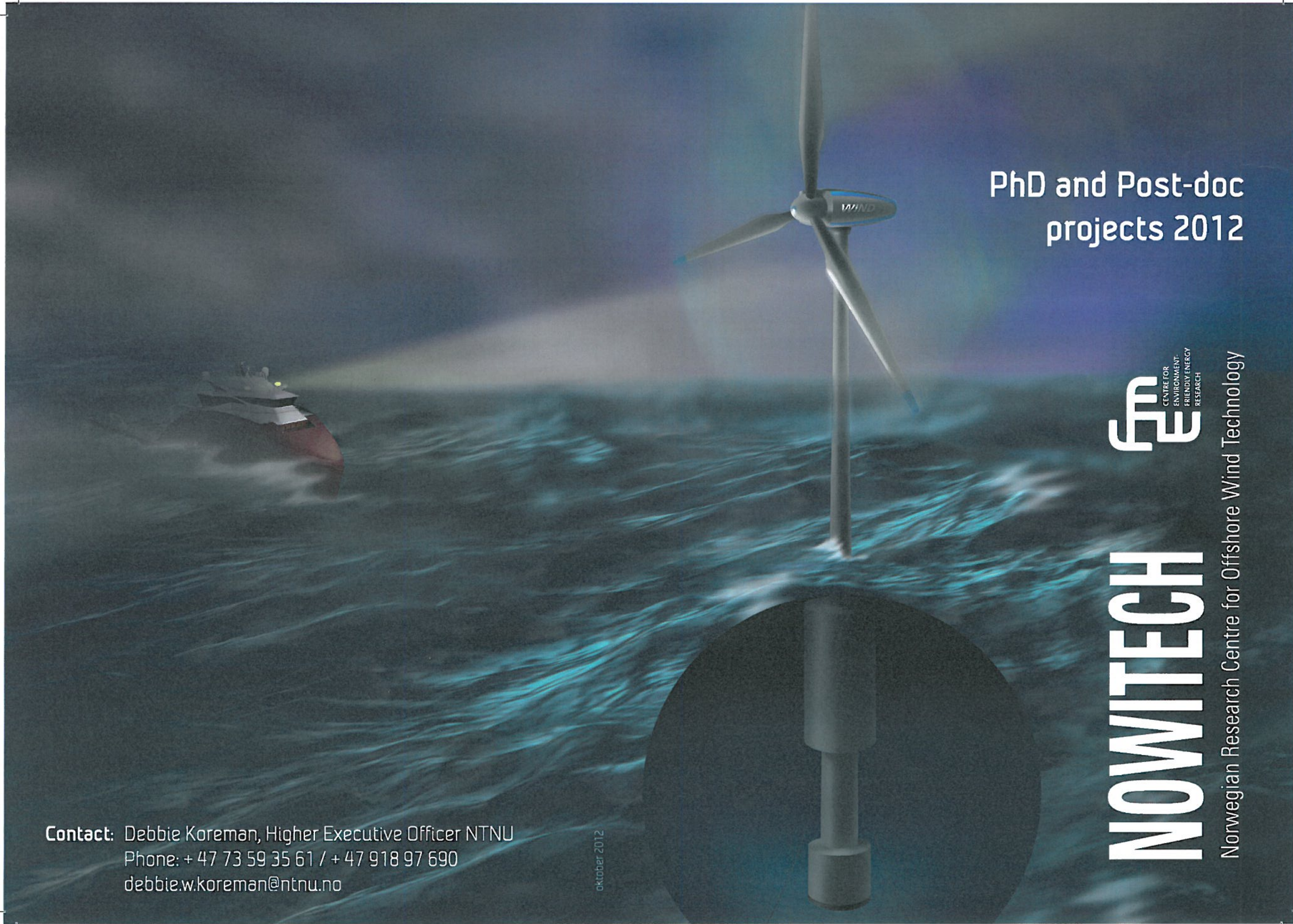


PhD and Post-doc
projects 2012
NOWITECH
Norwegian Research Centre for Offshore Wind Technology
CENTRE FOR ENVIRONMENT-FRIENDLY ENERGY RESEARCH
WIND
Contact: Debbie Koreman, Higher Executive Officer NTNU
Phone: + 47 73 59 35 61 / + 47 918 97 690
debbie.w.koreman@ntnu.no
oktober 2012

An overview over NOWITECH PhDs and Post-docs 2012

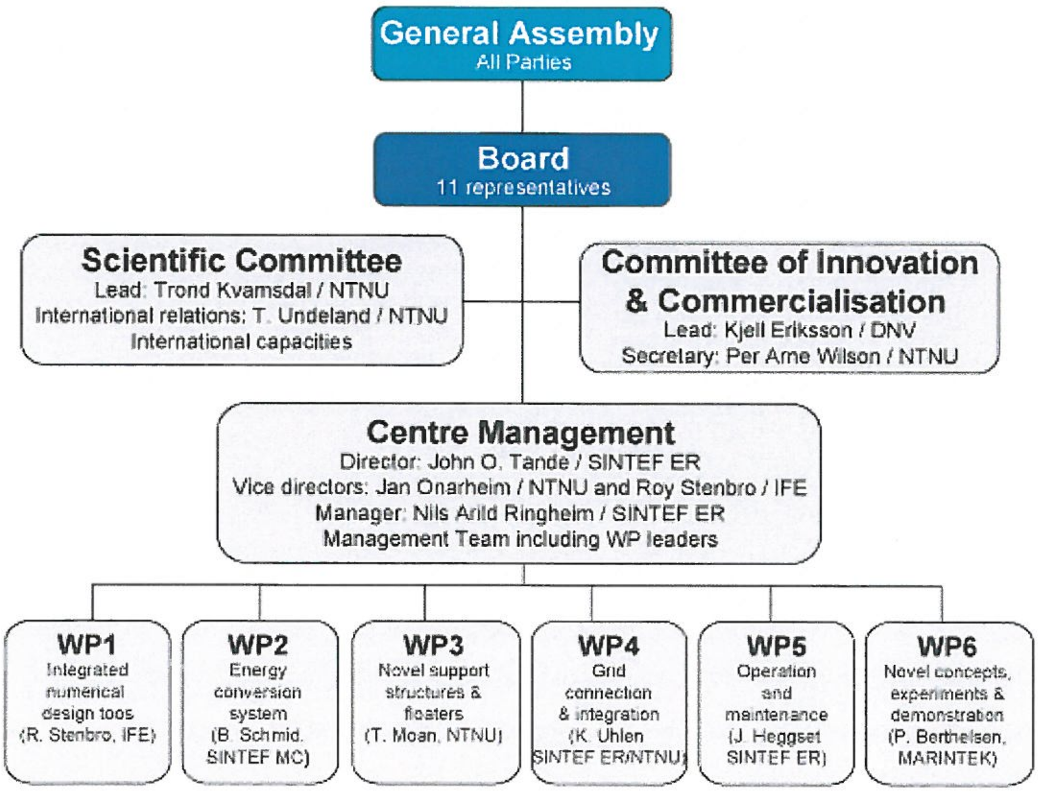
The Norwegian government has established 8 national research centers on climate friendly energy. **NOWITECH** (Norwegian Research Centre for Offshore Wind Technology) is one of them.

