Annual report 2011

NOWITECH

Norwegian Research Centre for Offshore Wind Technology

www.NOWITECH.no

NOWITECH Annual Report 2011

April 2012

Editorial: Nils Arild Ringheim and John Olav Tande

Contribution from the following members of the Centre Management Group:
Roy Stenbro, Bernd Schmid, Torgeir Moan, Kjetil Uhlen,
Jørn Heggset, Petter Andreas Berthelsen, Trond Kvamsdal,
Jan Onarheim, Debbie W. Koreman and Randi Aukan.

SUMMARY

NOWITECH's vision is to contribute to large scale deployment of deep sea offshore wind turbines, and to be an internationally leading research community on offshore wind technology enabling industry partners to be in the forefront.

The objective is to provide pre-competitive research laying a foundation for industrial value creation and cost-effective offshore wind farms. Emphasis is on "deep-sea" (+30 m) including bottom-fixed and floating wind turbines.

The research activities are organised into six work packages (WP):

- WP 1: Development of integrated numerical design tools for novel offshore wind energy concepts.
- WP 2: Investigation of new energy conversion systems for offshore wind turbines.
- WP 3: Analysis of novel substructures (bottom-fixed and floaters) for offshore wind turbines.
- WP 4: Assessment of grid connection and system integration of large offshore wind farms.
- WP 5: Development of operation and maintenance (O&M) strategies and technologies.
- WP 6: Assessment of novel concepts for offshore wind turbines by numerical tools and physical experiments, hereunder developing control systems and combining results from WP1 and WP5.

NOWITECH is organized with a General Assembly (GA), a Board, a Centre Director, a Scientific Committee (SC), a Committee for Innovation and Commercialisation (CIC) and a Centre Management Group (CMG).

Industry involvement has high priority: The industry parties participate by in-kind supplies and direct involvement in WP and CIC activities. All industry parties are represented in the GA and the industry parties are active and in majority in the Board. The CIC is enhancing industry involvement and facilitating that results from NOWITECH are communicated to the industry parties. Commercialisation is by transfer of knowledge to the industry parties and their use of this in developing their business, through spin-off projects and creation of new industry.

The SC is developing a top quality PhD and post doc programme in collaboration with the CMG. A total of 22 PhD students and 5 Post Doc students have started with funding from NOWITECH. In addition, NTNU has 25 PhD and 9 Post Doc candidates with funding from sources outside NOWITECH working on topics related to offshore wind and associated with the NOWITECH research team. The SC has also started a research school for PhD and Post Doc candidates to enhance the quality of education and research. During 2011, professors and scientific staff at NTNU with relations to NOWITECH were supervisors for 28 Master Degree theses within offshore wind.

The main activities in 2011 were:

- Documentation of the results from the work packages through journal papers, conference papers, reports etc; in total 110 publications in 2011.
- Software development and application for design and analyses of offshore wind technologies.
- Participating in national and international activities in order to influence future offshore wind research strategies, establish and maintain international R&D networks, and become a partner in new R&D projects on offshore wind energy.
- Developing specifications for the 10 MW NOWITECH reference wind turbine; a multidisciplinary activity established to generate and support cooperation between the work packages.
- Publishing three issues of NOWITECH Newsletter for enhancing dissemination of results to partners and relevant external companies and organisations.
- Preparation of NOWITECH internal industry workshops/meetings within all WPs.

- Organisation of open workshops:
  - A Wind Power R&D seminar hosting above 200 delegates in Trondheim and a workshop seminar in Bergen on wake effects, both jointly with NORCOWE.
  - A seminar in UK on North Sea Offshore Electricity Grids jointly with CEDREN and UK organisations.
- In collaboration with NORCOWE, further developing the joint application NOWERI (Norwegian Offshore Wind Energy Research) through a pre-engineering phase as well as preparing the legal basis for ownership and contract negotiations with the Research Council of Norway.

Fedem Technology, Norway, became a new industry party in NOWITECH in 2011, while Nanyang Technological University (NTU), Singapore, joined as a new associate research party. TrønderEnergi withdraw from NOWITECH 1 January 2011 because of reconsiderations regarding their strategy on offshore wind energy.

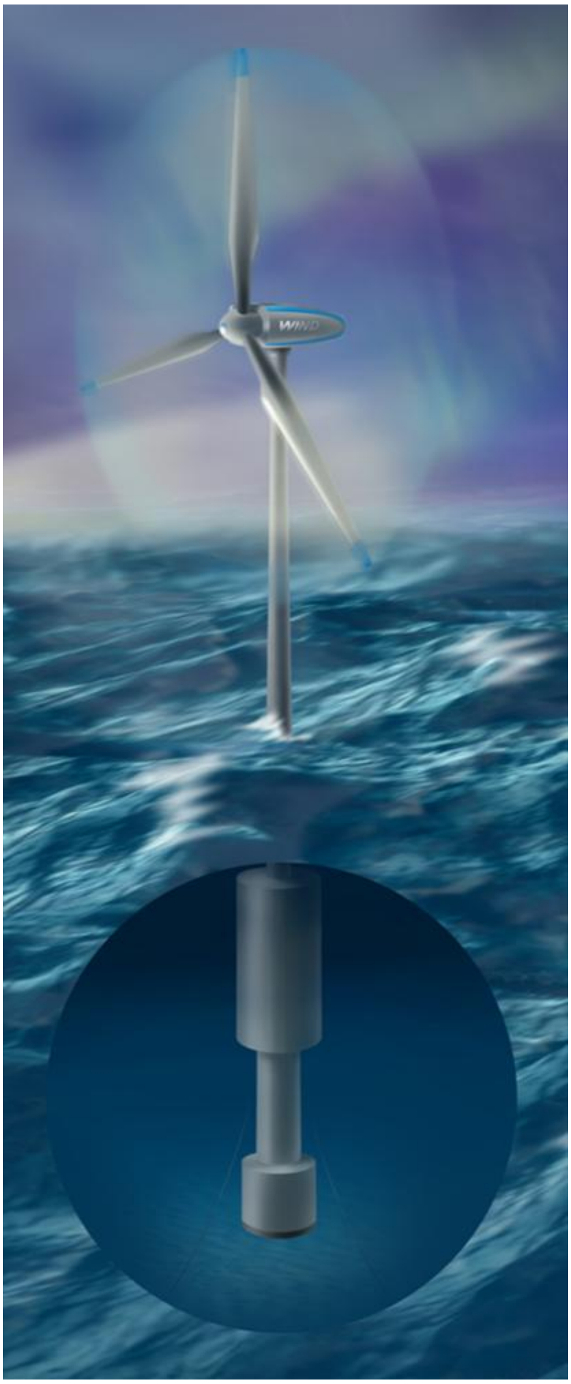
New agreements of cooperation were signed in 2011 with Windcluster Mid-Norway (WMN) and Access Mid-Norway (AMN). WMN is an industry cluster promoting business and economic development for wind energy in Norway, and will strengthen NOWITECH contact with SMEs. AMN will appoint a business development manager for three years to attract new business focusing on offshore wind (NOWITECH) and smart grids.

The accumulated costs in 2011 was NOK 44,4 millions co-funded by the Research Council of Norway, the industry parties and the research parties.

Stories of Innovations

In this section we are presenting four stories of innovations by NOWITECH. We believe these stories are good examples of what NOWITECH is about. The stories can be read as an introduction to the annual report, or they can be read independently.

Optimization of floating support structure



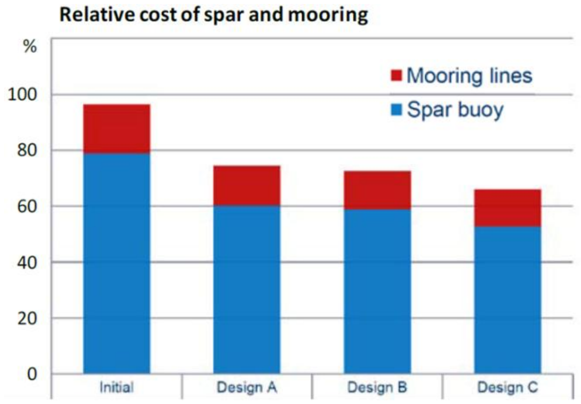
An efficient tool for optimization of floating support structure for deep water wind turbines has been developed in NOWITECH.

WINDOPT is a program for conceptual optimization of floating wind turbine support structure of the spar buoy type, including mooring system and power cable. Optimization in this context is the same as minimizing the material cost while satisfying functional and safety related design requirements.

Typical design requirements (constraints) considered are: Vessel motion, tower inclination, tower top acceleration, cable tension and curvature radius, mooring line load limitations and minimum fatigue life, minimum horizontal line pretension, and maximum offset.

The program utilizes efficient design tools for analysis of mooring system forces and vessel motions, and combines this with a gradient method for solution of non-linear optimization problems with arbitrary constraints.

Test cases show that WINDOPT can give significant savings in the spar buoy design, mooring system and power cable.



Read more in articles and reports at NOWITECH e-room (for NOWITECH partners only).

Contact person in NOWITECH: Petter Andreas Berthelsen, p.a.berthelsen@marintek.sintef.no

The 10 MW reference turbine

NOWITECH reference turbine	
Nominal power output	10 MW
Design wind velocity	13.0 m/s
Tip speed ratio	7.7
Hub height	93.5 m
Turbine diameter	141 m
Design water depth	60 m

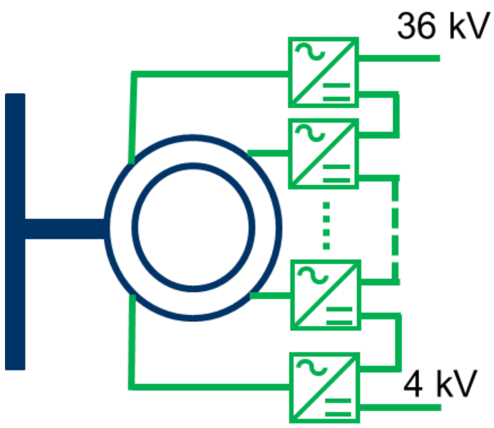
How does the future of wind energy look like? Present trends suggest that 10 MW machines are within reach, and the next generation of wind turbines will be larger machines of this size.

Within NOWITECH an initial design of a 10 MW turbine has been specified that incorporates a number of state-of-the-art features. A main purpose is to facilitate a common basis for exploring new design ideas of the wind turbine, sub-structure, grid connection and operation and maintenance.

The initial design is for a water depth of 60 m and a wave climate resembling the Doggerbank site. A novel full-height lattice tower has been developed that promises less steel weight and cost than the traditional hybrid solution where a tubular tower is connected to an offshore jacket by an expensive transition piece.

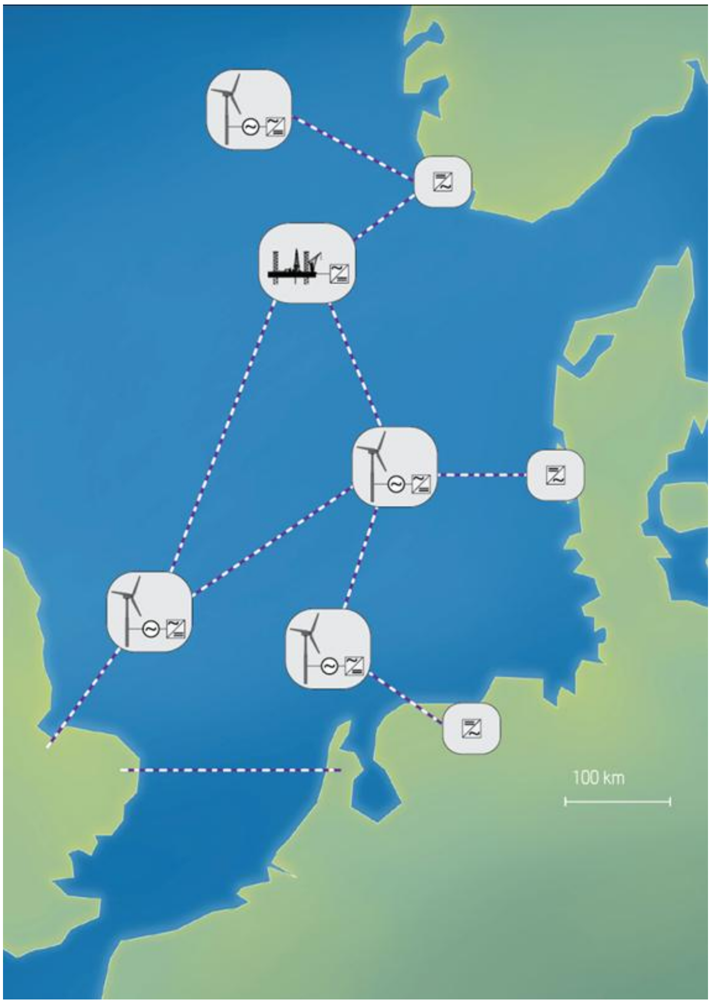
Another novel concept included in the reference turbine is a special segmented direct drive generator connected to modular power electronic AC/DC-converters. Here the DC-output of the converters are connected in series stepping the voltage up to 36 kV DC. Advantages include omitting the need for a step-up transformer inside the wind turbine and a modular design reducing cost.

Full details and publications related to the 10 MW reference turbine can be found at NOWITECH e-room (for NOWITECH partners only). Open info is available at web.



Contact person in NOWITECH:
Prof Ole Gunnar Dahlhaug, ole.g.dahlhaug@ntnu.no / Post Doc Karl Merz, karl.merz@ntnu.no

Cost effective offshore grid configurations



A North Sea multi-terminal high voltage DC grid has the potential to improve security of supply when interconnecting offshore wind farms and oil and gas platforms with the European power grids:

- A multi-terminal HVDC grid in the North Sea can effectively integrate the UK, UCTE and Nordic power systems
- The power system can be operated as ***one*** control area (if desirable)
- Reserves can be shared without "technical constraints"
- Fast control and protection will enable network splitting to avoid risk of cascading outages and complete blackouts
- The offshore grid can integrate the power markets across the asynchronous areas.

A key challenge is to identify cost-effective offshore grid configurations. This is addressed in NOWITECH.

A method is developed extending the mixed-integer linear programming approach to transmission expansion planning and accounting for variations in wind power generation and load. The method is demonstrated by a case study of the North Sea region. The method can be further developed for optimization of grids between wind farms in clusters.

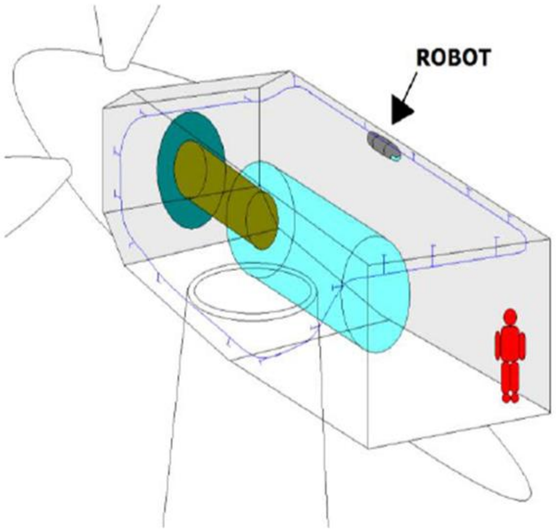
See article at NOWITECH e-room for further reading (requires password, for NOWITECH partners only).

Contact person in NOWITECH: Prof Kjetil Uhlen (Kjetiluh@elkraft.ntnu.no)

Remote presence reduces O&M costs

It is costly and sometimes impossible to have maintenance staff visiting offshore turbines. Can some of these visits be avoided by a new concept for remote presence?

