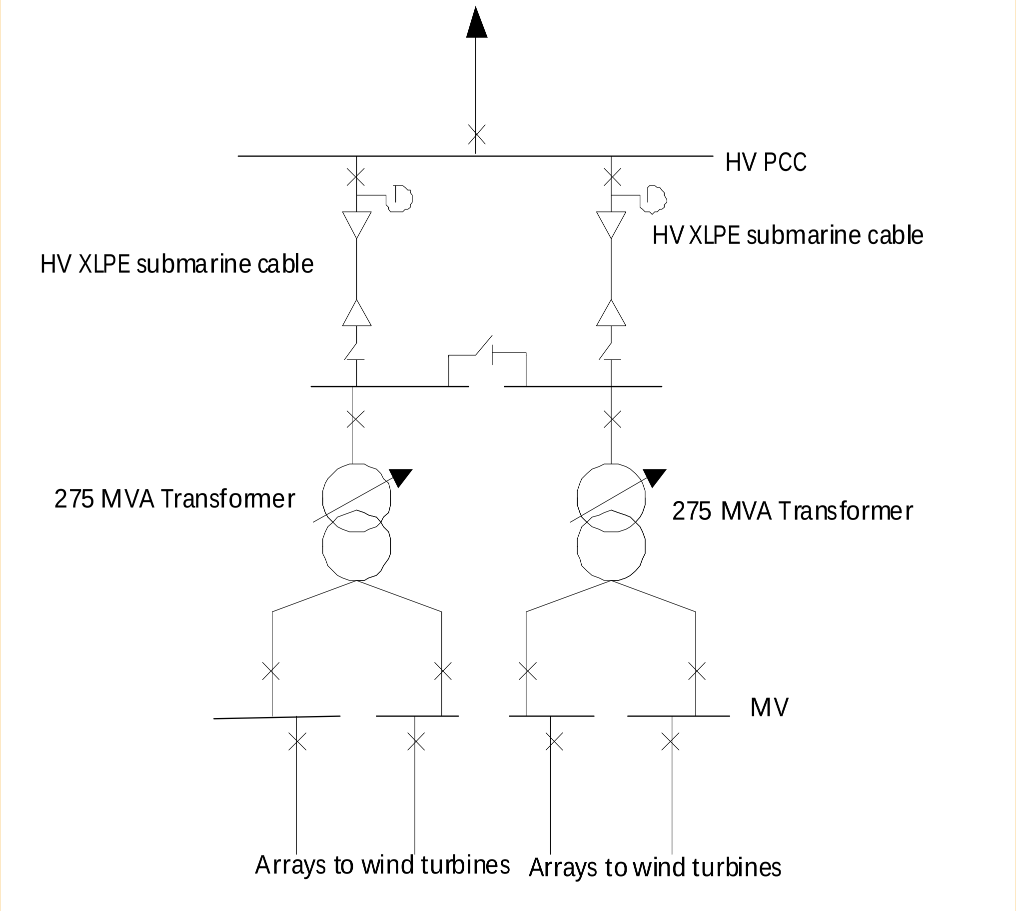
Reference wind farm	500 MW	1000 MW
Water depth	30 m	60 m
Distance to shore	25 km	100 km
Area	Square	Square / double square

WG 8 Electrical grid

Cost modelling; grid connection architecture

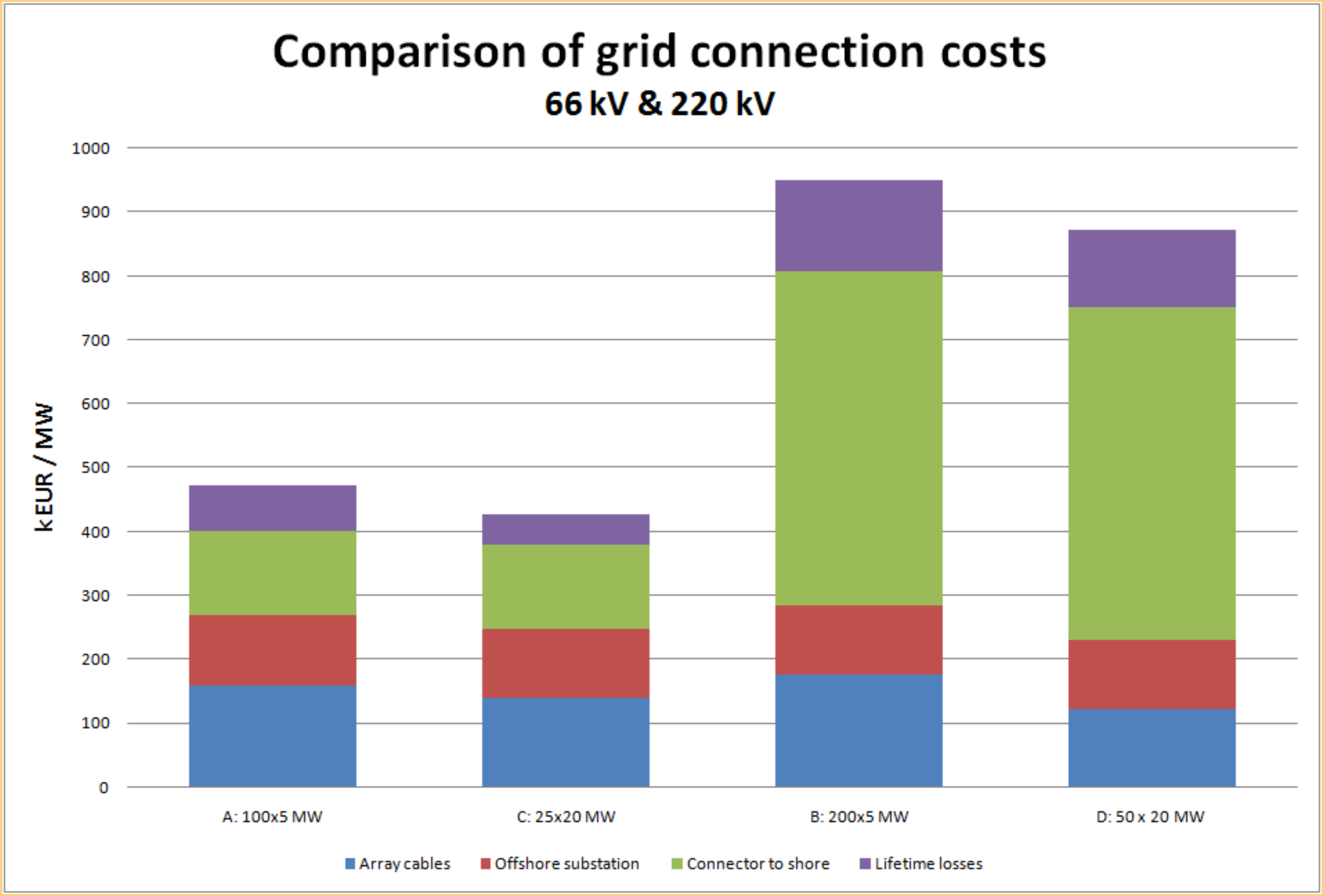
Simplifications:

- AC only
- Standard layout
- Present design principles



WG 8 Electrical grid

Cost modelling; comparison different configurations



WG 8 Electrical grid

Cost modelling; Conclusions

- Increase of voltage level of internal network is important
- Increase of voltage of connector to shore
  220 kV technical limit for AC. DC to be considered
- Costs mainly depending on distance to shore
- Costs are less depending on wind turbine size.

WG 11 Dissemination of knowledge

EWEA

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WG 11 Dissemination of knowledge

Challenge

Research activities

Results and expectations

Contact data

Participants of WG

THE RESEARCH ACTIVITIES

The main research activities for the integral design approach and standards' work package include:

- Defining and updating a reference wind turbine and a reference technical-economic cost model for benchmarking to be used for communication of the design parameters and design developments and the main economic and dynamic performance parameters for all UpWind project activities;
- Development, application and evaluation of an integral design approach methodology in offshore wind turbine design;
- Development of standards in general and for the application of the integral design approach, including definitions of interfaces between models, including data needs, specifications and protocols;
- Definitions and specifications of experimental data to be condensed into input design parameters for the design models or to verify critical design and performance issues.

In practical terms, the above research activities are sub-divided into 4 tasks.

SUBTASK A: REFERENCE WIND TURBINE AND COST MODEL

The subtask is dedicated at facilitating the integration of the different activities in all the horizontal (and vertical) work packages throughout the project. For this, a reference wind turbine will be defined to provide a basis for communication and comparisons. The design parameters and the main characteristics, including results of parameter sensitivity studies, will be defined and kept up to date. Input data will be provided from the other work packages. The data will be made easily accessible to all partners in the project.

SUBTASK B: INTEGRAL DESIGN APPROACH METHODOLOGY

Other technology sectors, such as air-transport, have experienced a development similar to wind energy with respect to increasing complexity and focus on specialists. For some of these technologies "Knowledge Based Engineering" (KBE) is investigated as a means to increase productivity of the design teams and to reduce the boundaries between disciplines. KBE tries to model not only properties of a product, but also the knowledge about the product that captures the engineering intent behind the design. KBE can be used in Design and Engineering Engines (DEE), to automate the multi-disciplinary processes. This automation is not intended to replace the design team, but rather to replace routine activities and to improve efficiency and consistency of information exchange. As a result, design teams will have more time for their creative contributions and thus can increase their productivity. Core element of the DEE is a (multi-) model generator in which the parametrical description of the product resides. It gets input from a concept generator and (re)generates the input for the analysis tools: the discipline silos. Typically, the discipline silos are commercial off-the-shelf analysis tools. The Knowledge Based Engineering tools reside in the concept generator.

Thus, the objective of this activity is to assess the feasibility of this approach for wind turbine design and to develop the knowledge needed to generate a DEE for this purpose. It is noted that the analysis tools in the discipline silos are external tools and are not part of the development undertaken in this activity. However, this activity will contribute to and make use of the common formats developed in this task, as these represent the interfaces between the model generator and the analysis tools. The reference turbine will be used as a case study.

SUBTASK C: DEVELOPMENT OF (PRE) STANDARDS FOR THE APPLICATION OF THE INTEGRAL DESIGN APPROACH

This subtask is dedicated to the development and formulation of standards in a broad sense, and for the application of the integral design approach of subtask B. Hence the subtask C aims at integrating the design models, experimental methods and concepts arising from the horizontal work packages.

SUBTASK D: INTEGRATION, REVIEW AND PLANNING WORKSHOPS

This subtask focuses on coordination and cross-cutting activities.

RESULTS AND EXPECTATIONS

So far cost functions for the components of the wind turbine, for which the input from parallel project activities is needed have been developed.

This WP works in close cooperation with the WP Upscaling (1B4).

The final results of the work package include:

- Guidelines for the integral design approach, including guidelines for design models, experimental methods and concepts arising from the scientific WP's;
- Recommendations and pre-standards to be submitted for IEC/ISO and CEN/CENELEC for the revision or development of international standards for design and tests of wind energy systems.

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Acknowledgements

WG 4: Martin Kühn, Tim Fischer, Wybren de Vries

WG 6: Hans Jørgensen

WG 7: Jochen Giebhardt

WG 9: Ole Holmstrøm

Thank you for your attention !