The research partners are NTNU, SINTEF and IFE, whereas leading national and international companies are industrial partners (i.e. Statoil, Statkraft, Dong Energy and several more). Recognized international research organizations are collaborating with the Centre (i.e. DTU (Denmark), University of Strathclyde (UK), Fraunhofer (Germany), TU Delft (The Netherlands), MIT (USA), NREL (USA) and NTU (Singapore)).

There is ongoing collaboration with relevant centers at NTNU, such as the Center for Ships and Ocean Structures (CeSOS – www.cesos.ntnu.no) and the Center for Integrated Operations in the Petroleum Industry (www.ntnu.no/iocenter). NOWITECH has its focus on research within offshore wind technology, thus reducing CO_2 emissions and the effects on the climate.

Many professors and researchers are engaged in this field together with a significant number of PhD students and Post-docs. See www.nowitech.no for more details. With the establishment of NOWITECH, the research in offshore wind in Norway has significantly increased.

NOWITECH Organization Chart



With this report we give an overview of current NOWITECH PhD and Postdocs research projects; PhDs and Post-docs who work at several institutes (to be exact 9 departments) of NTNU.

Currently 24 students are registered in our PhD program. This number has been reached within two years, and there was much interest both times the positions were published. The first round was in Spring 2009 (13 positions); the second round was in Spring 2010 (12 positions). About 20 Professors and associate professors are directly involved as supervisors and co-supervisors.

The PhD and Postdocs are under auspices of the NOWITECH Scientific Committee who is responsible for develop, in collaboration with the Centre Managements and WP leaders of NOWITECH, a top quality PhD and Postdoc program. 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.

Trond Kvamsdal
Chairman of NOWITECH SC

List of contents

Völler, Steve*	Balance management with large scale offshore wind integration	25
Wang, Kai	Comparative study of floating concepts	26
Zhang, Zhaoqiang	Coupled 3D models of permanent magnetic generators with very large diameters and with a special focus on losses	27
Zwick, Daniel	Design of nodes in lattice towers for effective production	28
Bardal, Lars Morten	Design wind and sea loads for offshore wind turbines	Appen-dix

* Finished/Stopped (status September 30, 2012)

Mayilvahanan Alagan Chella

Home country	India
Year of birth	1980
Master's degree	M.Sc. (Ocean Engineering)
University	Indian Institute of Technology Madras, India
Graduation year	2010
Research group	Marine Civil Engineering
Supervisors	Michael Muskulus and Dag Myrhaug
PhD start	October, 2010
Phone	73594667
E-mail	acm@ntnu.no
Home page	http://www.ntnu.edu/employees/chella

Wave forces on wind turbine substructures at moderate water depths

The wave forces acting on the substructure depends on several parameters such as depth at which it is located, wave climate and current intensity etc. The offshore wind turbine structures are slender and wave loads act on the lower part of the tower. Near to the free surface zone, the wave forces may obtain their maximum values. The hydrodynamic issues pertaining to offshore wind turbine substructures are to be investigated, such as the variation of the wave forces due to the local modifications of free surface and the impact load on the substructure. The objective of the present work is to investigate the wave forces with emphasis on the free surface zone on the offshore wind turbine substructures. The scope of the work includes the study of variation of wave forces due to local modification of the free surface and also the impact force on substructures due to steep and breaking waves. The substructure considered for this study is Monopile or Jacket structure in moderate water depth ranging from 10m to 50m. The outcome of this study can be an improved characterization of the free surface effects of the wave forces on offshore wind turbine substructures.

Anthonippillai Antonarulrajah

Home country:	Great Britain
Year of birth:	1969
Supervisor:	Andreas Echtermeyer
Post-doc start:	December 2009
Post-doc end:	September 2011

Stanislav Shchebetov

Home country:	Russia
Year of birth:	1985
Supervisor:	Andreas Echtermeyer
Post-doc start:	September 2011 (to finish Antonarulrajahs work)
Post-doc end:	December 2011

Topic

Influence of material and process parameters on fatigue of wind turbine blades in a marine environment.

René Alexander Barrera Cárdenas

Home country	: Colombia
Year of birth	: 1982
Master's degree	: Electrical Engineering
University	: Universidad Industrial de Santander
Graduation year	: 2010
Research group	: Power systems
Supervisor	: Marta Molinas
PhD start	: March 2011
Phone	: +47 73 59 4224
E-mail	: rene.barrera@elkraft.ntnu.no
Home page	: http://www.ntnu.edu/employees/rene.barrera

Multi-Domain Optimization Model for Evaluation of Power Density and Efficiency of Wind Energy Conversion Systems

The prospective development of the wind energy conversion systems is mainly promoted by demand for higher efficiency and power density. These requirements can be satisfied through the use or development of new topologies, modulation strategies or new semiconductor technologies. The gain in performance improvement is reduced over time, once the new concept or technology has been established. After the basic concept has been adopted, a significant gain in performance can only be achieved by allocating the optimal values of design variables during the design process. In the other hand, by detecting the sensitivity of the system level performance on component parameters, the development of components could be adjusted for maximal impact on the system level.

So to achieve such an optimization first a complete model of the converter circuit must be set, including thermal and magnetic component models. This model could be based on analytical equations, on numerical simulations or on a combination of both. The analytical models enable fast calculation but are more complicated and/or have more time consuming to develop, additionally could not be easily adjusted to further topologies or modulation schemes. Moreover, simulations are fairly flexible but could require substantial computational effort to the point of becoming a non-viable option. In order to reduce the burden on the computation, Meta-Modeling will be considered. Basically, Meta-Modeling is a method of further modeling the model, which is, generating a simpler model that captures only the relationships between the relevant input and output variables.

Based on converter circuit model, an optimization for multiple objectives, efficiency and power density, will be performed. The optimization makes best use of all degrees of freedom of a design and also allows determining the sensitivity of the system performance based on technologies like measurement of the efficiency of the power semiconductors or properties of the magnetic core materials. Furthermore, different topologies can be easily compared and inherent performance limits can be identified.

This project is looking for developing a methodology of multi-domain design to optimize the power density and efficiency of the wind energy conversion system in offshore wind farms. Analytical approaches for designing the main functional elements of a wind energy conversion system will be described and arranged to a linear design process in a first step. Moreover, the linking of the component models, i.e. of the electric, magnetic and thermal design domains and an overall optimization of the respective design variables based on the linked models will be considered and including the coupling of the different domains.

Tania Bracchi

Home country:	Italy
Year of birth:	1982
Master's degree:	Aerospace Engineering
University:	Politecnico di Torino
Graduation year:	2009
Research group:	Fluid mechanics
Supervisor:	Per-Åge Krogstad
PhD start:	September 2009
Phone:	+47 46861200
Home page:	http://www.ntnu.edu/employees/tania.bracchi

Assessment of benefits of downwind rotors due to weight savings using new and thinner airfoils and improved directional stability of turbine

Offshore wind is a rich energy resource and it will have a strong contribution in the achievement of EU's energy policy objectives for 2020, and later for 2030. At the end of 2011 the total offshore installed capacity in European water was 3813MW (EWEA report) and the target is 40GW by 2020 and 150GW by 2030.

The strong and stable offshore wind consents high power extraction and the environment is favorable for increasing the size, hence the capacity, of wind turbines. Nevertheless rotors of large size imply structural difficulties.