Responding on this**, in NOWITECH, a preliminary design of a complete remote presence system for O&M of an offshore wind turbine has been prepared**.



A remote presence system makes it possible to feel present and perform work at a remote location, like O&M operations at an offshore wind turbine. Such a system has the potential to significantly reduce the need for manned maintenance visits, since some O&M operations can be performed without having to leave the office. Less transportation is both cost-effective and environmentally friendly.

Development of the concept is on-going, including preparation of a scaled rig that demonstrates the remote presence system.

Read more in article at NOWITECH e-room (requires password, for NOWITECH partners only)

Contact person in NOWITECH:
Jørn Heggset (Jorn.Heggset@sintef.no) / Prof. Amund Skavhaug (amund.skavhaug@itk.ntnu.no)

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1 VISION AND OBJECTIVE

VISION

- Contribute to large scale deployment of deep sea offshore wind turbines
- Be an internationally leading research community on offshore wind technology enabling industry partners to be in the forefront.

OBJECTIVE

Provide pre-competitive research laying a foundation for industrial value creation and cost-effective offshore wind farms. Emphasis is on "deep-sea" (+30 m) including bottom-fixed and floating wind turbines.

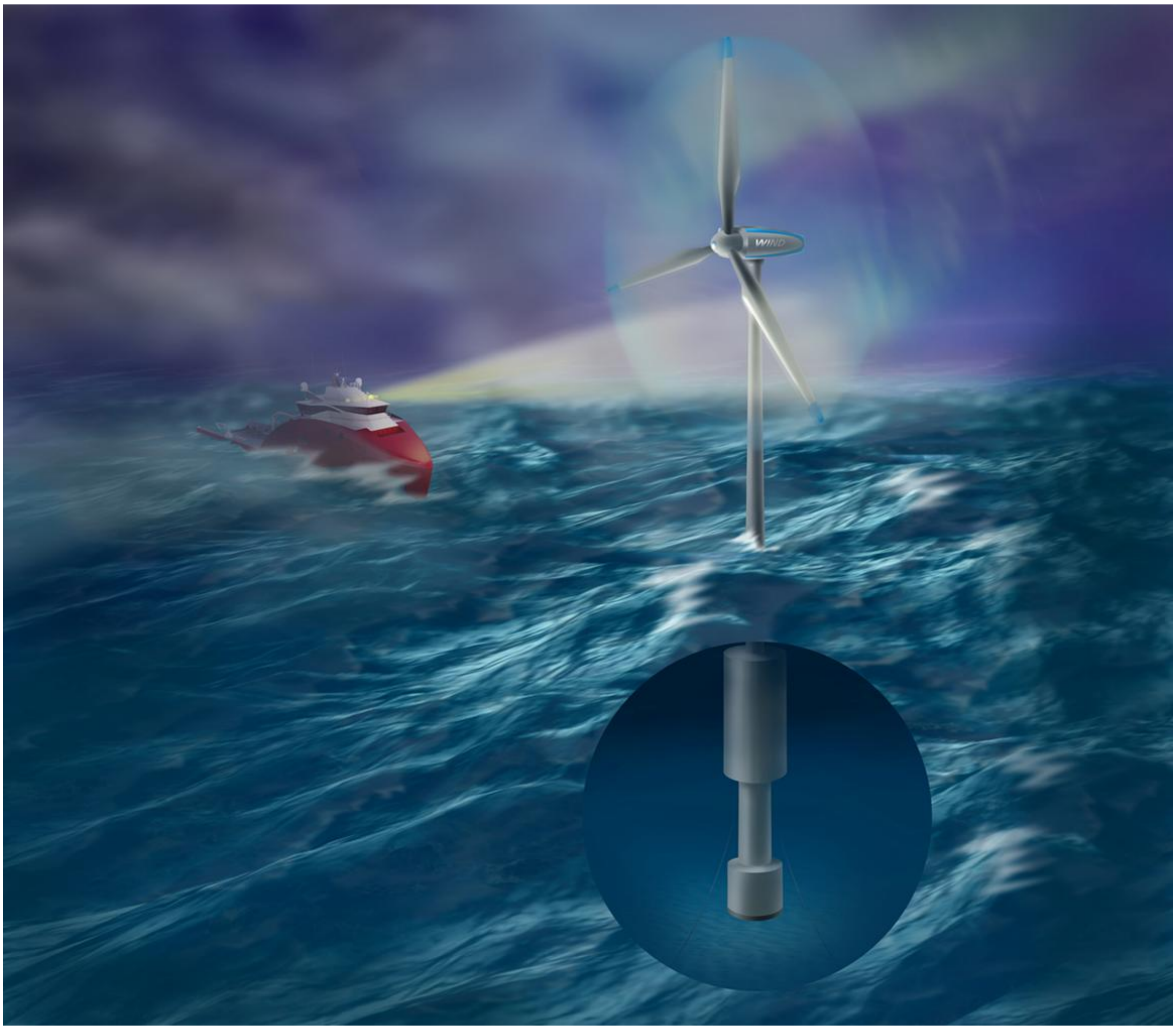


Figure 1 Illustration of an offshore wind turbine on a floating spar sub-structure together with a vessel.

2 RESEARCH PLAN AND STRATEGY

2.1 CHALLENGE AND POTENTIAL

The EU 2020 target implies a massive installation of offshore wind. A ballpark estimate is investments of NOK 750 billions for installation of offshore wind farms in European seas during the next 10 years. About 4 GW of offshore wind farms have so far been installed, whereas plans for Europe indicate 40 GW by 2020 and 150 GW by 2030. Other regions, in particular China, Japan, South Korea and USA also have advanced plans for large scale development of offshore energy. A main challenge for NOWITECH is to contribute towards innovations leading to cost reductions of offshore wind energy. See also Figure 2.

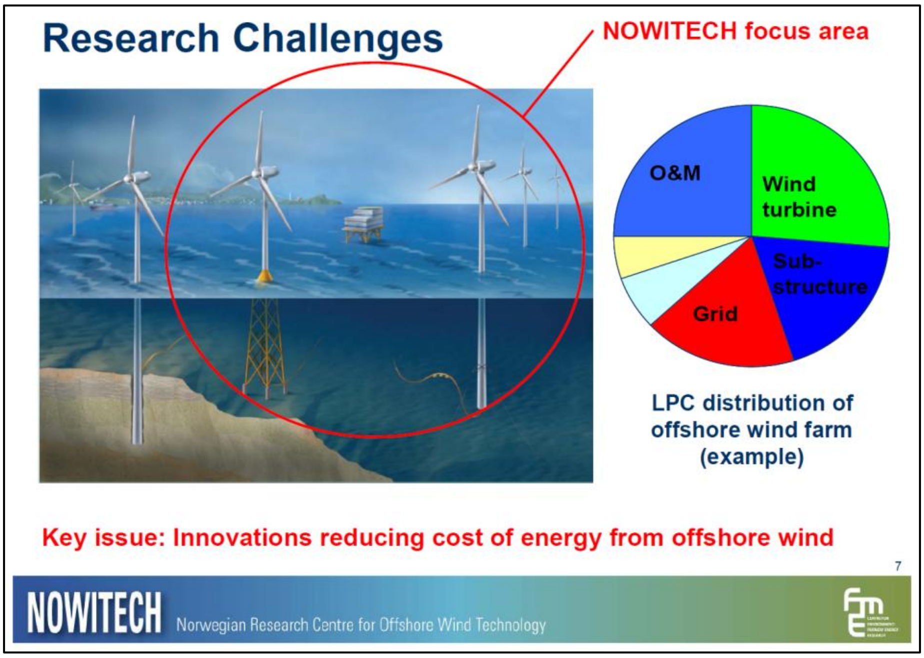


Figure 2 NOWITECH focus area and research challenge.

The potential for wind farms at deeper water is huge provided that costs can be reduced to a competitive level. This requires development of offshore technology, and within this field Norwegian industry and research units are in the forefront. Examples are sub-structure design and supply by Kverner Verdal, subsea cables by Nexans Norway, HyWind by Statoil, novel generator design by SmartMotor, Statkraft and Statoil's development of offshore wind farms in UK (Sheringham Shoal and Dogger Bank), and Vestavind Offshore's development of Havsul. In total more than 140 companies in Norway are engaged in the offshore wind industry[1]. Considerable research efforts are needed to support this development.

New offshore wind farms are expected to be large, e.g. Dogger Bank is planned for 9 GW and located 125 to 195 km from shore. The environmental conditions here differ considerably from standard onshore conditions and new different design specifications have to be taken into account. This gives a basis for development of novel wind turbine concepts optimized for operation at rough offshore conditions. The distant offshore location and size of installations further calls for development of new systems for maintenance, grid connection and system integration.

[1] Intpow, Offshore Wind Norway. Market and Supply Chain 2011.

2.2 NOWITECH'S APPROACH

The Centre comprises interdisciplinary tasks that are required for successful development of offshore wind farms. Emphasis is on "deep-sea" (+30 m) including bottom-fixed turbines and floaters. The Centre will

- Combine wind technology know-how with offshore and energy industry experience to enhance development of offshore wind.
- Establish a recruitment and educational programme that provides for highly qualified staff at Master and PhD level for serving the industry.
- Build strong relations with selected top international research partners.
- Facilitate active involvement by industry partners to ensure relevance and efficient communication and utilization of results.
- Support to industry is through pre-competitive research – commercial development will come as a result and be run in separate projects.
- Actively pursue opportunities to increase R&D activity on critical issues.

The research is carried out in six work packages (WPs):

- WP 1: Development of integrated numerical design tools for novel offshore wind energy concepts. The goal is establishment of a set of proven tools for integrated design of deep-sea wind turbines, hereunder characterization and interaction of wind, wave and current.
- WP 2: Investigation of new energy conversion systems for offshore wind turbines. The goal is to contribute to the development of efficient, low weight and robust blade and generator technology for offshore wind turbines.
- WP 3: Identification and assessment of novel substructures (bottom-fixed and floaters) for offshore wind turbines. The goal is to pin-point cost-effective solutions for deep-sea wind turbines.
- WP 4: Assessment of grid connection and system integration of large offshore wind farms. The goal is to develop technical and market based solutions for cost-effective grid connection and system integration of offshore wind farms.
- WP 5: Development of operation and maintenance (O&M) strategies and technologies. The goal is to develop a scientific foundation for implementation of cost-effective O&M strategies and technologies for offshore wind farms.
- WP 6: Assessment of novel concepts for offshore wind turbines by numerical tools and physical experiments, hereunder developing control systems and combining results from WP1 and WP5. Assessment is by numerical tools and by utilizing "in-house" labs and results from full scale field tests (e.g. HyWind).

The WPs are closely interlinked (see Figure 3) with a joint aim to provide new knowledge, tools and technologies as basis for industrial development of cost-effective offshore wind farms at deep sea. The research is mainly of pre-competitive nature including a strong PhD and post doc programme. Dissemination of results are through international conference papers, continuation and development of the established yearly wind R&D seminar in Trondheim[2], work-shops for industry and public bodies, newsletters and web.

[2] http://www.sintef.no/deepwind_2012

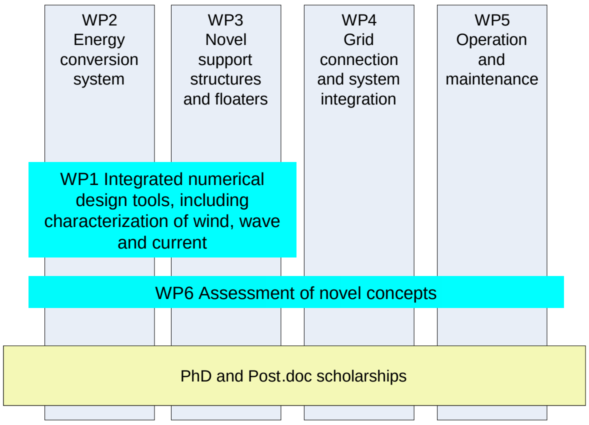


Figure 3 Interplay between work packages

Work is carried out in coordination with the two other CEERs (Centres for Environmental Energy Research; in Norwegian: FME) on offshore wind, CEDREN and NORCOWE. Together, the three centres contribute to a strong research effort on offshore wind, see Figure 4. There is, however, still need for further increase in the research efforts. NOWITECH will in coordination with CEDREN and NORCOWE continuously seek opportunities to establish new research projects, research infrastructure as well as test and demonstration projects. NOWITECH and NORCOWE are also collaborating through their Scientific Committees (SC). Trond Kvamsdal is representing NOWITECH in NORCOWE's SC, while Ivar Langen represents NORCOWE towards NOWITECH's SC.

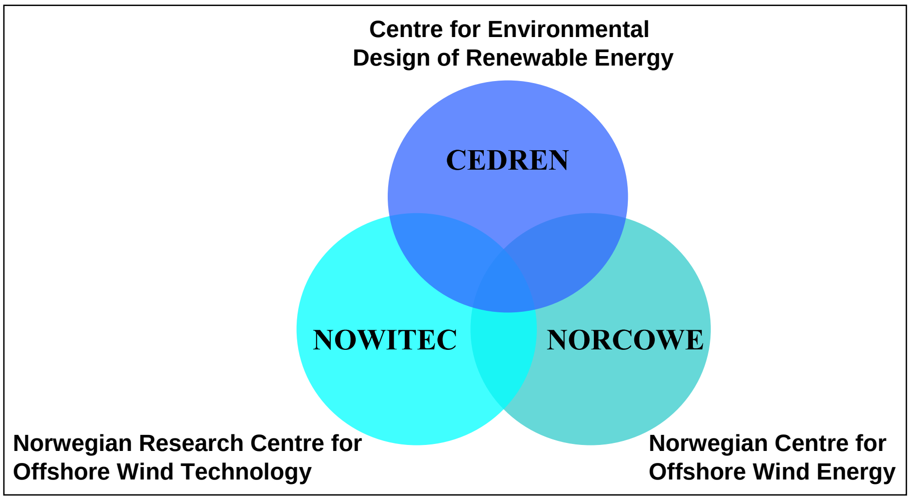


Figure 4 The three CEERs constitute a strong cluster on offshore wind.

3 ORGANISATION

3.1 GOVERNANCE STRUCTURE

NOWITECH is organised as shown in Figure 5.

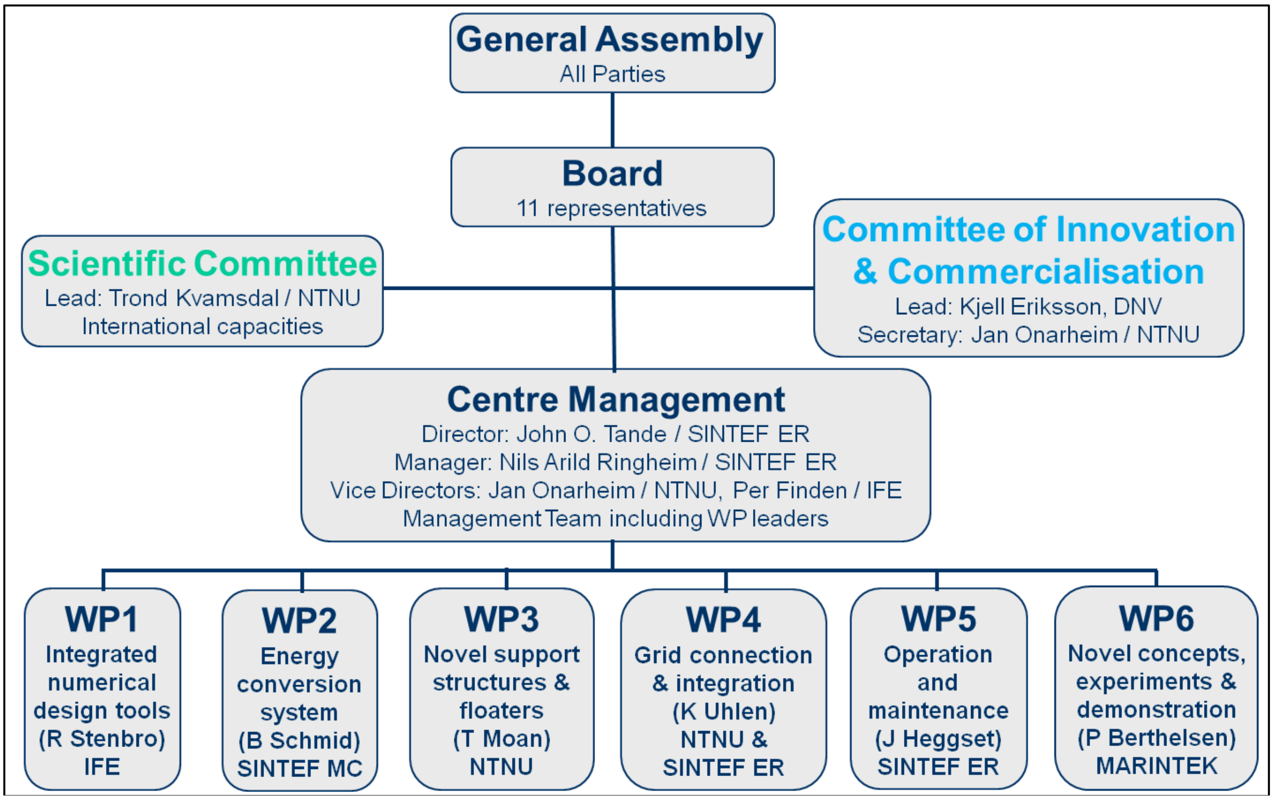


Figure 5 Outline of governance structure for the NOWITECH Consortium (2011).

The General Assembly is the ultimate decision making body of the Consortium where all partners are represented.

The Board is the operative decision-making body for the execution of the Consortium with 11 members: Eight from industry, one from SINTEF, one from NTNU and one from IFE. The Board members in 2011 were: Sverre Aam (chairman; SINTEF), Kjell Eriksson (DNV), Jean-Benoitz Ritz (EDF), Frode Berge (Fugro Oceanor), Martin Degen (GE Wind Energy), Per Finden (IFE), Johan Hustad (NTNU), Jørgen Krokstad (Statkraft), Gudmund Per Olsen (Statoil), Jens Jakob Wedel-Heinen (Vestas), Dag T. Breistein (Vestavind Offshore)

Industry partners are involved through representation in General Assembly and Board and through direct involvement in the Work Packages and their reference groups.

The host institution, SINTEF Energy Research, has John Olav Tande as the Centre Director.

NOWITECH is managed by the Centre Director in close cooperation with the Centre Management Group (CMG). The CMG consists of the Centre Director, Centre Manager, two Vice Directors, the Work Package leaders, representatives from the Scientific Committee and Committee for Innovation and Commercialisation and other staff appointed by the Centre Director. The CMG meets on a regular basis, typically once a month.

3.2 SCIENTIFIC COMMITTEE

The Scientific Committee (SC) is developing a top quality PhD and post doc programme in collaboration with CMG. This includes an active recruitment strategy, invitation of international capacities for giving lectures, arrangements of scientific colloquia and seminars, and exposing scholars to industry and leading international research groups. The members of the SC are listed below:

- NTNU-members
  - Geir Moe, (chairman until 2011-08-31)
  - Tore Undeland, NTNU
  - O.G. Dahlhaug, NTNU
  - Trond Kvamsdal, NTNU (chairman since 2011-09-01)
  - Torgeir Moan, NTNU
  - Marta Molinas, NTNU
  - Jan Onarheim, NTNU
  - SC Secretary, Debbie Koreman, NTNU
- Other Norwegian members
  - Tor Anders Nygaard, IFE
  - Ivar Langen, UiS
  - Finn Gunnar Nielsen, Statoil
  - Terje Gjengedal, UMB
- Associated members
  - Paul Sclavounos, MIT, USA
  - Senu Sirnivas, NREL, USA
  - Peter Hauge Madsen, Risø-DTU, Denmark
  - Hans-Gerd Busmann, Fraunhofer IWES, Germany
  - William E. Leithead, Strathclyde University, UK
  - Gerard J.W. van Bussel, TU Delft – Aerospace Engineering Wind Energy (DUWIND)
  - Seri Lee, Nanyang Technological University (NTU), Singapore

In memory of
Professor Geir Moe (1938-2011)

Professor Geir Moe passed away 73 years of age at 3 December 2011 after some months of serious illness. Geir Moe was one of the pioneers in wind energy at NTNU. He was a much appreciated colleague and a great inspiration for all who worked with him. He headed the Scientific Committee of NOWITECH and developed a strong team at NTNU within offshore wind constructions. Geir Moe was an excellent scientist and always appeared very enthusiastic and positive in his work. He made a great contribution to the development of NOWITECH and offshore wind technology. We remember him with respect and joy.

John Olav Tande
Director NOWITECH

3.3 COMMITTEE FOR INNOVATION AND COMMERCIALISATION

The Committee for Innovation and Commercialisation (CIC) enhances industry involvement, ensures industry relevance within the research of NOWITECH, pursues possibilities for establishing new projects, services or processes with partners and contributes to commercialisation of relevant ideas created in NOWITECH. The committee is industry driven, with chairman Kjell Eriksson (DNV) and secretary Jan Onarheim, NTNU.

3.4 NOWITECH PARTNERS

The NOWITECH Consortium Partners in 2011 are listed below:

The Host Institution:
SINTEF Energy Research

Research Partners:
Norwegian University of Science and Technology (NTNU)
Institute for Energy Technology (IFE)
Norwegian Marine Technology Research Institute (MARINTEK)
Stiftelsen SINTEF (SINTEF)

Industry partners:
Kværner Verdal (former Aker Solutions)
Devold AMT AS
Det Norske Veritas AS (DNV)
DONG Energy Power AS
EDF R&D Division
Fedem Technology
Fugro OCEANOR AS
GE Wind Energy (Norway) AS
Lyse Produksjon AS
NTE Holding AS
SmartMotor AS
Statkraft Development AS
Statnett SF
Statoil Petroleum AS
Vestas Wind Systems AS
Vestavind Kraft AS

"DONG Energy is supporting NOWITECH and has particular interest in the work streams on bottom fixed and floating foundations as well as grid connection and system integration. DONG Energy finds that the research activities and development of new calculation tools and models contribute to pave the way for new offshore wind power solutions in both the medium and long term. Therefore DONG Energy is pleased to support the NOWITECH program and to follow and influence the work that is being carried out."

Jørn Scharling Holm
Dong Energy's representative in NOWITECH's General Assembly

In addition NOWITECH has agreements on cooperation with the following associate partners:

Associate research partners:
Massachusetts Institute of Technology (MIT), USA
National Renewable Energy Laboratory (NREL), USA
Risø-DTU, Denmark
Fraunhofer IWES, Germany
University of Strathclyde, UK
TU Delft, Netherlands
Nanyang Technological University (NTU), Singapore

Associate industry partners:
Innovation Norway, Enova, NCE Instrumentation, NORWEA, NVE, Energy Norway, Navitas Network, Windcluster Mid-Norway

4 SCIENTIFIC WORK AND RESULTS

This section presents the objectives and tasks of the existing work packages (WP) in NOWITECH as well as some of the results achieved in 2011.

4.1 MANAGEMENT AND COORDINATION (WP 0)

The objective is to manage and coordinate the activities of NOWITECH, ensuring progress and cost control according to approved plans.

The Work Package is divided into four tasks:
0.1 Start-up of centre (Completed)
0.2 Management
0.3 Outreach activities
0.4 Integration activity

The Management activity takes care of the day-to-day operation of the Centre. This includes follow up on administrative, financial and legal issues, meetings in the CMG with WP leaders and representatives from the SC and CIC, preparations for the GA and Board, reporting to the RCN etc.

CMG meetings have been held about once every month to a total of eleven for 2011. These are mainly for team-building, information exchange and strategic discussions. In addition web-based meetings with WP leaders are used for follow up on day-to-day business and administrative issues from the administration.

Two Board meetings were held in 2011, i.e. one in June and one in November. Both meetings were combined with a workshop the day before. The June workshop discussed NOWITECH strategy, while the November workshop presented results from the work packages. The work plans for 2012 were approved by the Board during the meeting in November.

The annual GA meeting was held in combination with the November Board meeting and workshop. During this meeting the GA elected SmartMotor as a new member of the Board replacing Fugro Oceanor from 1 January 2012.

Contact by e-mail and electronic voting have been applied between the Board and GA meetings for approval of new associated research partner, industry parties, agreement of co-operation with other organisations etc.

The research parties of NOWITECH appreciate the active participation of the industry parties in the GA, the Board and the reference group meetings of the different work packages.

The Research Council of Norway made a site visit to NOWITECH in May 2011. NOWITECH received a positive feedback from the Research Council after the site visit.

Figure 6 The Research Council of Norway on site visit at NOWITECH in May 2011. PhD student Pål Egil Eriksen holds a presentation about his work in the wind tunnel.

The Outreach activity includes preparing general presentations of the Centre, dissemination of results, keeping contact with prospect new industry parties, overall coordination towards other projects, relevant organisations and CEER's, in particular CEDREN and NORCOWE, and engagement in developing offshore wind projects and research strategies.

In 2011 dissemination of research results to partners and relevant external companies and organisations were enhanced by preparation of NOWITECH newsletters. Three editions were published and the feedback from the industry partners was very positive. See also section 7 for more information.

The activity on finding new industry parties resulted in that Fedem Technology (Norway) joined NOWITECH in 2011. In addition, NTU (Singapore) became a new associated research partner. TrønderEnergi withdraw from NOWITECH 1 January 2011 because of reconsiderations regarding their strategy on offshore wind energy.

New agreements of cooperation were signed in 2011 with Windcluster Mid-Norway (WMN) and Access Mid-Norway (AMN).

- WMN is an industry cluster promoting business and economic development for wind energy in Norway, and will strengthen NOWITECH contact with SMEs.
- AMN will appoint a business development manager for three years to attract new business focusing on offshore wind (NOWITECH) and smart grids.

Examples of engagement in developing offshore wind projects and research strategies are:

- Participation in the task force on wind energy in Energi21 suggesting future research strategy for wind energy in Norway,
- Contributing to outlining the need for offshore wind demonstration projects suggesting Demo2020,
- Participation in the European Technology Platform on Wind (TPwind) heading the working group on offshore wind and
- Taking a lead in developing the sub-programme on offshore wind energy in the European Energy Research Alliance (EERA) joint programme on Wind Energy.

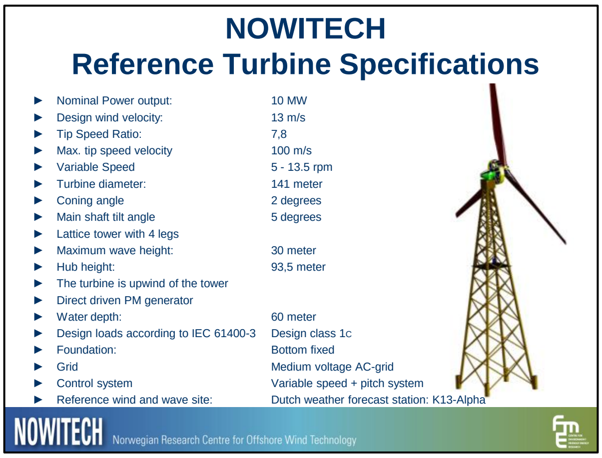
International engagement is further described in section 5.

Close cooperation with CEDREN and NORCOWE is established. Examples of cooperation are:

- A joint application with NORCOWE on Norwegian Offshore Wind Energy Research Infrastructure (NOWERI), granted by the Research Council of Norway, has been further developed through a pre-engineering phase. The infrastructure will include an offshore met-mast and a floating wind turbine as platform for open research. The project is now finalising the legal basis for the ownership and contract negotiations with the Research Council of Norway.
- NOWITECH and NORCOWE jointly organized a Wind Power R&D seminar hosting approximately 200 participants in Trondheim, January 2011.
- A common workshop on wake effect was arranged by NOWITECH and NORCOWE in October 2011, see section 5.1.
- A seminar on North Sea Offshore Networks was organized by CEDREN, NOWITECH and UK organisations in London June 2011
- Meetings between the management of NORCOWE, CEDREN and NOWITECH for overall coordination, information exchange, etc.
- Various joint workshops and meetings between the researchers as part of the activity of the scientific WPs.

The integration activity shall improve the common understanding of challenges and their interplay between the WPs, and may potentially lead to new innovative ideas and solutions that exist in the boarders of a traditional split between the engineering sciences.

The main activity in 2011 was the NOWITECH reference turbine, a multidisciplinary activity established to generate and support cooperation in between the work packages. Researchers, PhD and Post Doc candidates accomplished three workshops in 2011 with the objective to define the main design criteria and specifications for a 10 MW reference turbine. The results were summarized in a report. Detailed design of tower and turbine blades have been carried out, while design of i.a. hub, nacelle and bearing are in progress. Eight publications are written on the reference turbine since 2010 and six more are ready to be presented on the DeepWind conference in Trondheim in January 2012.



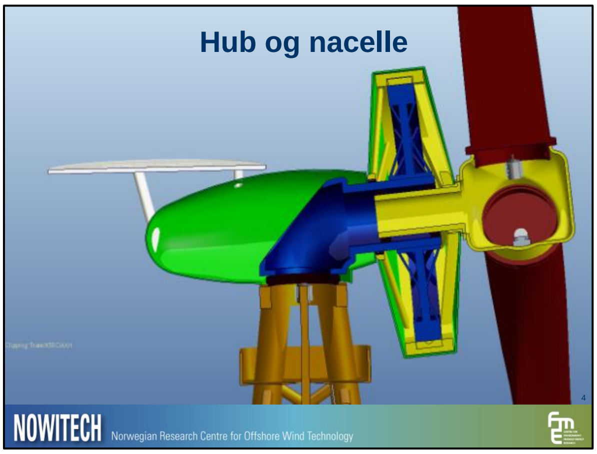


Figure 7 NOWITECH reference turbine. Summary of specifications (left) and extract from hub and nacelle construction (right).

The integration activity also included two internal strategy seminars, where topics like NOWITECH's strategic road map, teamwork, how to improve industry contact and involvement were discussed.

NOWITECH Days is a third integration activity. This was prepared in June 2011 as an internal seminar for all students and researchers involved in NOWITECH. It included presentation of all PhD and Post Doc students, both by posters and by oral presentations.

Several spin-off projects have arisen from the NOWITECH consortium, see section 4.9.

4.2 INTEGRATED NUMERICAL DESIGN TOOLS (WP 1)

The objective is establishment of a set of proven offshore wind turbine simulation tools for integrated design of deep-sea wind turbines, hereunder enhanced knowledge of wake, wind, wave and current. The WP is divided into two tasks.

1.1 Software development
1.2 Wake, wind, waves and ocean current

WP1 develops software that accurately simulates the behavior of wind turbines. Such tools are vital to those doing research, development and engineering of whole wind turbines and their components. Tools for optimization of components and systems are also part of the scope. The research activity includes the interaction of waves, current and wind, which is the origin of motion, loads and power output of an offshore wind turbine.