The research work focuses on the design of a new and thinner blade for downwind rotor layout application. In fact the blade can be more flexible in downwind rotors compared to upwind, since in normal operation the blade bends away from the tower, avoiding striking it. The result is that a thinner blade would have better aerodynamic performances, moreover the rotor weight and the blade loads would be reduced. In addition the tower shadow effect and the directional stability of the turbine are investigated.

Valentin Chabaud

Home country	:	France
Year of birth	:	1987
Master's degree	:	Energy & Processes
University	:	Grenoble–INP & NTNU
Graduation year	:	2011
Research group	:	Marine Technology
(Co)Supervisors	:	Sverre Steen, Roger Skjetne
PhD start	:	08/2011
Phone	:	73595977
E-mail	:	valentin.chabaud@ntnu.no
Home page	:	www.ntnu.no/ansatte/valentin.chabaud

Real-time hybrid testing of floating wind turbines

Scale model testing of offshore wind turbines suffers from a lack of appropriate facilities and scaling effects. The actual trend is to prematurely bypass this step by launching small or full scale prototype testing, with its considerable risk of failure and corresponding huge costs. Moreover, one may likely have the will to test only one aspect of such a system among many (aerodynamics, hydrodynamics, control, structural dynamics, power generation...).

From these considerations comes the idea of real-time hybrid testing, consisting in testing physically only one part of the total loading. The remainder is simulated numerically, in order to be actuated back in real-time on the physical model by mean of actuators.

The Phd topic consists in investigating the applicability of real-time hybrid testing to hydrodynamics, through the relevant case of floating wind turbines. Suitable numerical models are first to be created/adapted to calculate loads in real time from measured motions. These loads are sent as a reference to a controller driving actuators whose dynamics are crucial regarding the final performance and need to be studied thoroughly. Comparing the results of this method with advanced numerical models and model and/or full scale testing would give an assessment on its applicability.

Kevin Cox

Home country : USA
Year of birth : 1984
Master's degree : Mechanical Engineering
University : University of Colorado at Boulder
Graduation year: 2007

Research group : Engineering Design and Materials
Supervisor : Andreas Echtermeyer
PhD start : November 2010

Phone : +47 94161394
Email : kevin.cox@ntnu.no
Home Page : http://www.ntnu.no/ansatte/kevin.cox

Lift control of wind turbine blades by using smart composite materials to manipulate aerodynamic rotor properties

The development of offshore wind turbines poses significant engineering challenges that must be addressed before cost effective wind machines can be successfully installed in moderately deep water. When moving turbines offshore, the trend is to increase the rotor diameter to harness a larger amount of wind, ultimately decreasing the cost of energy. The increase in diameter creates design issues for many of the components, with the blade length being the first parameter affected. One of the major challenges for all turbines is designing the blade so that it is robust, low weight, cost effective, and highly efficient. Because the wind speed is ever-changing, the blades must be able to adapt to a variety of loading conditions to remain efficient.

Passive pitch control can save money through improved aerodynamic efficiency and a reduction of loading conditions. The concept refers to the ability of a turbine blade to automatically adapt to the changing wind conditions without the input of external energy. One method for passively controlling the pitch of a wind turbine blade is achieved by utilizing anisometric materials that deform nonuniformly under applied loads. Fiber composites are the leading material choice used in today's industrial turbine blades mainly because of their cost and strength and stiffness to weight ratios. It is possible to tailor the properties of composites so that they become anisometric materials and exhibit bend-extension and bend-twist coupling. By utilizing these couplings, a composite structure can be designed to twist from an applied bending or axial load, thus creating a response not possible with isometric materials.

The aim of this project is to develop a wind turbine blade capable of passive pitch control and suitable for a 10 MW offshore wind turbine. This will be achieved through the design and simulation of blades made of carbon and or glass fiber composite laminae oriented at various angles and stacked in a laminate. The number, thickness, orientation, and fiber material (carbon or glass) will be determined and verified through finite element analysis (FEA). Due to the large size of the 10 MW turbine blades, this project will employ pitching towards feather to reduce the flap bending moment at high wind speeds. Furthermore, the affects of fatigue, buckling, and aerodynamic flutter instabilities on anisometric composites will be studied.

Pål Egil Eriksen

Home country:	Norway
Year of birth:	1984
Master's degree:	Energy and environment
University:	NTNU
Graduation year:	2010
Research group:	Fluid mechanics
Supervisor:	Per-Åge Krogstad
PhD start:	August 2010
Phone:	73593707
E-mail:	pal.egil.eriksen@ntnu.no
Home page:	http://www.ntnu.no/ansatte/palegil

Rotor wake turbulence

As wind energy is becoming a more mature technology more and more wind farms will be put up around the world. A single wind turbine can in itself be an impressive piece of engineering. But when you combine a large number of wind turbines in a wind farm it is taken to a new level and so is the complexity of the flow conditions experienced by the individual turbine. Depending on the wind direction, weather conditions and operating points of the other turbines in the park, the wind conditions seen by two turbines in the same park can therefore be very different. While one turbine has optimum conditions, another turbine can at the same time experience a high load conditions and have low production. A lot of work is being put into developing numerical models, capable of predicting the flow conditions inside wind parks. An important input in the process of validating such models is experimental data obtained under controlled conditions in a wind tunnel.

My project focuses on obtaining such experimental data. This is mainly achieved using constant temperature hot-wire anemometry (CTA). A CTA system has a high frequency response and is capable of capturing the fluctuating flow field in a wind turbine wake. The result is detailed information about the turbulent statistics in the wake. This information will be used in the development of integrated numerical design tools for wind park planning.

Lars Frøyd

Home country:	Norway
Year of birth:	1984
Master's degree:	Energy and environment
University:	Norwegian University of Science and Technology
Graduation year:	2009
Research group:	Fluid engineering
Supervisor:	Ole Gunnar Dahlhaug
PhD start:	August 2009
Phone:	+47 735 93165
E-mail:	lars.froyd@ntnu.no
Home page:	http://www.ntnu.no/ansatte/lars.froyd

Wind turbine design: Dimensioning, dynamic forces on large offshore wind turbines

The first generations of offshore wind turbines are designed more or less similar to onshore turbines, with three-bladed rotors mounted upwind of the tower and moderate tip speeds. This design compromise emerged because wind turbines traditionally were made for onshore locations, with corresponding constraints on visual appearance and noise that do not apply to the same degree offshore. Now the offshore wind energy business is beginning to mature and we see that the design trends are starting to change: After stagnation in turbine sizes between three and five MW and rotors up to 126 *m* diameter, we again see larger turbines being presented by the manufacturers, with rated powers ranging from six to ten MW.

Larger turbines make sense as it will reduce the number of foundations and marine operations for a given park rating, and give benefits regarding maintenance. The head mass is, however, one of the largest cost drivers for the turbine, and because the rotor mass generally scales with the cube of the rotor diameter and the energy production only scales with the square of it, it is essential to gain confidence in lightweight rotor designs. To keep the cost down in large offshore specific turbines, one can allow higher absolute tip speeds to reduce the drive train torque and more slender blades to reduce ultimate loads. Others have suggested two-bladed designs for weight savings or more flexible, downwind designs to alleviate fatigue loads. All of these design changes have the potential to reduce the cost of offshore wind energy, which is the ultimate goal, but they also introduce new challenges, for instance regarding dynamic behaviour and aeroelastic stability of the turbines.