Major achievements/highlights:
- WP1 is up and running well with a strong group of people from the both industry and R&D partners.
- First generation software from both MARINTEK and IFE for integrated simulations of slender floating offshore wind turbines developed and verified
- Second generation integrated models 3DFloat from IFE for turbines with bottom fixed jacket foundation verified in IEA OC4. The tool also now supports tension leg buoy concepts (TLB) which have been extensively investigated.
- A software tools for optimization of spare type offshore wind turbines and one general tool that can be used with most numerical models has been developed. They have been applied to spare horizontal axis, spare vertical axis, TLB and 5 MW 1-, 2- and 3-bladed rotors.
- Good results with full 3D CFD wake simulations of a wind turbine park and single rotor are provided and a wake work shop and blind test has been accomplished jointly with NORCOWE.
- Generally high productivity of deliverables

All four PhD/Postdoc positions are engaged, are progressing well and have started to deliver R&D results, see appendix A.1.3.

Both Fugro OCEANOR and Fedem Technology have industry in-kind contribution in WP1: Fugro OCEANOR has contributed to task 1.2 with in-kind in the form of reports. FEDEM has contributed with software licenses in task 1.1. Industry involvement is shown in section 4.8.

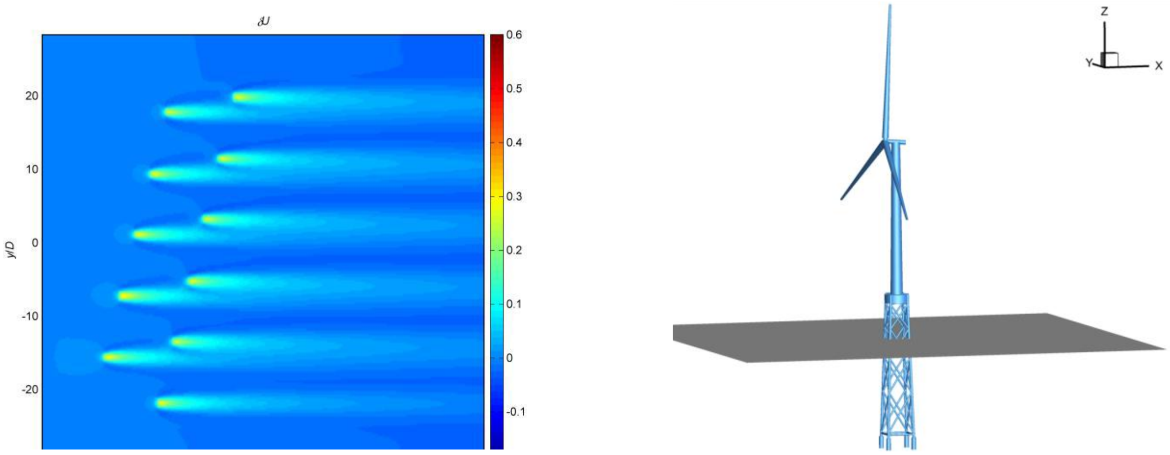


Figure 8 3D CFD wake simulation of Vindeby offshore wind farm compared well will with measurements (left). Integrated simulations of jacket offshore wind turbines with NOWITECH developed software performed well in the international comparison IEA Annex 30 OC4 (right).

4.3 ENERGY CONVERSION SYSTEM (WP 2)

The objective is to contribute to the development of efficient, low weight and robust blade and generator technology for offshore wind turbines.

WP2 has been structured into two tasks in 2011:
2.1 Rotor blades
2.2 Generators

The energy conversion system of the offshore wind turbines being installed today are basically as for onshore wind turbines. The expectation is that significant life-cycle cost reductions can be achieved by developing an energy conversion system specifically for offshore conditions. The research activities given in WP2 are defined in order to “bridge” the competence gaps and to create a basis for innovation necessary to move beyond the today’s “show stoppers” that the industry is facing..

Two main conceptual topics have been treated in task 2.1 Rotor blades:
- Smart blade technology involving actuator and sensor concepts.
- Influence of material and process parameters on fatigue of composites.

Generator design has been approached in task 2.2 by modeling and understanding the thermal and electromagnetic conditions in new design.

Major achievements/highlights:

- Fatigue properties of composite materials for wind turbine blades
  Fatigue testing of laminates is mostly completed and data is being analyzed. Voids have a clear detrimental effect on fatigue performance at high loads, but they seem to be less critical at low load, i.e. at high number of cycles. Carbon-glass hybrid laminates improve fatigue performance compared to pure glass. The effect of stitching pattern is under investigation.
- Modelling approach for assessment of fatigue properties of composite materials
  The Kinetic of Fracture theory, which is basically a combination of continuum and multiscale theory, has been chosen to predict fatigue behavior of laminates. The goal of the methodology is to predict mean fatigue behavior and not the absolute probability of failure; in this sense the method is intended to be used as a design tool to compare different layups, materials, and structural variations so that fatigue damage can be minimized in a particular structural design.
- Structural design and analysis of a 10 MW wind turbine blade
  A study has been undertaken to determine an accurate composite ply layup of the structural components of a 70 m wind turbine blade to be used as a reference case for future industry and research projects. The ply layup of the reference blade shall be modified to incorporate bend-twist coupling in an attempt to increase the amount of energy captured through adaptive pitching techniques.

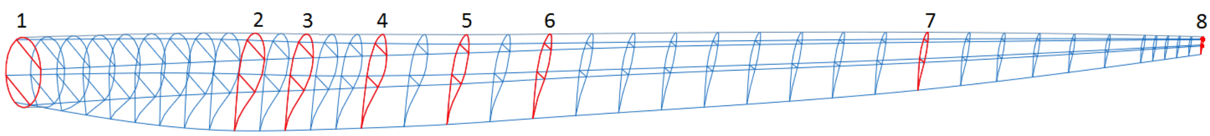


Figure 9 Shell of 10 MW wind turbine blade split into 39 sections along the length used as reference case.

- State of the Art in Generator Technology for Offshore Wind Energy Conversion Systems
  An overview and analysis of the state-of-the-art generator technology for offshore wind energy conversion systems (WECS) has been made in order to identify the current technology frontier and development trends. Key Performance Indicators (KPI) were chosen for in-depth evaluation of the drive trains: total drive train efficiency and generator weight. A

novel way of comparison of various generator technologies on weight in the form of a map power density vs. torque density' was proposed. The map allowed showing the technology state of art and frontier for all the existing generator solutions independent of speed and power.

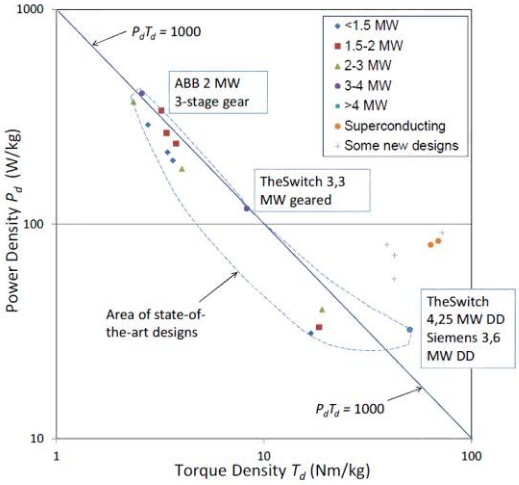


Figure 10 Map showing power density vs. torque density for electrical generators for offshore wind turbines.

Two PhD students working on "Lift control of wind turbine blades" and "Novel generator concepts" proceeded their work as planned in 2011. A third PhD student on the topic of "Magnetic forces and vibrations in wind power generators" started his study on the turn of the year 2010 to 2011.

The PostDoc working on "Influence of material and process parameters on fatigue of wind turbine blades" left his position in fall 2010, but was replaced by a temporarily employed researcher familiar with the field.

Devold AMT and SmartMotor have been heavily involved in WP2 during 2011.
Contribution of Devold AMT has been on scientific guidance and defining industrial relevance besides supplying material samples to the project. SmartMotor is deeply involved in supervision and guidance of the PhD students within generator modeling, but has also made valuable results of their in-house research available to the project. An example is the work on key performance parameters for comparison and benchmarking of different generator technologies and outlining future generator development.

Industry involvement is shown in 4.8.

4.4 NOVEL SUPPORT STRUCTURES AND FLOATERS (WP 3)

The objective is to develop novel, cost-effective support structures for deep-sea wind turbines. This goal is addressed by the following three tasks:

3.1 Bottom-fixed support structures
3.2 Floating support structures
3.3 New coatings

The first two tasks deal with the analysis and design of alternative concepts for bottom-supported and floating support structures for wind turbines by assessing design criteria, establising benchmark analysis procedures for evaluating the structural effects of wave, current and wind loads on different wind turbine concepts. The third task addresses existing and novel coatings for surface protection of offshore wind turbine support structures.

Major achievements/highlights:

- A NOWITECH project across WPs with the aim of jointly designing a 10 MW reference turbine for research activities was initiated in the last quarter of 2011 through three workshops. WP3 members (NTNU BAT) lead the design of the support structure.
- Advances on assessing analysis tools applicable to floating and fixed offshore structures supporting wind turbines, including:
    - Refinement of NIRWANA wind model: implementation of a aerodynamic rotor model and a second-order random wave model for bottom fixed turbines (by MARINTEK)
    - Integration of the Aerodyn and SIMO/Riflex codes and applying it to semi-submersible and tension-leg wind turbines (by MARINTEK and NTNU CeSOS)
- IFE and NTNU CeSOS have carried out analyses in the IEA OC4 benchmark study of software for wind turbines with jacket support structures.
- NTNU partners in WP3 tasks 3.1-2 have been involved in an EC FR7 project: the Marina Platform and Orecca as well as the HiPRwind project in 2011.
- SINTEF MC made the following achievements regarding corrosion protection systems for the support structure:
    - Cost effective duplex coating systems have been developed for corrosion protection in the atmospheric zone
    - One-coat instead of three-coat coating system was developed using modified coatings applied at Jotun. Field testing of coated panels at Helgoland since March 2011, indicate promising corrosion protection performance.
    - New paints modified with functionalized hybrid nanoparticles were tested in erosion tests, showing improved erosion performance.
    - Polyurethane (PU) coatings obtained by thermal spray were obtained and tested; with promising results.

The results are documented in publication listed in section A.3. Kværner Verdal contributed in-kind to the WP3 activities by offering an interesting workshop relating to the analysis and design of shallow water wind turbines. While 3 of the PhD candidates are well underway with their research, the fourth PhD candidate supported by this WP was engaged in August 2011, see appendix A.1.5.

Industry involvement is shown in section 4.8.

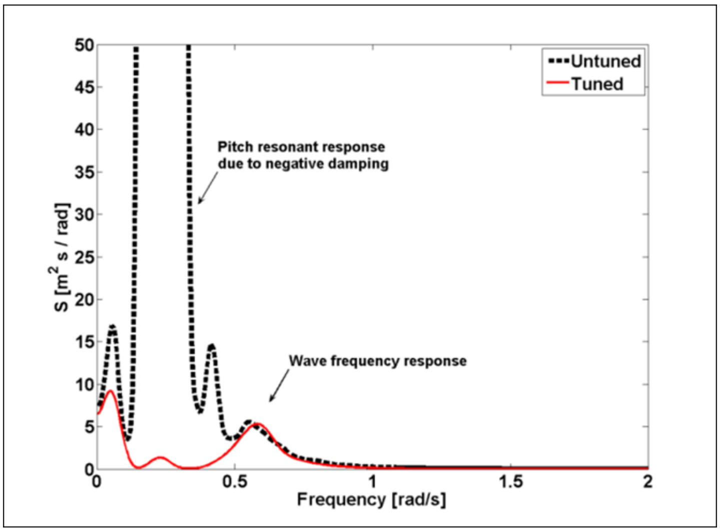


Figure 11 Spectrum of nacelle surge motion of a tension leg spar (TLS) with a downwind wind turbine under simultaneous wind and wave loading, and operating at an above rated wind speed. By tuning the controller, the pitch resonant motion was reduced, and the power production was significantly improved. (From Dr. Madjid Karimirad's thesis.)

4.5 GRID CONNECTION AND SYSTEM INTEGRATION (WP 4)

The objective is to develop technical and market based solutions for cost effective grid connection and system integration of offshore wind farms.The work is divided into three tasks:

4.1 Internal electrical infrastructure for offshore wind farms
4.2 Grid connection and control
4.3 Market integration and system operation

Offshore wind power is of little value unless the power plants are well integrated in the power system and able to compete successfully in the electricity market. This requires cost effective solutions on grid connection and system integration that will contribute to attract investments in offshore wind. The research activities in WP4 aim to remove barriers and close competence gaps on grid connection solutions, wind farm operation and control concepts, market design and regulatory issues. The main focus is on system analysis and model developments for simulation of wind farm operation and control. Moreover, models are developed for grid design and analysis in order to make recommendations on market adaptations and regulatory framework.

Main achievements in 2011 are related to wind farm measurements and model validations for power system studies, analysis of offshore grids including studies on integration of offshore wind farms with offshore platforms and further development and use of numerical tools for offshore grid design and analysis:

- On-going measurement campaigns have provided very good information about performance of existing wind farms related to power system behaviour, including power variations and voltage quality issues. The analyses of wind farm measurements and model validation have been completed and documented in 2011.
- Problems related to very high frequency transients when energizing offshore wind turbines through submarine cables have been investigated and have resulted in three scientific papers in 2011 (including one IEEE journal paper).
- Analysis of a 100 MW offshore wind farm connected to offshore oil and gas platforms has been documented (technical report). One master student has spent four weeks at Statoil in Bergen working on his thesis on this subject.
- Further work on the design and analysis of coordinated control of multi-terminal HVDC for offshore transmission grids have resulted in two scientific papers (including one IEEE journal paper).
- The numerical tools for offshore grid design and power market analysis (PSST and Net-op) continue to be extensively used within related R&D projects (KPN and EU-projects). Among these is the recently completed EU-IEE project “Offshore Grid”. The PSST simulation tool has been further improved, including representation of grid losses and with interface to the EMPS power market model. Studies related to North Sea area transmission grid expansion and the use of Norwegian hydro power as “Europe’s energy battery” (journal paper) have resulted from this development.

There has been a close collaboration with EERA (European Energy Research Alliance) on grid connection and offshore wind. Several on-going EU-projects are closely coordinated with the in WP4.

The progress on publications and deliverables has been very good. Three journal papers are written and accepted in 2011 as indicated above. In addition there have been several conference papers and presentations on offshore grid analysis and multi-terminal HVDC operation and control.

WP4 has organised a panel session at the IEEE PowerTech conference that was hosted by NTNU in Trondheim, June 2011.

One PhD candidate has started in 2011, see appendix A.1, and there are now two PhD students and one Post doc financed by Nowitech under WP4. The third PhD position is advertised.

The industry partners with main interests in this WP are primarily Statnett, Statkraft, Statoil and DNV.

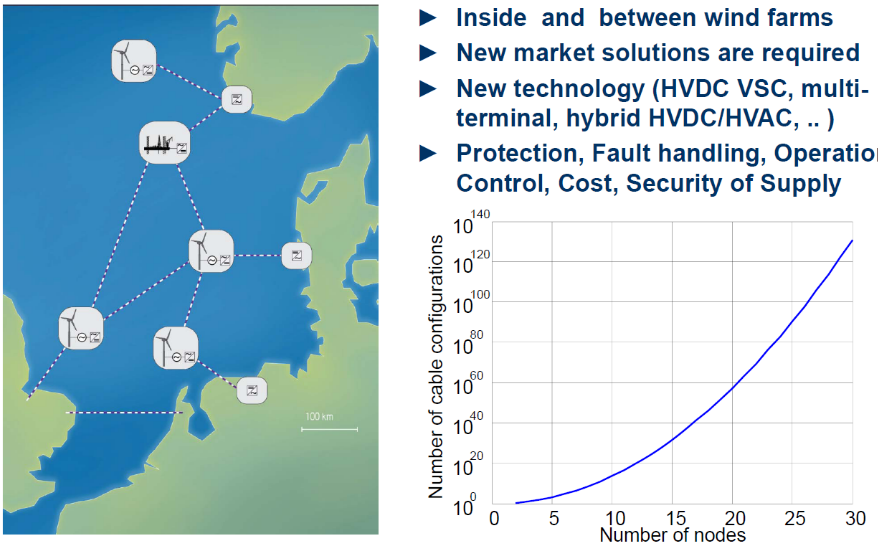


Figure 12 A main challenge in WP4 is the optimization of offshore grids and grid connections.