This project, which is part of *Work Package 1 - integrated numerical design tools*, deals with the design challenges of very large wind turbines. The objective is partly to develop a design tool for realistic aeroelastic blade design of large wind turbine rotors, and partly to utilize this tool to evaluate the design criteria regarding blade scaling and dynamic stability through parametric studies in aeroelastic simulation tools.

Zafar Hameed

Home country	: Pakistan
Year of birth	: 1975
Master's degree	: Mechanical Engineering
University	: Seoul National University South Korea
Graduation year	: 2008
Research group	: RAMS Group
Supervisor	: Jørn Vatn
PhD start	: October 2009
Phone	: +47 735 97102
E-mail	: zafar.hameed@ntnu.no
Home page	: http://www.ntnu.edu/ross/rams

Maintenance optimization of offshore wind turbines from design to operation (models, methods, framework)

Offshore wind energy has become an emerging area of research due to its rapid growth in the energy market. There are number of reasons of this trend due to environmental hazards being posed by traditional sources of energy like oil, gas and coal etc. From last three decades, wind turbines were installed on onshore with certain psychological impacts on the local community. To overcome the issues coupled with onshore wind turbines, the trend has been set to shift these wind turbines from onshore to offshore locations. While handling the impacts of land based wind turbines, new challenges have come in our ways to make the offshore wind turbines more reliable and efficient compared to onshore wind facilities. In the operations of offshore wind turbines, the important challenges are access, logistics and failure behavior.

The working environment of offshore is entirely different from the land based locations. For example, in case of failure, the repair is relative simple for onshore wind turbines but for marine location, the suitable vessel has to be arranged keeping in view the weather conditions. Then based on the nature of failure it may be required to transport heavy components to replace them with the faulted ones. There is another important challenge to understand the failure behavior of offshore wind turbines in marine environment which needs further investigation compared to onshore wind turbines. Keeping in view the issues of access, logistics, and failure patterns coupled with the operations of offshore wind turbines, it is necessary to address these demanding tasks to make them as a viable choice for power production compared with other sources of energy.

Keeping in view the intricacies related with the operations of offshore wind turbines, it is imperative to develop an overall framework to develop optimal strategies at the whole wind farm level. Additionally, there exists a need to understand the degradation mechanism of wind turbine components to decide which of them will follow condition based models and which ones are good to be repaired based on their age. The development of overall framework to handle different inspection, repair and renewal strategies at the wind farm level might be a gigantic task. To accomplish such a task, the development of an overall maintenance optimization framework is underway.

Madjid Karimirad

Researcher:	Dr. Madjid Karimirad
Home country:	Iran
Year of birth:	1982
Bachelor Degree (BSc):	Mechanical Engineering/Marine Engineering
Master's Degree (MSc):	Mechanical Engineering/Ship Structures
Doctoral Degree (PhD):	Marine Technology/ Marine Structures
University:	Sharif University of Technology (both BSc and MSc) and Norwegian University of Science and Technology (PhD)
Graduation year:	BSc (2005), MSc (2007) and PhD (2011)
Research group:	Post-Doctoral researcher at CeSOS
Supervisor:	Professor Torgeir Moan
Post-Doc start:	January 2011
Phone:	Mobile: 944 84 785 Work: 735 95 943
E-mail:	madjid.karimirad@ntnu.no
Home page:	http://www.cesos.ntnu.no/~madjid/

Post-Doctoral topic: "Alternative offshore wind turbines for moderate water depths"

The feasibility of application of offshore wind turbines at moderate water depths is studied in this post-doctoral research. In the oil and gas industries, offshore platforms are widely applied in the deep and moderate depths. The power performance, structural integrity and dynamic responses of offshore wind turbines in deep water (spar-type wind turbines with catenary or taut mooring systems) have previously been studied by Dr. Madjid Karimirad. In the current research, the alternative offshore wind turbines for moderate water depths are studied. The idea is to reduce the cost of electricity from offshore wind. Code-to-code comparison between the simplified and comprehensive aero-hydro-servo-elastic codes is among other issues in this research. The idea is to introduce fast methods with respect to processing-time while maintaining an acceptable accuracy.

Mukesh Kumar

Home country: India
Year of birth: 1983

Ph.D. Degree: Applied Mathematics
University: Indian Institute of Technology Delhi, India
Graduation year: 2009

Research group: Differential Equations and Numerical Analysis
Supervisor: Trond Kvamsdal
Post-doc start: January 2011

Phone: +47-735-90481
Email: Mukesh.Kumar@math.ntnu.no
Home page: http://www.math.ntnu.no/~mukeshk/

Adaptive methods for accurate CFD-simulations of aerodynamic loads on offshore wind turbines

The aerodynamic loads on the rotor blades are the largest loads acting on a wind turbine. The horizontal wind turbine types of blades are usually made of two or three airfoils such as a propeller. In these types of blades, it is the lift force which makes the rotor turn. The drag force acts perpendicular to the lift force due to the resistance of the airfoil from the wind and counteracts the rotation to rotor. Therefore, predicting these loads accurately is one of the most important parts of the calculations in wind turbine aerodynamics. Another reason for computing the aerodynamic loads on rotor blades is to model the aeroelastic response of the entire wind turbine construction. There are different methods to calculate the aerodynamic loads on a wind turbine rotor with different level of complexity such as Blade Element Momentum Method (BEM), Vortex Method(VM), and Computational Fluid Dynamics (CFD).

Though CFD has made significant inroads as a research tool, simple, inexpensive methods, such as blade element momentum (BEM) theory, are still the workhorses in wind turbine design and aeroelasticity applications. These methods generally assume a quasi-steady flowfield and use two-dimensional aerodynamic approximations with very limited empirical 3-D corrections. As a result, they are unable to accurately predict rotor loads near the edges of the operating envelope. CFD methods make very few limiting assumptions about the flowfield, and thus have much greater potential for predicting these flows.

Adjoint methods are becoming increasingly important in the CFD analysis of aerodynamic performance. These methods offer reliable estimates of the sensitivity of output functionals, such as lift or drag, to the many parameters involved in numerical simulations. The approach relies on the solution of an adjoint equation and provides error estimates that can be used to both improve the accuracy of the functional and guide a mesh refinement procedure. The aim of the project is to design such reliable error estimates for adaptive methods for accurate CFD-simulation of aerodynamic loads on offshore wind turbines.

Marit Irene Kvittem

Home country:	Norway
Year of birth:	1982
Master's degree:	Structural engineering
University:	Norwegian University of Science and Technology
Graduation year:	2007
Research group:	Centre for Ships and Ocean Structures
Supervisor:	Torgeir Moan
PhD start:	Fall 2009
Phone:	74595529
E-mail:	marit.irene.kvittem@ntnu.no
Home page:	http://www.cesos.ntnu.no/people/phds/13-phds/61-marit

Topic: Life cycle criteria and optimization of floating structures and mooring systems

Proposed concepts for offshore wind turbines for deep waters consist in general of a horizontal axis wind turbine mounted on a floating, moored structure. From a structural engineering point of view the main challenges for these concepts are large and fluctuating loads from wind, waves, current and rotor. These must be predicted as accurately as possible to balance material, installation and inspection costs.