4.6 OPERATION AND MAINTENANCE (WP 5)

The objective is to develop a scientific foundation for implementation of cost-effective O&M concepts and strategies for offshore wind farms, taking into account the whole life cycle of the equipment. This will be achieved through the following secondary goals:

- Development and adaption of methods and tools for assessing optimal O&M strategies, with particular emphasis on condition based maintenance
- Assessment of low-cost and efficient surveillance and condition monitoring concepts, including remote presence
- Analyses of access techniques and assessing their impact on maintenance opportunities and O&M costs
- Development and adaption of methods and tools for assessing optimal logistics strategies
- Develop new materials/coatings with improved Life Cycle Costs (LCC)

The work is divided into three tasks:
5.1 Maintenance strategies
5.2 Surveillance and condition monitoring
5.3 Access and logistics techniques

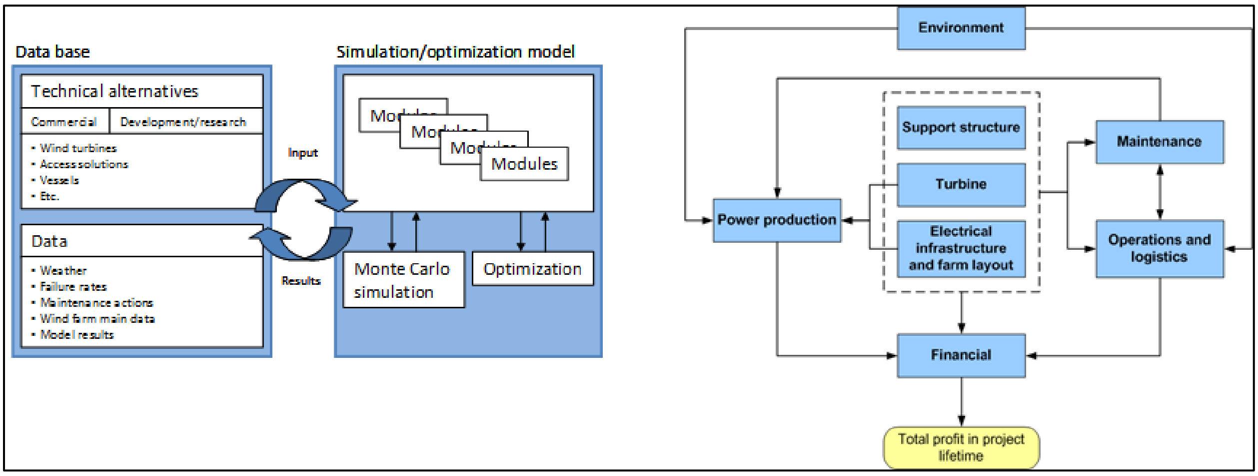


Figure 13 Holistic/integrated model concept for Life Cycle Profit analysis of an offshore wind farm, including all phases from design to decommissioning (Task 5.1).

Major achievements/highlights:

- A first version of a holistic life-cycle profit (LCP) software for offshore wind farms is finalized (Task 5.1)
- The Remote Presence concept has been further developed and tested in the laboratory (Task 5.2)
- Wear and erosion resistant plasma spray coatings for wind turbines has been tested with promising results (Task 5.3)
- Three journal papers were submitted and 15 conference papers were published and presented in 2011.
- Joint collaborations/applications with European research institutes:
- AERTO project OMO (Operation and Maintenance (monitoring) of Offshore wind parks). A two year project was finalized in 2011and resulted in a Strategic Research Agenda on a distributed, hierarchical sensor network enabling park wide control of O&M and maintenance-on-demand (Fraunhofer, VTT, TNO, SINTEF)
- EU FP7-ENERGY-2010: HiPRwind (O&M activities). Project started.
- Cooperation with Tampere Univ. of Technology on development of thermal spray technology
- Participation in EERA working group on O&M of offshore wind power
- Participation in coming IEA Task 33 on standardization of reliability data
- Nordic wind power O&M network has just started, so far together with Chalmers Univ. of Technology, VTT, Risø/DTU, Elforsk and Energi Norge.
- Member of Reference groups in Vindforsk's "Wind Power Asset Management" and "Wind Power RAMS-Database" projects

One PhD candidate started in 2009, and two in 2010. One more PhD position has been advertised but no candidate has been employed so far. In addition, three PhD students are associated with WP5, but financed by other sources than NOWITECH.

Industry involvement is shown in Table 1 in Section 4.8.

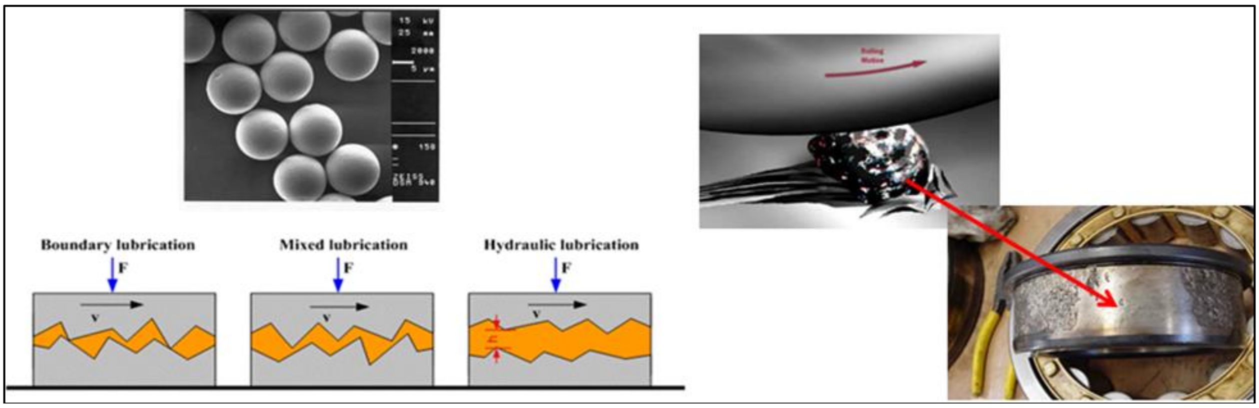


Figure 14 New, cost-effective methods for production and maintenance of low friction surfaces and surface protection (Task 5.3).

4.7 ASSESSMENT OF ALTERNATIVE DESIGN CONCEPTS (WP 6)

The objective is to develop and assess novel concepts of deep-sea wind turbines by numerical tools and physical experiments, hereunder developing control systems and combining results from WP1 to WP5. Assessment is by numerical tools and by utilizing “in-house” labs and results from full scale field tests.

The work is divided into three tasks:
6.1 Development of advanced control system
6.2 Assessment of alternative and novel design concepts
6.3 Experiments and demonstration

New improved concepts and technologies for offshore wind turbines should be developed by combining wind and offshore oil and gas experience. Robust and reliable technology is of paramount importance in order to keep repair and maintenance costs down. Conceptual design studies, exploring the interaction between the energy conversion, support structure and control system, should be carried out in order to minimize life cycle costs. Therefore, proper tools for these integrated design studies must be developed (WP1) and validated with experiments. Further, applying smart control systems for load mitigation and structural stabilization is also a key for cost reduction.

The 2011 work focused on exploring alternative concepts such as short spar type floating wind turbines for intermediate water depths and floating vertical axis wind turbines, and development of a model based control system for floating wind turbines. Wind tunnel experiments have been performed to investigate the yaw moment sensitivity to upwind and downwind configurations. Further, scaling effects on airfoils has been investigated experimentally in a circulating water tank.

Results from the work package have been presented at several international conferences in 2011, including EWEA2011, EWEA Offshore 2011, and ISOPE2011, and several papers based on results from 2011 are planned to be presented at international conferences in 2012.

The work package has also been involved in:
- NOWERI pre-study
- Nowitech integration activity – planning and arranging work shop related to NOWITECH Reference Turbine
- EERA meeting, Risø January 2011
- EU FP7-ENERGY-2010-FET: DeepWind. Exploration and evaluation of a simple floating vertical axis offshore wind turbine.

There are 4 PhD-students and 1 Post Docs engaged in this work package. One PhD students started in 2011.

Industry involvement is shown in 4.8.

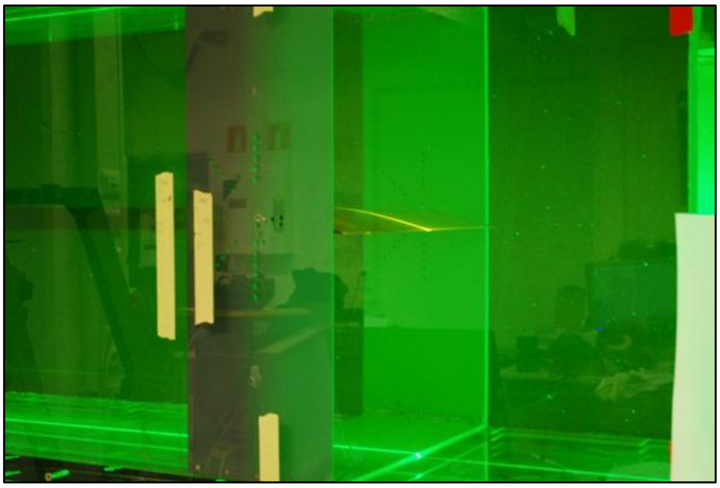


Figure 15 An airfoil model mounted wall-to-wall in the circulating water tank for PIV-experiments. The experiment was carried out to investigate the effect of scaling in model tests. The measurement plane is vertically orientated in mid-span position.

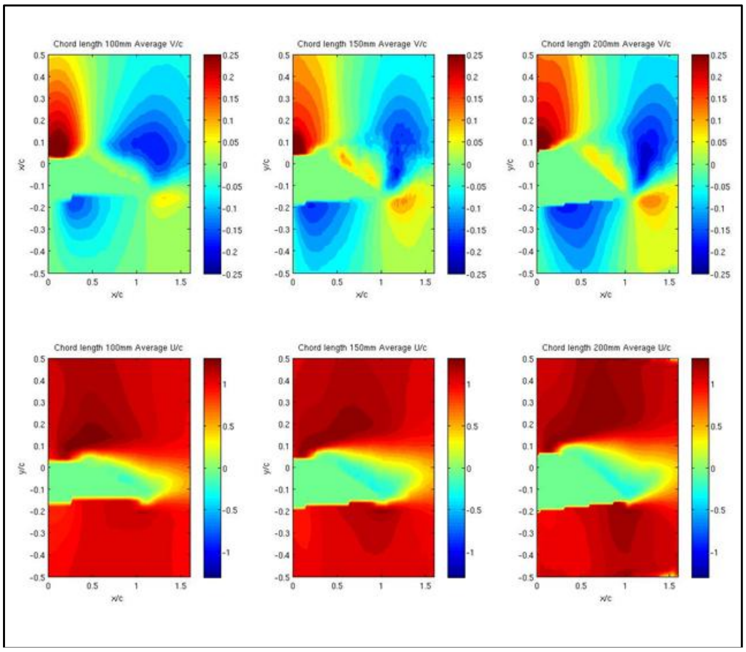


Figure 16 Results from the PIV-experiments in the circulating water tank. The plots show the horizontal and vertical velocity component near the trailing edge of an airfoil tested at three different model scales.

4.8 INDUSTRY INVOLVEMENT

Industry involvement is given high priority. The industry parties participate by in-kind supplies and direct involvement in WP and CIC activities. All industry parties are represented in the GA and the industry parties are active and in majority in the Board.

An overview of the NOWITECH partners' meeting attendance is shown in Table 1.

Table 1 Overview of meeting attendance by NOWITECH's industry partners in 2011.

Industrial involvement

Overview of meeting attendance by industry parties Jan-Dec 2011

Party	GA	Board	WP1	WP2	WP3	WP4	WP5	WP6	CIC	SC
Kværner Verdal (former Aker Solutions)					XX					
Det Norske Veritas	X	XX	*		XX	X	X		X	
Devold AMT	X			X						
DONG Energy Power	X		XX		XX			XX	X	
EDF R&D		XX		X						
Fedem			X	X				X		
Fugro OCEANOR		X	*	X						
GE Wind Energy (Norway)	X	XX	X				X	X		
Lyse Produksjon					X		X			
NTE Holding							X			
SmartMotor				X						
Statkraft Development	X	XX	XX	X*	XX	X	XX	XX	X	
Statnett SF	X					*				
Statoil Petroleum	X	XX	XX		XX	X	XX	XX		
Vestas Wind Systems	X	XX								
Vestavind Offshore	X	XX	X		XX		X	X		

X = Participated on meeting (X = one meeting, XX = two meetings)
* = Partner did not have the opportunity to participate on industry meeting, but has communicated suggestions previous to the meeting
= Not relevant

1

NOWITECH Norwegian Research Centre for Offshore Wind Technology

The CIC is enhancing the industry involvement and making sure that results from NOWITECH are communicated to the industry parties, and that the possibilities for establishing new projects, products, services or processes with one or more partners are pursued. Commercialisation is by transfer of knowledge to the industry parties and their use of this in developing their business, through spin-off projects and creation of new industry.

"Statoil has cooperated with research institutes in the SINTEF group for several years. As a developer in the offshore wind sector, Statoil can clearly see the need for research and competence to reach grid parity with offshore wind developments. Considering the rapidly evolving nature of the offshore wind sector, and the need to remain at the cusp of leading research, Statoil has decided to support the NOWITECH project since this project has the potential of significant benefit to the industry. Statoil has already implemented some of the NOWITECH research result in our offshore wind software"

Gudmund Per Olsen
Statoil's representative in NOWITECH's Board and General Assembly.

The CIC cooperates with NTNU's Entrepreneurship School (NEC) and NTNU Technology Transfer (TTO) in commercialisation of ideas created in NOWITECH, while Innovation Norway and Enova assist CIC in project development between SMEs and NOWITECH industry partners.

A strong link to relevant SMEs is also made through NOWITECH's close cooperation with Windcluster Mid-Norway (WMN), an Innovation Norway Arena project. NOWITECH and WMN have an agreement of cooperation involving i.e. plans for joint seminars and NOWITECH is represented in WMN's board as an observer.

The CIC has initiated a re-vitalisation of the committee in 2012. This will involve assessing the mandate, way of working, benefit for the participating companies, and funding of the committee and has a link to a similar activity in NORCOWE's corresponding CIC.

A number of spin-off projects have been created (see next section).

4.9 SPIN-OFF PROJECTS

Many NOWITECH partners have participated in applications for national and international research projects in 2011. Table 2 shows a selection of some relevant projects where NOWITECH partners are involved.

Table 2 Overview of some projects (ongoing or about to be started) in 2011 where NOWITECH partners are involved. Projects directly funded from industry are omitted due to confidentiality.

Project title	Project type	Partners	Status
ORECCA (**O**ff-shore **R**enewable **E**nergy **C**onversion platforms **C**oordination **A**ction)	EU	Coordinator: Fraunhofer IWES. Partners: NTNU, LyseEnergi +	Ongoing
Marine Research Infrastructures Network for Energy Technologies: MARINET	EU	Coordinators: HMRC University College Cork. Partners: Risø DTU, NTNU, Universityof Strathclyde, Fraunhofer IWES, SINTEF ER+	Ongoing
Marine Renewable Integrated Application Platform (MARINA platform)	EU	Coordinator: Acciona, Partners: NTNU etc	Ongoing
Future Deep Sea Wind Turbine Technologies (DeepWind)	EU	Coordinator: Risø DTU. Participants: Statoil, SINTEF ER, MARINTEK etc.	Ongoing
High power, high reliability offshore wind technology (HiPRwind)	EU	Coordinator: Fraunhofer. Participants: SINTEF ER, NTNU etc.	Ongoing
Twenties	EU	Coordinator: Red Electrica; Partners: SINTEF ER +	Ongoing
Operation and maintenance (monitoring) of Off-shore wind parks (OMO)	EU Aerto	Coordinator Fraunhofer. Partner: SINTEF ER +.	Ongoing
Grid integration of offshore wind farms	EU Aerto	Coordinator: SINTEF ER. Partners: VTT, Fraunhofer	Ongoing
Offshore Grids	EU IEE	Coordinator: 3E; Partners: ForWind, EWEA, RENES, SENERGY, SINTEF ER +	Ongoing
WindSpeed	EU IEE	Coordinator: ECN; Partners: DLR, German Offshore Wind Energy, SINTEFER +	Ongoing
Autonome målinger av vindprofil, strømprofil og bølger for kartlegging av energipotensialet, design og operasjon av vindmøller til havs	BIP	Coordinator: Fugro Oceanor. Partners:, StatoilHydro, MARINTEK, CMR, UiB GFI	Ongoing
OSCAR – Optimized large-scale floating offshore wind energy converter	BIP	Coordinator: GE Wind Energy. Partners: IFE, MARINTEK etc	Ongoing
Improving the availability of offshore wind turbines	BIP	Coordinator: GE, Partners: Statoil, NTE, SINTEF ER, MARINTEK	Ongoing
RAWi, Radio Acoustic Wind Sensor	BIP	Coordinator: Triad. Partners: IFE, UIB, Kjeller Vindteknikk, NORBIT	Ongoing
Role of North Sea power transmission in realising the 2020 renewable energy targets	KMB	Cordinator: SINTEF ER Partners: Statnett, Statkraft, EDF R&D, Siemens, NVE +	Ongoing
BALANCE – Norwegian hydropower as balancing services in Europe – opportunities and challenges	KMB	SINTEF ER, NTNU	Ongoing
EWEM – European Energy Master (Erasmus Mundus programme)	EU	TU Delft, DTU, NTNU, Universität Oldenburg	Approved: starts in 2012

Project title	Project type	Partners	Status
EERA Design Tools for Offshore Wind Farm Cluster (EERA-DTOC)	EU FP7	Coordinator: DTU Wind Partners: SINTEF ER +++	Approved
Far offshore operation and maintenance vessel concept development and optimization (FAROFF)	IPN	Coordinator: Statkraft Partners: MARINTEK, Fred Olsen, Odfell, SINTEF ER	Approved
WINDSENSE	IPN	Coordinator: Kongsberg Maritime Partners: Statoil, NTE, SINTEF ER, Marintek, NTNU, WCMN +	Approved
Protection and Fault Handling in Offshore HVDC Grids (ProOfGrids)	KPN	Coordinator: SINTEF ER Partners: NTNU, RWTH Aachen University, Statnett, Statoil, NationalGrid, EDF, GE Power Conversion, NVE, Siemens, Statkraft	Approved
Fluid Structure Interactions for Wind Turbines	KPN	Coordinator: SINTEF IKT Partners: Statoil, TrønderEnergi, Kjeller Vindteknikk, FFI, NTNU, SINTEF +	Approved
Utviklingen av havvind (offshore vind) i Norge	Syntese	SINTEF ER	Approved

5 INTERNATIONAL COOPERATION

This section outlines NOWITECH's international cooperation in 2011.

5.1 INTERNATIONAL COOPERATION THROUGH SCIENTIFIC COMMITTEE

The Scientific Committee (SC) is made up by
- NTNU members
- Other Norwegian members
- Associated research members

The associated members of the SC are international experts on relevant topics within offshore wind. The associated research partners are represented by:
- Paul Sclavounos, MIT, USA
- Senu Sirnivas, NREL, USA
- Peter Hauge Madsen, Risø-DTU, Denmark
- Hans-Gerd Busmann, Fraunhofer IWES, Germany
- William E. Leithead, Strathclyde University, UK
- Gerard J.W. van Bussel, TU Delft – Aerospace Engineering Wind Energy (DUWIND)
- Seri Lee, Nanyang Technological University (NTU), Singapore

The SC accomplished two meetings in 2011 where the associated research partners participated. Among their role are visiting lectures, exchange of PhD candidates and evaluation of scientific results in NOWITECH.

The SC, lead by NTNU, has established NOWITECH Mobility Programme for exchange of students and researchers between NOWITECH and associated partners.

The SC co-funded a "blind test" workshop on wake effects organized jointly by NOWITECH and NORCOWE in Bergen October 2011. The workshop assessed results from eight research groups (including research parties of NOWITECH and NORCOWE, DTU in Denmark and AIST in Japan) having estimated the performance of a model turbine and the wake formed by the rotor. The methods ranged in complexity from standard Blade Element Momentum methods to Large Eddy Simulations. The overall trend was that the current methods predict the power generation as well as the thrust force reasonably well, but there is a large uncertainty in the prediction of the turbulence field in the wake.

5.2 INTERNATIONAL COOPERATION THROUGH WORK PACKAGES

Engagement in international projects, networks and applications, IEA cooperation and IEC standardisation are considered important for enhancing the quality of research within the WPs. Basically all WPs are involved, though with varying degree. Examples of international cooperation are:

- EERA (European Energy Research Alliance) Joint Programme on Wind Energy, SINTEF Energy Research is heading Sub Program on "Offshore Wind Energy". All research partners in NOWITECH take part in one or more subprograms, including "Structures and materials" and "Grid".
- EU TPwind, www.windplatform.eu (John Tande is Chairman of Working Group 4 "Offshore")
- EU FP7-ENERGY-2010-FET: DeepWind. Exploration and evaluation of a simple floating vertical axis offshore wind turbine.
- EU FP7-ENERGY-2010: HiPRwind (O&M activities). Project started.
- EU FP7: Twenties
- EU FP7: Marine Renewable Integrated Application Platform (MARINA platform)
- EU FP7: ORECCA (Off-shore Renewable Energy Conversion platforms Coordination Action)

- EU FP7: EERA-DTOC
- EU FP7: MARINET (Marine Renewable Infrastructure Network)
- IEA Wind Task 25: System operation (grid integration)
- IEA Wind Task 29 Mexnext: Analysis of wind turbine measurements
- IEA Task 30 OC4: Comparison of Dynamic Computer Codes and Models for offshore Wind Energy
- IEA Task 33; Standardisation of reliability data
- EAWE, European Academy of Wind Energy, www.eawe.eu (Tor Anders Nygård, IFE, is member of the Executive Committee)
- AERTO project OMO (Operation and Maintenance (monitoring) of offshore wind parks). A two year project was finalized in 2011 and resulted in a Strategic Research Agenda on a distributed, hierarchical sensor network enabling park wide control of O&M and maintenance-on-demand (Fraunhofer, VTT, TNO, SINTEF)
- IEC TC88, www.iec.ch (SINTEF Energy Research is heading the Norwegian sister-organization NK88, and representing Norway in TC88)
- Cooperation with Tampere Univ. of Technology on development of thermal spray technology
- Nordic wind power O&M network has just started, so far together with Chalmers Univ. of Technology, VTT, Risø/DTU, Elforsk and Energi Norge.
- Member of Reference groups in Vindforsk's "Wind Power Asset Management" and "Wind Power RAMS-Database" projects.

6 RECRUITMENT

Four PhD and two Post Doc candidates started in 2011 with funding from NOWITECH, thus in total 22 PhD and 5 Post Doc candidates are funded by NOWITECH, see Appendix A.1.5 and A.1.3. In addition, NTNU has 25 PhD and 9 Post Doc candidates with funding from sources outside NOWITECH working on topics related to offshore wind and are associated to the NOWITECH research team. See appendix A.1.6 and A.1.4.

The research school for offshore wind power that was started earlier by the Scientific Committee are continued. The research school has the goal to improve the quality of research within the field of Offshore Wind Power.

During 2011, professors and scientific staff at NTNU with relations to NOWITECH were supervisors for 28 Master Degree theses. See appendix A.1.7.

Figure 17 Four new PhD students started up in 2011. From left: René Alexander Barrera Cárdenas, Chenyu Luan, Valentin Chabaud and Vaclac Slimacek.

7 COMMUNICATION AND DISSEMINATION

NOWITECH publications include a total of 110 publications in 2011, whereof 21 journal paper, 28 conference papers, 42 conference presentations, 14 reports and 5 media contributions (newspaper articles and feature articles). See appendix A.3.

NOWITECH partners have access to a project e-room, where all internal information and project results are presented. Further, NOWITECH has a web site (www.nowitech.no), where relevant NOWITECH news and information are presented to external interests.

An annual Wind Power R&D seminar is held in January in Trondheim. This seminar has been arranged every year since 2004 with SINTEF Energy Research as host in close cooperation with NTNU and IFE. It is established as an important venue for the wind sector in Norway and with international participation over the past years. The seminar is a mix of plenary presentations with broad appeal, and presentations in parallel sessions on specific technical themes. NOWITECH arranged the seminar in cooperation with NORCOWE in 2011. The seminar keeps a strong focus on deep sea offshore wind and the PhD students working on projects in the centre are invited to give a poster presentation of their work.

NOWITECH Newsletter was introduced in 2011 and three editions were published. The Newsletter provides snapshots of selected research results in NOWITECH and the target group are partners and relevant external companies and organisations.

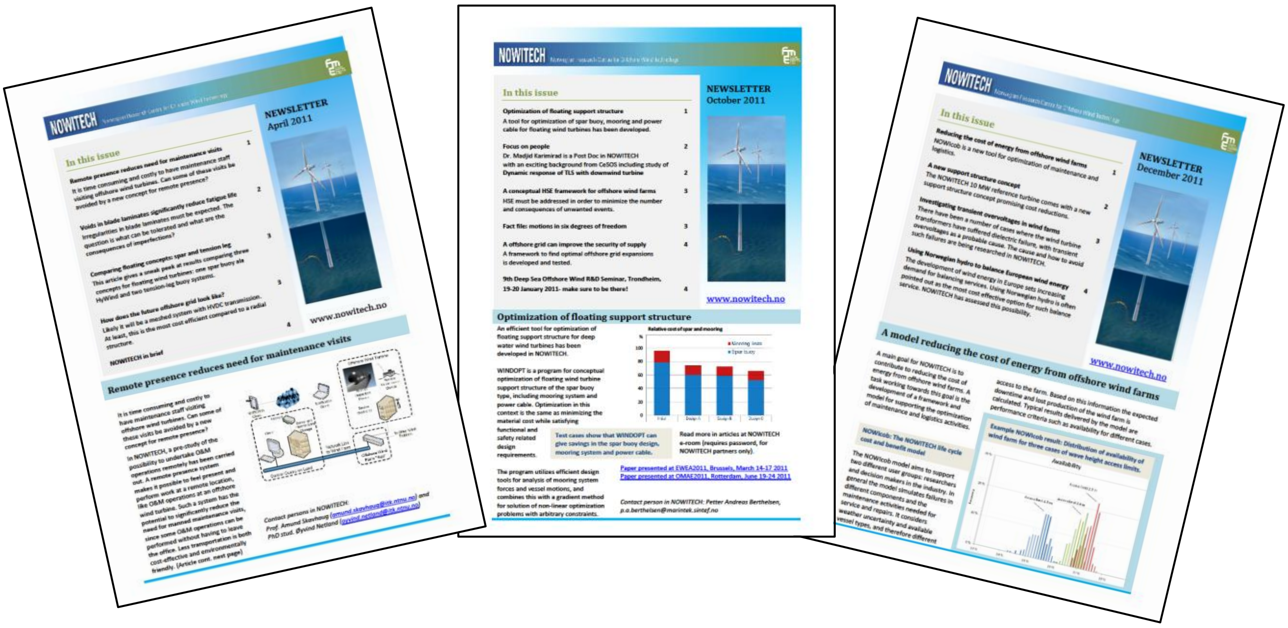

NEWSLETTER April 2011
Remote presence reduces need for maintenance visits
NEWSLETTER October 2011
Optimization of floating support structure
NEWSLETTER December 2011
A model reducing the cost of energy from offshore wind farms

Figure 18 Front pages of the three NOWITECH Newsletters published in 2011. Copies can be downloaded from NOWITECH web site (www.nowitech.no).

A.1 PERSONNEL

A.1.1 Key Researchers

#	Name	Institution	Main Research Area
1	Petersen, Idar	SINTEF Energy Research	WP4, WP6
2	Gustavsen, Bjørn	SINTEF Energy Research	WP4
3	Heggset, Jørn	SINTEF Energy Research	WP5, Management
4	Hernando, Daniel Huertas	SINTEF Energy Research	WP4
5	Hofmann, Matthias	SINTEF Energy Research	WP5
6	Korpås, Magnus	SINTEF Energy Research	WP4, Management
7	Ringheim, Nils Arild	SINTEF Energy Research	Management
8	Svendsen, Harald	SINTEF Energy Research	WP4, WP6
9	Tande, John Olav Giæver	SINTEF Energy Research	Management, WP1-WP6
10	Marvik, Jorun	SINTEF Energy Research	WP4
11	Årdal, Atle Rygg	SINTEF Energy Research	WP4
12	Endegnanew, Atsede	SINTEF Energy Research	Management, WP4, WP6
13	Magnusson, Niklas	SINTEF Energy Research	WP2
14	Finden Per	IFE	Management
15	Knauer Andreas	IFE	WP1, WP2, WP3, WP6
16	Nygaard Tor Anders	IFE	WP1, WP2, WP3, WP6
17	Rij Jennifer Van	IFE	WP1, WP2, WP3, WP6
18	Stenbro, Roy	IFE	WP1, WP2, WP3, WP6, Managmnt
19	Sørheim, Einar Arne	IFE	WP1
20	Valland, Anders	Marintek	WP5
21	Ormberg, Harald	Marintek	WP1,
22	Nonås, Lars Magne	Marintek	WP5
23	Graczyk, Mateusz	Marintek	WP1
24	Luxcey, Neil	Marintek	WP1, WP3
25	Berthelsen, Petter Andreas	Marintek	WP1,WP3, WP6, Management
26	Halvorsen-Weare, Elin	Marintek	WP5
27	Echtermeyer, Andreas	NTNU	WP2
28	Moe, Geir	NTNU	Management (including SC), WP3
29	Onarheim, Jan	NTNU	Management (including SC, CIC)
30	Vatn, Jørn	NTNU	WP5
31	Uhlen, Kjetil	NTNU / SINTEF Energy Research	WP4, WP6, Management
32	Ole Gunnar Dahlhaug	NTNU	Management (including SC), WP1
33	Krogstad, Per Åge	NTNU	WP1,WP2, WP6
34	Moan, Torgeir	NTNU	WP3, WP6, Management (incl SC)
35	Skavhaug, Amund	NTNU	WP5
36	Espallargas, Nuria	NTNU	WP5
37	Utne, Ingrid Bouwer	NTNU	WP5
38	Lindqvist, Bo	NTNU	WP5
39	Kvamsdal, Trond	NTNU/SINTEF ICT	WP1, SC
40	Molinas, Marta	NTNU	SC, WP4
41	Nysveen, Arne	NTNU	WP2
42	Nilssen, Robert	NTNU	WP2
43	Høidalen, Hans Kristian	NTNU	WP4
44	Doorman, Gerard	NTNU	WP4
45	Holdahl, Runar	SINTEF ICT	WP1
46	Bjørgum, Astrid	SINTEF MC	WP3, WP5
47	Tveiten, Bård Wathne	SINTEF MC	WP2
48	Schmid, Bernd	SINTEF MC	WP2, Management
49	Delhaye, Virgile	SINTEF MC	WP2
50	Equey, Sebastien	SINTEF MC	WP3, WP5
51	Jørgensen, Jens Kiær	SINTEF MC	WP2
52	Simon, Christian	SINTEF MC	WP3
53	Armada, Sergio	SINTEF MC	WP3
54	Albrechtsen, Eirik	SINTEF TS	WP5