Since there is limited experience with floating wind turbines, no design codes for floating wind turbines exist today. A design code must specify important load cases, analysis sample size, safety factors etc. which must be based on experience from model tests, prototypes and numerical simulations.

In this project the focus is on testing simplified design approaches and identifying important load cases within the life cycle of a floating wind turbine from after installation to decommissioning. The studies are done through numerical simulations of wind turbines on catenary moored semi-submersible platforms.

Chenyu Luan

Home country:	China
Year of birth:	01 .03.1987
Master's degree:	MSc in Marine Technology
University:	NTNU
Graduation year:	2011
Research group:	Work package 3
Supervisor:	Torgeir Moan
PhD start:	08.2011
Phone:	73595658
E-mail:	chenyu.luan@ntnu.no
Home page:	http://www.ntnu.no/ansatte/chenyu.luan

Efficient stochastic dynamic response analysis for design of offshore wind turbines

There is a significant potential for offshore wind energy. In deeper water it may be most cost effective to exploit this potential by using floating wind turbines. Some floating wind turbine concepts have already been proposed such as Hywind, Sway, WindFloat, WindSea, HiPRwind, DeepWind and so on.

Floating support structure has been approved and used by offshore oil industry for several decades. However, the combination of hydrodynamic load, aerodynamic load and wind turbine control, the non-linear coupling effect of flexible structure and mooring system and the requirement of saving cost significantly increase the complexity of the design work

As a result, it is very important to have a numerical tool that can well develop aero-hydro-servo-elastic model of floating wind turbine in time domain and enlighten the understanding of dynamic response behaviors.

Due to the complexity of the numerical model, it may be very time consuming to do numerical analysis, such as fatigue assessment, in time domain using a refined analysis tool. Consequently, the object of this research is to contribute some effort to find simplified method that can give simulation results in a short time with acceptable accuracy and can be used for design purpose in industry. Special emphasis of this research will be given to floating wind turbine with semi-submersible supporting structure and catenary mooring system. The refined model can be simplified in terms of aerodynamic loads, hydrodynamic loads, structural modeling for global response analysis, and so on.

There are many simplification methods that may be helpful to improve the efficiency of the design work. Careful research study, comparisons between the simplified methods and refined model and benchmark work are need before we can use these simplified methods.

Fahmi Mubarok

Name:	Fahmi Mubarok
Home country:	Indonesia
Year of birth:	1978
Master's degree:	European Master in Material Science (EMMS)
University:	Technische Universität Hamburg-Harburg (TUHH), Hamburg, Germany
Graduation year:	2008
Research group:	Tribology, Surface Treatment and Corrosion
Supervisor:	Nuria Espallargas
PhD start:	March 2010
Phone:	+47 73591624
E-mail:	fahmi.mubarok@ntnu.no
Home page:	www.ntnu.no/ansatte/fahmi.mubarok

Novel coating for improving tribological performances on rotating components of offshore wind turbines

Large capacity of wind turbines up to 10MW were preferred to install offshore to avoid negative scenery problem and noise pollution despite of its higher costs. As the turbine goes bigger, the mechanical components in the offshore wind turbine will be induced to higher stresses due to massive turbine blades weight and wind alteration. Thus, the gearbox system and main bearings become a critical component subjected to tribological conditions. The extreme static and dynamic loads will affect the fatigue life of the components to meet its design goals of 20 years minimum service life. Moreover, these parts should be corrosion resistant since they will be exposed to harsh seawater environments. In order to ensure that the tribological systems in wind turbine run smoothly, this system must be installed with sophisticated materials or coatings and equipped with effective lubrication systems.

One of the methods that can be applied to improve the tribological properties of the rotating parts of these turbines is surface treatments. Due to the large dimension of offshore wind turbine rotating components, only specific surface treatment methods can actually be employed. Among them, thermal spray is considered to be one of the most efficient and versatile techniques to obtain coatings of all classes of materials on large surfaces. Thermal spray coating generally use wire, rod or powder feedstock materials that pass through a high temperature regime generated by plasma or gas flame where they are fully or partially melted, accelerated in gas stream and impinged towards the substrate to form a coating layer by layer.

Todays, many of wear and corrosion resistance coatings are widely sprayed using flame spray, high velocity oxy-fuel (HVOF), detonation gun or atmospheric plasma spray (APS). Particular attention has been devoted in the very recent past to the possibility of depositing nano- (<100 nm) or sub-microstructured (100 nm – 1 μm) ceramic coatings to yield the potential of exceptional improvements of mechanical and tribological properties. Among the thermal spray processes that advance to achieve this goal is HVOF and APS technique utilizing suspension or solution precursor as it starting feedstock materials. These new systems circumvent the normal feeding problem with nano- and submicron particles and solve the handling difficulties when working with these fine particles.

The potential of suspension thermal spray (STS) and solution precursor thermal spray (SPTS) has driven the thermal spray researchers to explore these new systems to produce the oxide-based wear-resistant coatings (e.g. Al_2O_3, TiO_2, ZrO_2, Y_2O_3) starting from stabilized suspension containing dispersed fine particles and homogenous solution precursor containing dissolved metal salts, organometallic precursor or liquid oxide precursor. However, only few studies are focused on spraying carbide-based materials (e.g. SiC, TiC, WC) using these systems despite of the superior tribological properties of these materials. This circumstance arises due to the difficulties in spraying carbide- and nitride-based materials as they tend to decompose during elevated temperature process under atmospheric condition. This PhD ambition is to explore the possibility to produce carbide- and nitride-based coatings with focus on silicon carbide using the STS and SPTS systems. It is expected that the liquid carrier and correct recipe of SiC suspension+solution precursor can prevent the decomposition, enabling good quality and high strength SiC coatings to be attained. The thermally sprayed silicon carbide coatings owing its nano or submicro-structures are an ideal material for tribological application in wind turbines industries.

Øyvind Netland

Home country:	Norway
Year of birth:	1981
Master's degree:	Engineering Cybernetics
University:	Norwegian University of Science and Technology
Graduation year:	2007
Research group:	Engineering Cybernetics
Supervisor:	Amund Skavhaug
PhD start:	April 2010
Phone:	+47 48084653
Email:	oyvind.netland@itk.ntnu.no
Home Page:	http://www.ntnu.no/ansatte/oyvind.netland

Cost-effective monitoring for remote environmental friendly O&M of offshore wind turbines

Wind energy is considered to be an important addition to fossil fuels in the future, and offshore wind energy is increasing in popularity because of the large areas available offshore with good wind conditions. Offshore wind turbines are unfortunately expensive to operate and maintain, mainly due to turbine access being expensive, time consuming and weather dependent. This research explores the possibility for performing operation and maintenance tasks remotely to avoid the high cost of access, and to enable work to be done regardless of weather conditions.

During the research a prototype of a remotely controlled maintenance and/or inspection robot will be created, and the capability and usability of the prototype will be tested by a group of users. This robot is intended as a tool for maintenance personnel, so they can perform work in a turbine without leaving their office. Since maintenance personnel are not expected to be experienced in robotics, it is important that the system is intuitive and easy to use, and techniques from human-computer interaction will be applied to ensure this. The goal is that the user feels like he is present in the turbine and can perform his work there, i.e. remote presence.

Amir Rasekhi Nejad

Nationality:	Iranian
Year of birth:	1977
Master's degree:	Mechanical Engineering, Subsea Engineering
University:	University of Aberdeen, UK
Graduation year:	2010
Research group:	WP5, O&M and Monitoring
Supervisors:	Professors Torgeir Moan, Jørn Vatn
PhD start:	August 2012
Phone:	+47 735 95506
Email:	Amir.Nejad (at) ntnu.no
Home page:	http://www.ntnu.edu/employees/amir.nejad

Condition monitoring of mechanical drivetrain of a farm of wind turbines in service

Mechanical drive trains in wind turbines normally consist of simple, compound or coupled planetary gear systems with parallel trains. Even though similar configurations have been employed in other industries, gears in wind turbines are not like any other "conventional" power transmission system. The energy conversion mechanism in wind turbines has its own laws with its own specific problems. The specific characteristics of mechanical drive train in the wind industry can be identified such as:

- Very high gear ratio, high operating torque
- Large torque variation
- Large in size & weight
- High reliability requirement, high availability expectation
- Difficult & expensive maintenance
- Difficult access

Using the drive train in this challenging industry with considerable differences with other industries requires more insight knowledge and modelling tools especially when the wind industry trend is toward bigger turbines in deep waters. The main objective of this research work is to explore methods improving reliability of wind turbine gearboxes and establish models for preventive actions and condition monitoring.

Knut Nordanger

Home country:	Norway
Year of birth:	1980
Master's degree:	Industrial Mathematics
University:	NTNU
Graduation year:	2005
Research group:	Differential Equations and Numerical Analysis
Supervisor:	Trond Kvamsdal
PhD start:	November 2010
Phone:	+47 73 59 04 81
E-mail:	knut.nordanger@math.ntnu.no
Home page:	http://www.math.ntnu.no/~nordange/

Topic: Coupled fluid-structure interaction of offshore wind turbines

Much effort, both in research and engineering, is needed to achieve the goals for increased electricity production from offshore wind turbines in the coming years. Advanced simulation tools will definitely be necessary.

The need for dynamic numerical simulation software is increasing as the size of of commercial wind turbines is increasing. Modern design tools should model the entire wind turbine construction, and full CFD simulations are required for detailed investigations of wind turbines where simpler tools based on static simulations are inadequate.

Furthermore, with a structural model of the wind turbine it is possible to determine material loads in the various wind turbine components as a function of time. Almost all structural models are based on classical beam theory. A common trend is to include non-linear structural dynamics in the code.

Accurate modelling of wind turbines requires coupled fluid-structure interaction (FSI), but such simulations have traditionally been considered computationally too expensive to carry out. However, with more powerful computers and better solution techniques based on isogeometric analysis, such simulations become a far more attractive alternative. A key feature in isogeometric analysis is to use the same set of basis functions for both the geometry and the analysis, i.e. the solution space for the dependent variables.

The main focus of my work is to build a working FSI simulation model based on isogeometric analysis for an offshore wind turbine. This model can then be used to investigate aerodynamic flutter as this is highly relevant for fatigue and thus blade damage. Furthermore, it is of interest to investigate how wake operation affects the loading of the wind turbines.

Morten D. Pedersen

Home Country:	Norway
Year of Birth:	1981
Education:	M.Sc. Engineering Cybernetics
University:	NTNU
Graduation Year:	2009
Research group:	Control Engineering
Supervisor:	Thor I. Fossen
Co-Supervisor:	Kjetil Uhlen
PhD start:	Feb 2010
Phone:	+4741602135
Email:	morten.d.pedersen@ntnu.no

Control Systems for Load Mitigation and Stabilization of Floating Wind Turbines

The modern wind turbine usually relies on some form of automatic control to ensure safe and optimal operation. The generator torque is constantly adjusted to maintain a desired rotational rate and extract the right amount of power, whilst the blades may pitch to stabilize the turbine in high wind speeds. In some cases, unwanted vibrations are also damped through blade pitching.

To achieve this one relies on the application of control theory. The onboard computer acts in concert with various sensors and actuators to satisfy the control objectives set by the engineer. Central to this is the control algorithm that generates the right outputs for the actuators, based on a history of the inputs.

Floating wind turbines have presented the engineer with a special set of problems, due to their lack of a fixed base. The range of motion made possible by floating operation has proven to be very problematic for simple control algorithms and has underlined the need for more sophisticated approaches.

Most advanced control algorithms are based on a mathematical model of the system to be controlled. This is referred to as model-based control. The aim of this research may be stated in two objectives. (1): To produce an efficient low-order dynamic model of the turbine, capturing all relevant effects with adequate fidelity. (2): Application of the model towards generating better model-based control algorithms.

Control engineering is a vital aspect of present wind-turbine design. Improved control algorithms have the potential to increase the performance and reliability of wind turbines in a very cost effective manner.

Martin Resell

Home country:	Norway
Date of birth	1983
Master's degree:	M.Sc. Mathematics and Applied Physics
University:	NTNU
Graduation year:	2009
Supervisor:	Lars R. Sætran
PhD start:	November 2010
Phone:	73593707
Email:	martin.resell@ntnu.no

Topic: Offshore wind characteristics

Field measurements of offshore wind at Titran/Frøya.

Most people will find it reasonable to believe that offshore sites are associated with rather high winds. Besides, it also turns out that wind offshore shows other characteristics than what measured over land.

Offshore wind is different from onshore mainly due to two factors. The shear stress is different and factors related to heat transfer is different. We also know that the latter is directly connected to how turbulence characteristics behave.

The focus of the Titran measurement is to characterize offshore wind.

Phen Chiak See

Home country	: Malaysia
Year of birth	: 1983
Master degree	: Mechanical Engineering
University	: University of Technology, Malaysia
Graduation year	: 2008
Research group	: Power system group
Supervisor	: Olav Bjarte Fosso, and Marta Molinas
Phone	: 47 73 59 42 39
E-mail	: phen.chiak.see@elkraft.ntnu.no
Home page	: http://www.ntnu.no/ansatte/phen.chiak.see

Topic: Development of Market Models incorporating Offshore Wind Farms and Offshore Grids

In recent years, the development of offshore wind farms has become increasingly interesting. For instance, the Offshore Center Denmark (www.offshorecenter.dk) has mentioned in their On/Off Yearbook (2012) that Denmark will soon achieve 1GW of power production from offshore wind farm in autumn 2012, as the result of power delivery from the Anholt offshore wind farm. This is a remarkable milestone after Her development of the world's first offshore wind farm that delivers power to the public grid around 20 years ago.

Meanwhile, the development of the infrastructural supports and electricity market models that facilitate the trading of this renewable energy source in the existing marketplace remain as an open and active topic of research. As for this work, the primary scope is on the establishment of a robust economic model (viewed from the power system engineering perspective) that connects the electricity production from the offshore wind farms and offshore grids to the liberalized market.

The research involves the following tasks: i.) creation of an analytical model for offshore wind power grids which will be used to support technical reasoning related to the development of market model, ii.) development of a power flow model for offshore grid, which connects the offshore wind energy sources, the local power demand (load profile), and the market model, and iii.) development of market model for offshore wind farms and offshore grids that includes the following topics: economic dispatch, electricity pricing, coupling between market models (day-ahead, intra-day and balancing), and interactions between players within the de-regulated market structure.