A.1.2 Visiting Researchers

Name	Affiliation	Nationality	Sex	Duration	Topic
Robert Parker	Univ.of Michigan-Shanghai Jiao Tong Univ.	American	Male	7 days (April 2011)	Drivetrain dynamic modelling for wind turbine
Robert Proskovics	University of Strathclyde	British	Male	2 months (Aug-Sep 2011)	Offshore Wind Energy

A.1.3 Postdoctoral Researchers with financial support from the Centre budget

Name	Nationality	Period	Sex	Topic
Anthonippillai Antonarulrajah	British	2009-2011	M	Influence of material and process parameters on fatigue of wind turbine blades in a marine environment (WP2)
Steve Völler	German	2010-2012	M	Balance management with large scale offshore wind integration (WP4)
Madjid Karimirad	Iranian	2010-2012	M	Alternative floating wind turbines for moderate water depths (WP6)
Stanislav Shchebetov	Russian	2011	M	Influence of material and process parameters on fatigue of wind turbine blades in a marine environment (WP2)
Mukesh Kumar	Indian	2011-2013	M	Alternative floating wind turbines for moderate water depths (WP6)

A.1.4 Postdoctoral Researchers working on projects in the Centre with financial support from other sources

Name	Nationality	Period	Sex	Topic
Muyiwa Adaramola	Nigerian	2010-2012	M	Resource optimization and recovery in the materials industry
Zhen Gao	Chinese	Started 2008	M	Reliability and stochastic response analysis of marine structures
Elisabetta Tedeschi	Italian	2009-2011	F	Design and control of energy conversion systems for the integration of offshore renewable energy sources into the electric grid
Paul Thomassen	Norwegian	2008-2012	M	Deep sea offshore structures
Rabah Zaimeddine	Algerian	2008-2011	M	Grid Integration Technologies of Offshore Wind
Michael Muskulus	German	2010-2011	M	Analysis and measurements of structural behaviour of offshore wind turbines
Olivia Langhamer	German	2010-2013	F	Renewable offshore energy and the marine environment:biofouling and artificial reefs
Karl Merz	American	2011-2013	M	Offshore Wind Turbines in EU Projects
Muk Chen Ong	Malaysian	2011-2012	M	Dynamic analysis of offshore monopole wind turbine including the effect of scour
Hui Li	Chinese	2011-2012	M	Dynamic analysis of offshore monopole wind turbine including the effect of scour

A.1.5 PhD Students with financial support from the Centre budget

Name	Nationality	Period	Sex	Topic
Knut Nordanger	Norwegian	2010-2013	M	Coupled fluid-structure interaction simulation of offshore wind turbines (WP1)
Lars Frøyd	Norwegian	2009-2012	M	Evaluation of the design criteria and dynamic forces on large floating wind turbines (WP1)
Martin Resell	Norwegian	2010-2014	M	Design wind and sea loads for offshore wind turbines (WP1)
Pål Egil Eriksen	Norwegian	2010-2014	M	Rotor wake turbulence (WP1)

Name	Nationality	Period	Sex	Topic
Kevin Cox	American	2010-2013	M	Lift control of wind turbine blades by using smart composite materials manipulating aerodynamics rotor properties (WP2)
Mostafa Valavi	Iranian	2010-2013	M	Magnetic forces and vibrations in wind power generators (WP2)
Zhaoqiang Zhang	Chinese	2010-2013	M	Novel generator concepts for low weight nacelles. Integrated design of generator and mechanical structure for a maintenance free system (WP2)
Daniel Zwick	German	2009-2013	M	Design and production of offshore jacket structures (WP3)
Eric Van Buren	American	2009-2012	M	Bottom-fixed support structure for wind turbine in 30-70 m water depth (WP3)
Marit Irene Kvittem	Norwegian	2009-2012	F	Life cycle criteria and optimization of floating structures and mooring systems (WP3)
Mayilvahanan Chella	Indian	2010-2013	M	Wave forces on wind turbine structures (WP3)
Amir Hayati Soloot	Iranian	2009-2013	M	Analysis of switching transients in wind parks with focus on prevention of destructive effects (WP4)
Fahmi Mubarok	Indonesian	2010-2013	M	Novel coating and surface treatment for improved wear resistance (WP5)
Zafar Hameed	Pakistani	2009-2012	M	Maintenance optimization of wind farms from design to operation (models, methods, framework) (WP5)
Øyvind Netland	Norwegian	2010-2013	M	Cost-effective monitoring for remote environmental friendly O&M of offshore wind turbines (WP5)
Tania Bracchi	Italian	2009-2012	F	Assessment of benefits of downwind rotors due to weight savings using new and thinner airfoils and improved directional stability of turbine (WP6)
Kai Wang	Chinese	2010-2013	M	Comparative studies of floating concepts (WP6)
Morten Dinhoff Pedersen	Norwegian	2010-2013	M	Design of control systems for load mitigation and stabilization of floating wind turbines (WP6)
René Alexander Barrera Cárdenas	Columbian	2011-2014	M	Multi-domain optimization model for the evaluation of power density and efficiency of wind energy conversion systems (WP4)
Valentin Chabaud	French	2011-2015	M	Experimental investigation of coupled hydrodynamic and aerodynamic performance of floating wind turbines (WP6)
Chenyu Luan	Chinese	2011-2015	M	Efficient stochastic dynamic response analysis for design of offshore wind turbines (WP3)
Vaclav Slimacek	Czech	2011-2015	M	Reliability analysis of offshore wind turbines/plants and their connection to Smart Grids (WP5)

A.1.6 PhD Students working on projects in the Centre with financial support from other sources

Name	Funding	Nationality	Period	Sex	Topic
Alejandro Garces Ruiz	NTNU	Colombian	2008-2012	M	Electrical system for offshore wind parks: from the generator to the grid connection onshore
Anders Arvesen	NTNU	Norwegian	2008-2012	M	Assessment of environmental benefits and costs of a large-scale introduction of wind energy
Bing Lui	NTNU	Chinese	2008-2012	M	Offshore wind power electronics
Fabio Pierella	NTNU	Italian	2008-2012	M	Wind energy: Full scale and wind tunnel simulated measurements; consequential wind turbine design optimization, model construction and experimental testing
Fredrik Sandquist	NTNU	Austrian	2006-2010	M	Individual Pitch Control of Large Scale wind turbines

Name	Funding	Nationality	Period	Sex	Topic
Ingrid Øverås	NTNU	Norwegian	2008-2012	F	Grid Integration Technologies of Offshore Wind
Lijuan Dai	NTNU	Chinese	2009-2013	F	RAMS engineering and management in the development and operation of offshore wind turbines
Madjid Karimirad	CeSOS	Iranian	2007-2011	M	Structural Dynamic Response of Floating Wind Turbine
Muhammed Jafar	NTNU	Pakistani	2008-2012	M	Electrical Conversion Systems for Offshore wind farms: from the generator to shore
Raed Khalil Lubbad	NTNU	Palestinian	2006-2010	M	Dynamic Response of Slender Offshore Structures
Raymundo Torres Olguin	NTNU	Mexican	2008-2012	M	Offshore Wind Farms Electrical System and grid Integration
Sverre Gjerde	NTNU	Norwegian	2009-2013	M	Integrated converter design with generator for weight reduction of offshore wind turbines
Temesgen Haileselassie	NTNT	Ethiopian	2008-2012	M	Grid Connection of Deep Sea Wind Farms
Tobias Aigner	NTNU	German	2008-2012	M	System impacts of large scale wind power
Gursu Tasar	NTNU	Turkish	2009-2012	M	Full Scale Measurements of Wind Conditions Relevant for Offshore Wind Turbines
Karl Merz	NTNU	American	2008-2011	M	Deep water offshore turbine structures
Mahmoud Valibeiglou	NTNU	Iranian	2009-2012	M	Area in Operation and Maintenance – in on-line monitoring and use o f on-line data for maintenance decision for offshore wind farms
Marit Reiso	NTNU	Norwegian	2009-2012	F	Design and analysis of downwind rotor for WT with jacket tower
Wenbin Dong	CeSOS	Chinese	2008-2011	M	Reliability of wind turbines
Sara Heidenreich	NTNU	German	2010-2014	F	Public engagement in offshore wind energy
Markus Steen	Geography	Norwegian	2010-2014	M	Commercialization and industrial development of new renewable energy with focus on offshore wind
Thomas Pagaard Fuglseth	NTNU	Norwegian	2005-2011	M	Control of Wind Energy Plants
Nathalie Holtsmark	NTNU	Norwegian	2010-2014	F	Wind Energy Conversion using high frequency transformation and DC collection
Mehdi Shirani	NTNU	Iranian	2007-2011	M	Probabilistic and defect tolerant fatigue assessment of wind turbine castings
Kristian Vrana	NTNU	Norwegian	2009-2013	M	Development and Operation of the North Sea Super Grid

A.1.7 Master Degrees

Name	Sex	Topic
Line Teigen Døssland	F	Corrosion protection
Anne Frehle	F	Corrosion protection
Yu Li	F	Dynamic Response Analysis of an Offshore Jacket Wind Turbine
Chenyu Luan	M	Dynamic Response Analysis of a Semi-Submersible Floating Turbine
Jon Erik Lønøy Lygren	M	Dynamic Response Analysis of a Tension-Leg Floating Wind Turbine
Erik Lønøy	M	Dynamic Response Analysis of a Tension-Leg Floating Wind Turbine

Name	Sex	Topic
Thomas Solberg	M	Dynamic Response Analysis of a SPAR Type Floating Wind Turbine
Live Salvesen Fevåg	F	Influence of marine growth on support structure design for offshore wind turbines
Håvard Molde	M	Simulation-based optimization of lattice support structures for offshore wind energy
Stine Moen Al-Kasim	F	Livssyklusanalyse av offshore vindturbiner. Virkningen av å modellere gjennomsnittlige og væravhengige sviktrater
Maheshkumar Hadija	M	Case study of offshore wind farm integration to offshore oil and gas platforms as an isolated system – System Topologies, Steady State and Dynamic Aspects
Nahome Ayehunie	M	Multiphase Permanent Magnet Synchronous Generators for Offshore Wind Energy Systems
Kristin Bjerke	F	Control of Offshore Passive Platform System Voltage Frequency through Control of Onshore Back to Back Voltage Source Converters
Atle Rygg	M	Feasibility Studies on Integrating Offshore Wind Power with Oil Platforms
Karen-Christine Oehninger-Storvoll	F	Stress influence of offshore wind farms on the reproduction of the viviparous eelpout (Zoarces viviparous)
Peder Hesten	M	Scour around wind turbine foundations, marine pipelines and short cylinders due to long-crested and short-crested nonlinear random waves
Aina Crozier	F	Design and dynamic modeling of the support structure for a 10 MW offshore wind turbine
Jørgen Tande	M	CFD-analysis of a 10 offshore wind turbine
Hilde Evensen Liseth	F	Dynamic Modeling of Wind Turbine System
Sigrid Ringdalen Vatne	F	Design of 10 MW offshore wind turbine blades
Peter Kalsaas Fossum	M	Aeroelastic analysis of an offshore wind turbine
Hilde Evensen Liseth	F	10 MW Reference Wind Turbine (Generator design)
Ebbe Smith	M	Nacelle and main shaft design for the 10 MW Reference Wind Turbine
Mohammad Akram Khan	M	Hub design for the 10 MW Reference Wind Turbine
Tor Mæhlum Karlsen	M	Remote Presence for Offshore Wind Turbines
Jeremias Moragues Pons	M	Practical Experiments on the Efficiency Of the Remote Presence
Line Bergfjord	F	Wind in the North Sea. Effects of offshore grid design on power system operation
Mario Mesquita	M	Eddy current loss calculation

A.2 STATEMENT OF ACCOUNTS

(All figures in NOK 1000)

FUNDING

Name		Amount	Amount
The Research Council			20000
SINTEF Energi	(Host Institution)		2452
NTNU	(Research Partner)		5316
IFE	(Research Partner)		1221
Marintek	(Research Partner)		1169
SINTEF	(Research Partner)		1550
Aker Solutions		501	
Det Norske Veritas		500	
Devold AMT		325	
DONG Energy Power		500	
EDF R&D		826	
Fedem Technology		424	
Fugro OCEANOR		1423	
GE Wind Energy (Norway) [1)]		1800	
Lyse Produksjon		500	
NTE Holding		1000	
SmartMotor		633	
Statkraft Development		1500	
Statnett		500	
Statoil		1150	
Vestas Wind System		1200	
Vestavind Offshore		500	
Transferred from 2010		2585	
Transferred to 2012		-3161	
	Subtotal		12706
Public Partners			0
			44414

1) Whereof 600 constitutes late fee for 2009

COSTS

Name		Amount	Amount
SINTEF Energi	(Host Institution)		9809
NTNU	(Research Partner)		14424
IFE	(Research Partner)		4884
Marintek	(Research Partner)		5300
SINTEF	(Research Partner)		6343
Kværner Verdal		501	
Devold AMT		325	
EDF R&D		326	
Fedem Technology		424	
Fugro OCEANOR		1423	
SmartMotor		633	
	Subtotal		3632
Public Partners			0
Equipment			22
			44414

A.3 PUBLICATIONS

NOWITECH publications include a total of 110 publications in 2011, whereof 21 journal paper, 28 conference papers, 42 conference presentations, 14 reports and 5 media contributions. Below you will find the papers and reports listed.