The major focus of this work will be to gain insight and develop strategies for large-scale integration of intermittent generation in the European Power Market.

Amir Hayati Soloot

Home country:	Iran
Year of birth:	1984
Master's degree:	Electric Power Engineering
University:	Iran Uni. of Sci. and Tech. (IUST)
Graduation year:	2009
Research group:	Electric Power Technology
Supervisor:	Hans Kristian Høidalen
PhD start:	2009
Phone:	+47 7359 4233
Email:	amir.h.soloot@ntnu.no
Home page:	www.ntnu.edu/employees/amir.h.soloot

Switching Transient in Offshore Wind Farm

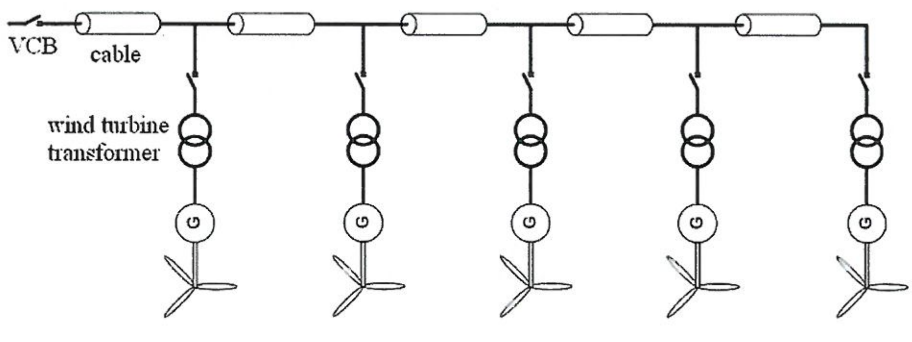
In order to connect the offshore wind turbines, large undersea cable connections are required. Since each wind turbine has a step-up transformer, a row of Offshore Wind Farm (OWF) composed of cable-transformer sections which are linked in series.

Wind Turbine Transformers (WTTs) can be exposed to dielectric failures, internal insulation damage as well as external one due to overvoltages, e.g. energization overvoltages, earth fault, current chopping, and voltage escalation of VCB during disconnection.

The aims of this PhD study are:

1- Study and simulation of transient phenomena in a row of OWF and focus on the potential of resonance phenomena with the help of black box modelling of WTTs. In this phase, the external overvoltage on transformer terminals are investigated in different transient phenomena for various OWF configurations.

2- Development of the High Frequency (HF) modelling of WTTs based on gray box models such as RLC expanded latter model and the analysis of resonance overvoltages along transformer winding. A 500 KVA transformer with probes along the winding is going to be applied to validate the HF model of WTT with experiments.



Mostafa Valavi

Home country:	Iran
Year of birth:	1985
Master's degree:	Electrical Power Engineering
University:	University of Tehran
Graduation year:	2010
Research group:	Electric Power Technology
Supervisor:	Arne Nysveen
PhD start:	December 2010
Phone:	+47 73594442
Email:	mostafa.valavi@elkraft.ntnu.no
Home page:	www.ntnu.no/ansatte/mostafa.valavi

Magnetic Forces and Vibrations in Wind Power Generators

Offshore wind energy will play a vital role in future world energy markets specially in US, UK and North Europe. There are a lot of challenges in developing offshore wind installations requiring strong R&D activities. One of the most important challenges in offshore installations is mechanical forces acting on wind turbine structures due to wind and also ocean waves. In addition, difficulties in access to the wind turbines and maintenance problems must be considered.

Direct-driven permanent magnet generators can reduce maintenance and increase system reliability in offshore installations by eliminating the gearbox. Direct-driven generators have a large diameter and short stator length and therefore moderate mechanical stiffness. This problem is very important especially in offshore applications, when large units are preferable.

The focus of this research work is on how to reduce the magnetic forces and vibrations in direct-driven permanent magnet generators. The magnetic flux in the airgap of the electrical machines contains harmonics and sub harmonics producing the magnetic forces and in special cases may cause critical vibrations in the generator. The main aim of this project is mitigation of magnetic vibrations in generator. The work will focus on winding arrangements and rotor and stator geometry in the design procedure.

Eric Van Buren

Home country:	USA
Year of birth:	1986
Master's degree:	Structural Engineering
University:	Texas A&M University
Graduation year:	2009
Research group:	Offshore Wind Group at Marine Civil Engineering
Supervisor:	Michael Muskulus
PhD start:	August 24 2009
Phone:	+47 97183382
E-mail:	eric.vanburen@ntnu.no
Home page:	

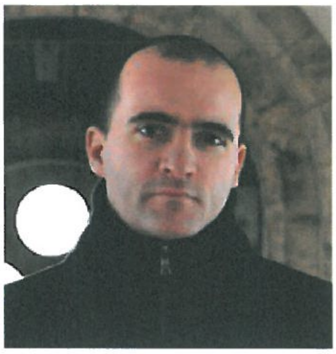
Bottom-fixed support structure for wind turbine in 30-70 m water depth

The overall theme of this research is aimed at developing a better understanding of the behavior of piled foundations for bottom-fixed offshore wind turbines. The currently existing pile design and analysis methods were developed several decades ago for the offshore oil and gas industry and are inadequate for use in large offshore wind applications due to the nature of loading experienced by the piles in such a structure. These currently available methods are quasi-static in nature, and thus not appropriate for performing dynamic time-domain simulations as is required for analyzing the performance of a wind turbine. Additionally, several important soil-structure interaction phenomena are ignored by the existing techniques, a significant short-coming which could possibly lead to non-conservative designs or incorrect fatigue life estimations. A more comprehensive pile model which is dynamic in nature and which accounts for as many soil-structure interaction phenomena as possible is therefore needed to fully and appropriately analyze an offshore wind turbine system including the piled foundation.

This PhD project will aim to develop such a model. Detailed self developed dynamic 3D finite element simulations of a soil-pile system will be created and utilized to define a simple, yet comprehensive model of the dynamic soil-pile system which can be implemented into existing aero-elastic wind turbine analysis software packages. The addition of a properly dynamic soil model to existing wind turbine solvers will allow for a complete analysis of an offshore wind turbine system from pile tip to blade tip. The dynamic soil model will make use of an arrangement of various nonlinear springs and dampers to as fully as possible describe the stiffness and damping of the system at any given instant in time. The model will allow for more nonlinear behavior than the currently available techniques while not significantly increasing the required computational effort.

The ultimate aim of the project is to investigate the effects of a more descriptive soil model on the performance and design of the foundation, the support structure, and the full wind turbine system by comparing the results of time domain simulations of an offshore wind turbine with and without the developed dynamic soil model. Possible impacts to the sizing of the piles and to the fatigue life of the support structure are of particular importance.

Steve Völler



Home country:	Germany
Year of birth:	1979
Diploma Degree:	Electrical Engineer
University:	Chemnitz Technical University, Germany
Graduation year:	2003
PhD:	University of Wuppertal, Germany, 2010
PhD title:	Optimized Operation Management of Wind Energy Plants by Energy Storage
Recent position:	Postdoc
Supervisor:	Gerard Doorman
Postdoc start:	03/2010
Phone:	735-94444
E-mail:	steve.voller@ntnu.no
Home page:	http://www.ntnu.no/ansatte/steve.voller

Postdoc title: **Balance Management with Large Scale Offshore Wind Integration**

Description:

The background is that large amounts of wind power create a need for other generation and/or demand resources to compensate for the variability and uncertainty of wind production. The research covers the quantification of the variability and uncertainty of the offshore wind farms, opportunities for the balancing control of the Norwegian power system, international energy exchange and trade and effects to the power grid. The main focus lies on the Norwegian power system and especially the hydro power system. How will the Norwegian system change or have to be changed under different future trends in the European power system.