A.3.1 Journal / Peer-Reviewed Papers

Title	Author	Journal/Peer-reviewed
A framework to determine optimal offshore grid structures for wind power integration and power exchange	Trötscher, T..; Korpås, M.	Wind Energy, Volume Volume 8, Issue 14, pp 977-992, Nov 2011
A review of decision support models for offshore wind farms with emphasis on operation and maintenance strategies	Hofmann, M.	Journal of Wind Engineering, Volume 35, Issue 1, pp 1-15,
Multivariate analysis of transformer resonant overvoltages in power stations	Gustavsen, B.; Brede, A.P.; Tande, J.O.	IEEE Transactions on Power Delivery, Vol. 26, No. 4, pp 2563-2572, October 2011
Challenges in the reliability and maintainability data collection for offshore wind turbines	Hameed, Z.; Vatn, J.; Heggset, J.	Journal of Renewable Energy, Volume 36, Issue 8, pp 2154-2165, August 2011
Connection Scheme for North Sea Offshore Wind Integration to UK and Norway: Power Balancing and Transient Stability Analysis	Haileselassie, T.; Uhlen, K.; Tande, J.O.; Anaya-Lara, O.	IEEE Powertech 2011 Conference Proceedings, Print ISBN: 978-1-4244-8419-5
An experimental and numerical study of the performance of a model turbine	Krogstad, P.Å.; Lund, J.A	Wind Energy, Online ISSN: 1099-1824, Article first published online: 13 June 2011
Frequency Domain Investigation of Switching Transients in Offshore Windfarms	Soloot, A.H.; Høidalen, H.K.; Gustavsen, B.	IEEE Powertech 2011 Conference Proceedings, Print ISBN: 978-1-4244-8419-5
Integration of offshore wind farm with multiple oil and gas platforms	Svendsen, H.; Øyslebø, E.V; Hadiya, M.; Uhlen, K.	IEEE PES Powertech 2011, Print ISBN: 978-1-4244-8419-5
WINDOPT - An optimization tool for floating support structures for deep water wind turbines	Fylling, I.; Berthelsen, P.A	Proceedings of the ASME 2011 30th International Conference on Ocean, Offshore and Arctic Engineering, Year 2011, Volume 5, ISBN: 978-0-7918-4437-3
Global analysis of a floating wind turbine using an aero-hydro-elastic numerical model. Part 1: Code development and case study	Ormberg, H. ; Passana, E.; Luxcey, N.	Proceedings of the ASME 2011 30th International Conference on Ocean, Offshore and Arctic Engineering, Year 2011, Volume 5, ISBN: 978-0-7918-4437-3
Global analysis of a floating wind turbine using an aero-hydro-elastic numerical model. Part 2: Benchmark study	Luxcey, N.; Ormberg, H.; Passano, E.	Proceedings of the ASME 2011 30th International Conference on Ocean, Offshore and Arctic Engineering, Year 2011, Volume 5, ISBN: 978-0-7918-4437-3
A Conceptual Design Method for Parametric Study of Blades for Offshore Wind Turbines	Frøyd, L.; Dahlhaug, O.G.	Proceedings of the ASME 2011 30th International Conference on Ocean, Offshore and Arctic Engineering, Year 2011, Volume 5, ISBN: 978-0-7918-4437-3

Title	Author	Journal/Peer-reviewed
Rotor Design for a 10 MW Offshore Wind Turbine	Frøyd, L.; Dahlhaug, O.G.	Proceedings of The Twenty-first (2011) International OFFSHORE AND POLAR ENGINEERING CONFERENCE, ISBN 978-1-880653-96-8
Experimental and Computational Comparisons of the OC3-HYWIND and Tension-Leg-Buoy (TLB) Floating Wind Turbine Conceptual Designs	Myhr, A.; Maus, K.A.; Nygaard, T.A	Proceedings of The Twenty-first (2011) International OFFSHORE AND POLAR ENGINEERING CONFERENCE, ISBN 978-1-880653-96-8
Impact of system power losses on the value of an offshore grid for North Sea offshore wind	Farahmand, H.; Hernando, D.H.; Warland, L.; Korpås, M.; Svendsen, H.	IEEE PES Transactions & PowerTech2011 IEEEXplore Conference Proceedings, Print ISBN: 978-1-4244-8419-5
Effect of Foundation Modelling Methodology on the Dynamic Responseof Offshore Wind Turbine Support Structures	Van Buren, E.	Proceedings of the ASME 2011 30th International Conference on Ocean, Offshore and Arctic Engineering, Year 2011, Volume 5, ISBN: 978-0-7918-4437-3
Main Grid Frequency Support Strategy for VSC-HVDC Connected with Wind Farms with Variable Speed Wind Turbines	Haileselassie, T.; Torres-Olguin, R.E.; Vrana, T.K.; Uhlen, K.; Undeland, T.	IEEE Trondheim PowerTech 2011, Conference proceedings, Print ISBN: 978-1-4244-8419-5
Power Flow Analysis of Multi-terminal HVDC Networks	Haileselassie, T.; Uhlen, K.	IEEE Trondheim PowerTech 2011, Conference proceedings, Print ISBN: 978-1-4244-8419-5
Ant Colony based Transmission Expansion developed for the Nordic Area and Great Britain	Fuchs, I.; Völler, S.; Gjengedal, T.	IEEE Trondheim PowerTech 2011, Conference Proceedings, Print ISBN: 978-1-4244-8419-5
Short-Term Fatigue Analysis of Semi-Submersible wind turbine tower	Kvittem, M.I.; Moan, T.; Gao, Z.; Luan, C.	OMAE 2011; Rotterdam; 19 - 24 June 2011
Characteristics of Steep Second-Order Random Waves In Finite and Shallow Water	Stansberg, C.T.	OMAE 2011; Rotterdam; June 19 – 24, The Netherlands Volume 6: Ocean Engineering ISBN: 978-0-7918-4438-0

A.3.2 Published Conference Papers

Title	Author	Conference
Control challenges and possibilities for large offshore wind farm	Anaya-Lara,O.; Tande, J.O.; Uhlen, K., Undeland, T.	EPE Joint Wind Energy and T&D Chapters Seminar; Trondheim; Norway, 9-11 May 2011
Task Analysis in the Development Process of Access Systems for Offshore Wind Turbines	Dai, L.; Rausand, M.; Utne, I.B.	EWEA 2011; Brussels; 14-17 March 2011
Development of the optimal inspection and repair strategies for offshore wind turbines	Hameed, Z.; Vatn, J.	ESReDA; Bordaux; France; May 25 - 26, 2011
Ameliorating the Negative Damping in the Dynamic Responses of a Tension Leg Spar-Type Support Structure with a Downwind Turbine	Karimirad, M.; Moan, T.	EWEA 2011 conference, 14-17 March 2011, Brussels, Belgium

Title	Author	Conference
An Integrated Design Tool for Large Wind Turbine Blades	Frøyd, L.; Dahlhaug, O.G.	7h PhD seminar on wind energy in Europe; Delft, The Netherlands; 27-28 Oct. 2011
Development and Evaluation of the 3rd wind actuator-disk wake model	Van Rij, J.	Wake conference 2011; Visby, Gotland, 8 – 9 June 2011
North Sea Offshore Networks Basic Connection Schemes: Dynamic Performance Assessment	Anaya-Lara, O.; Kalcon, G.; Adam, G.; Nieradzinska, K.; Tande, J.O.; Uhlen, K.; Undeland, T.	EPE Joint Wind Energy and T&D Chapters Seminar; 9, 10 and 11 May 2011; Trondheim, Norway
Integrated analysis of DFIG drivetrain and power electronics dynamics during electrical AC faults and wind disturbances	Barahona, B.; Sørensen, P.; Anaya-Lara, O.; Tande, J.O.	EPE Joint Wind Energy and T&D Chapters seminar; Trondheim, Norway; 9-11 May 2011
Control challenges and posibilities for large offshore wind farm	Anaya-Lara, O.; Tande, J.O.; Uhlen, K.; Undeland, T.	EPE Joint Wind Energy and T&D Chapters seminar; Trondheim, Norway; 9-11 May 2011
Control of multiterminal HVDC and its impact on multi-national power market	Haileselassie, T.; Uhlen, K.	CIGRE International Symposium; Recife 2011; Brasil; 3 – 6 April 2011
State of the Art in Generator Technology for Offshore Wind Energy Conversions Systems	Zhaoqiang, Z.; Matveev, A.; Øvrebø, S.; Nilssen, R.; Nysveen, A.	IEMDC 2011; Niagara Falls; 15 – 18 May 2011
DEEPWIND - AN INNOVATIVE WIND TURBINE CONCEPT FOR OFFSHORE	U.S. Paulsen, T.F. Pedersen, H.A. Madsen, K. Enevoldsen, P.H. Nielsen, J.Hattel, L. Zanne, L. Battisti, A. Brighenti, M. Lacaze, V. Lim, J.W. Heinen, P.A. Berthelsen, S. Carstensen, E.-J. de Ridder, G. van Bussel, G. Tescione	EWEA 2011 conference; 14 – 17 March 2011; Brüssel; Belgium
Transfer of methods and experiences from operation and maintenance in other industries to offshore wind farms	Valland, A.; Dyrkoren, E.; Heggset, J.	COMADEM 2011; Stavanger; 30th May – 1st June 2011
Optimization of floating support structures for deep water wind turbines	Berthelsen, P.A.; Fylling, I.	EWEA 2011 Conference; 14 – 17 March 2011, Brussels; Belgium
Reliability of offshore wind turbines by grouping suitable inspection regimes	Hameed, Z.; Vatn, J.	EWEA 2011 Conference; 14 – 17 March 2011, Brussels; Belgium
Extending Condition Monitoring of Offshore Wind Farms with Remote Inspection	Netland, Ø.; Skavhaug, A.	COMADEM 2011; Stavanger; 30 May – 1 June 2011
Role of condition monitoring in the realization of dynamic grouping and its optimization using Genetic Algorithm for offshore wind turbines	Hameed, Z.; Vatn, J.	COMADEM 2011; Stavanger; 30 May – 1 June 2011
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A study of switching overvoltages in offshore wind farm	Soloot, A.H.; Høidalen, H.K.; Gustavsen, B.	International Symposium on High Voltage Engineering; Germany; August 2011
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Title	Author	Conference
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Performance assessment of floating wind turbines during grid faults	Anaya-Lara, O.; Endegnanew, A.; Tande, J.O.; Svendsen, H.; Uhlen, K.; Gjerde, S.; Sætertrø, K.; Gjølmesli, S.	EWEA Offshore 2011; Amsterdam; The Netherlands; 29 Nov – 1 Dec. 2011
PLANT RELIABILITY - which turbine needs intervention, and when?	Valland, A.	EWEA Offshore 2011; Brussel; 14 – 17 March 2011
State based models applied to offshore wind turbine maintenance and renewal	Hameed, Z.; Vatn, J.	ESREL 2011; 18 - 22 September 2011; Troyes; France
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A framework and model for optimizing maintenance and logistics activities	Hofmann, M.; Halvorsen-Weare, E.; Nonås,L.M.,; Vatn,J.	EWEA Offshore 2011; Amsterdam; 29 November - 1 December 2011
Experimental design of a feasibility study for remote inspection of wind turbines	Netland, Ø.; Jensen, G.D.; Skavhaug, A.	EWEA Offshore 2011; Amsterdam 29 november - 1 desember 2011
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A.3.3 Books

Title	Author	Book

A.3.4 Reports

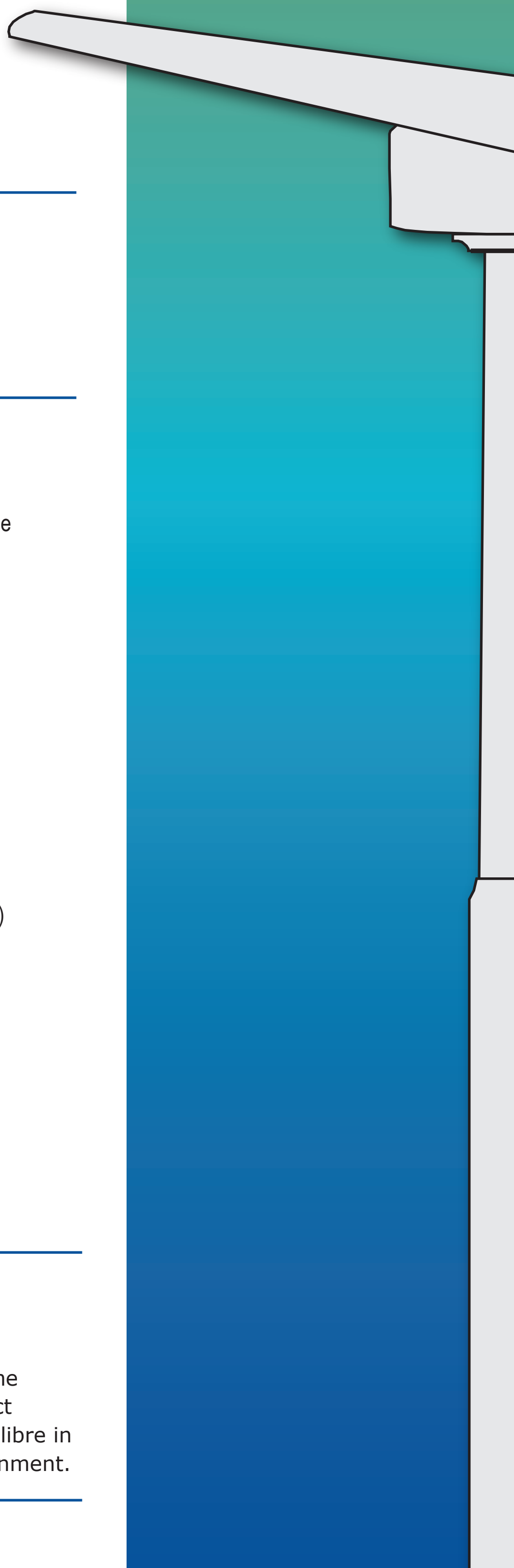
Title	Author	Institution
Assessment of production and maintenance required for wear resistant and low friction surfaces	Equey, S; Bjørgum, A; Armada Nieto, S	SINTEF Materials & Chemistry
Implementation and veri cation of a Spalart-Allmaras turbulence model	Kvarving, A.M.; Holdahl, R.	SINTEF ICT
IEA Wind Task 30 Offshore Code Comparison Collaborative Continuation (OC4) Project, IFE Status June 2011	Nygaard, T.A.	IFE
Power quality; Voltage dip statistics; Elspec measurements; Hitra wind farm; Hundhammerfjellet wind farm	Marvik, J.; Endegnanew, A.; Tande, J.O.	SINTEF Energi AS
State of the art review: Wireless communication (D5.2-5)	Skavhaug, A.	NTNU

Title	Author	Institution
Offshore wind farms: Safety management framework and issues (D5.1-3)	Albrechtsen, E.; Tveiten, C.	SINTEF Teknologi og Samfunn
State of the art multi-dicipline optimization.	Sørheim, E.	IFE
Experimental Techniques for Floating Offshore Wind Turbines - Literature survey	Muthanna, C.	MARINTEK
Wind Power R&D Seminar - Deep Sea Offshore Wind - Trondheim, Norway, 20 - 21 January 2011	Tande, J.O.	SINTEF Energi AS
Case Study of Bottom-Fixed Wind Turbine with Jacket Substructure	Graczyk, M.	MARINTEK
Case study of floating Wind Turbine Based on Windfloat Concept	Taby,J.; Graczyk, M.	MARINTEK
Pre-Study on Cost-effective, Remote, Environmental Friendly O&M of Large Scale Offshore Wind Turbine Plants	Netland, Ø.; Skavhaug, A.	NTNU
A Study of Wind Effects on a Spar Buoy Wind Turbine - Application of the Contour Line Method	Baarholm, G.S.	MARINTEK
Integration of offshore wind f arm with oil and gas platforms	Svendsen, H.G.; Hadiya, M.; Øyslebø, E.V	SINTEF Energi AS

NOWITECH (Norwegian Research Centre for Offshore Wind Technology) is a centre for environment-friendly energy research started in 2009 co-funded by the Research Council of Norway.

The objective of NOWITECH is pre-competitive research laying a foundation for industrial value creation and cost-effective offshore wind farms. Emphasis is on "deep-sea" (+30 m) including bottom-fixed and floating wind turbines. Work is focused on technical challenges including a strong PhD and post doc programme:

- Integrated numerical design tools for novel offshore wind energy concepts.
- Energy conversion systems using new materials for blades and generators.
- Novel substructures (bottom-fixed and floaters) for offshore wind turbines.
- Grid connection and system integration of large offshore wind farms.
- Operation and maintenance strategies and technologies.
- Assessment of novel concepts by numerical tools and physical experiments.



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