This will be done by using different models of the European power grid, including different HVDC grids, wind scenarios, changes in the power system (e.g. shut-down of and new built power plants, influences of other renewable sources, energy storage…).

Kai Wang

Home country:	China
Year of birth:	1983
Master's degree:	Mechanical Engineering
University:	Politecnico Di Milano, Italy
Graduation year:	2008
Research group:	CeSOS
Supervisor:	Torgeir Moan
PhD start:	12-08-2010
Phone:	+47 94122726
E-mail:	kai.wang@ntnu.no
Home page:	http://www.ntnu.edu/employees/kai.wang

Comparative study of floating concepts

Increasing demand for energy and associated services to meet social and economic development and improve human welfare and health leads to a number of different wind energy technologies available across a range of applications. The Vertical axis wind turbines (VAWT) have several advantages compared with Horizontal axis wind turbines (HAWT) such as lower centre of gravity, absence of yaw and pitch control system as well as gear box, which seems to be well fitted for floating offshore application. The difficult to develop the floating VAWT is mainly the feasibility and reliability of a new concept consisting of VAWT, floater and related mooring lines.

The research will be focused on dynamic response of floating vertical axis wind turbines for different support structure such as spar type floaters, with a catenary or tension leg mooring system, TLP and semi-submersible type. It is essential to create a time domain model of the floating vertical axis wind turbine where hydrodynamic loads on the structure are considered based on the linear hydrodynamic theory while the mooring lines are modeled as flexible finite elements. By combining the aerodynamic loads on the rotor and the hydrodynamic loads, the dynamic response of the floating platform can be simulated in the time domain so as to investigate the feasibility of the floating concept and the motion of the platform under the environmental loads.

Zhaoqiang Zhang

Home country:	China
Year of birth:	1981
Master's degree:	Electrical Engineering
University:	Shanghai Jiaotong University
Graduation year:	2007
Research group:	Energy Conversion
Supervisor:	Robert Nilssen
PhD start:	2010
Phone:	+47 7359 4271
Email:	zhaoqiang.zhang@ntnu.no
Home page:	www.ntnu.no/ansatte/zhaoqiang.zhang

Coupled 3D models of permanent magnet generators with very large diameters and with a special focus on losses

Generator is the key component of the WECS. For offshore application, the design of generator should take into account all of the offshore features: hash environment, large unit preferred, high reliability required and compact design desired. Furthermore, generator design is a highly multidisciplinary task that involves knowledge from electromagnetic, thermal design and so on. PM machine is very promising in offshore wind application. So far, a lot of research has been conducted on the radial flux machine and machine up to 4MW is now available in the commercial market.

Ironless AFPM machine is very promising in term of torque density and high efficiency, and it can be a competitive solution to meet the demand for large power (4-10MW) high performance generator in offshore wind application. However, there are insufficient knowledge on high power ironless AFPM, such as how to choose the slot/poles combination, how this combination influences the machine parameters, losses and torque, and how to accurately predict the machine performance with the latest modeling approach without making the expensive prototype.

The focus of this research work is to research and develop the 3D modelling approach in design of 10MW ironless axial flux permanent machine. Accurate modeling approach is to be studied, especially in losses/torque calculation. System level modeling approach and coupling modeling of EM-Thermal field is to be studied.

In this research, an analytical method for sizing of the ironless AFPM machine is to be developed. 3D FEA that is commonly regarded as the most accurate approach is to be adopted. In order to reduce the solving time in FEA, high performance computing (HPC) platform will be established for this research.

Daniel Zwick

Home country:	Germany
Year of birth:	1980
Master's degree:	Mechanical Engineering
University:	NTNU
Graduation year:	2007
Research group:	Marine Civil Engineering
Supervisor:	Michael Muskulus
PhD start:	August 2009
Phone:	+47 73594648
E-mail:	daniel.zwick@ntnu.no
Home page:	http://www.ntnu.edu/employees/daniel.zwick

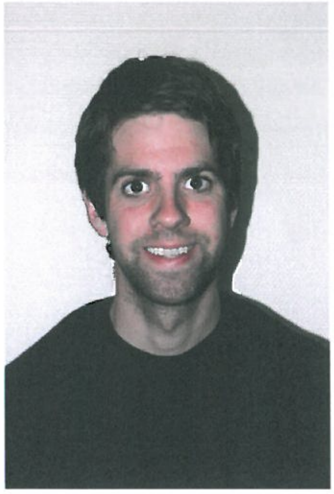
Design of nodes in lattice towers for effective production

The extremely ambitious political goals concerning extensive use of offshore wind energy result in an intense demand of research and development in this field. As an example, round 3 in UK could mean a need to install several thousands of offshore wind turbines within the next ten years. To be able to fulfil this goal, components for offshore wind farms has to be produced by mass production techniques and within reasonably short fabrication time.

Where offshore wind turbines are planned to be installed in the intermediate water depths of 30-70m, bottom-fixed support structures might be used. One promising concept is the lattice tower type, due to less material use compared to other concepts like monopile or tripod structures. A lattice topology could be used for the entire support structure between sea bottom and turbine nacelle or for the lower part of the tower only.

New node concepts might be of interest for more automated production of lattice towers. As a basis for such an investigation, loading and dynamic response by focusing on design of the nodes are objectives in this study of offshore wind turbines. If the complex fabrication of lattice towers can be solved in an effective way, this type might become a preferred solution for support structures of offshore wind turbines in the future.

Lars Morten Bardal



Home country:	Norway
Year of birth:	1985
Master's degree:	Energy and Environmental Engineering
University:	Norwegian University of Science and Technology
Graduation year:	2010
Research group:	Fluid dynamics
Supervisor:	Lars Sætran
PhD start:	October 2012
Phone:	+47 90695399
Email:	lars.m.bardal@ntnu.no

Design Wind and Sea Loads for Offshore Wind Turbines

The exploitation of offshore wind energy involves new challenges in structural design of wind turbines. In order to design robust and efficient wind machines it is necessary to have good knowledge of the dynamic loads on the structure and turbine blades. Such loads involve wind shear, turbulence, waves and current. The large turbine dimension of offshore wind turbines also represents challenges related to dynamic loads caused by the high wind shear. Wind characteristics of offshore winds differ from onshore conditions where most available wind data exists and it is therefore desirable establish time and space correlations of open sea winds and waves.

The research activity will be focused on collecting and analysing wind data from onshore sites exposed to open sea wind conditions. Based on both long and short time scale data the project aims to determine design conditions for wind and sea loads on offshore wind turbines. Field data will be collected from a measurement station at Titran with masts equipped with advanced wind measurement instruments and with the possibility to include wind lidar, scintillometer and offshore buoys. The site at Titran is especially suited for measurement of offshore winds from the north and the west and has a minimum of 10km of open sea over an angle of 225 degrees.