ANNUAL REPORT 2022

Norwegian Centre for
Environment-friendly
Energy Research

CONTENTS

Unless otherwise specified, all pictures are taken by Daniel Albert /SINTEF.

NORTHWIND IN A NUTSHELL

NorthWind – the Norwegian Research Centre on Wind Energy – is a strategic precompetitive research cooperation co-financed by the Research Council of Norway, industry, and research partners. The Centre is hosted and headed by SINTEF in close collaboration with research partners NTNU (Norwegian University of Science and Technology), UiO (University of Oslo), NGI (Norwegian Geotechnical Institute) and NINA (Norwegian institute for nature research).

NorthWind is part of the FME-scheme: Norwegian Centres for Environment-friendly Energy Research (in Norwegian: Forskningssenter for miljøvennlig energi). These are time-limited centres of excellence which conduct concentrated, focused and long-term research of high international quality to solve specific challenges in the field of renewable energy and the environment.

The Centre started in June 2021 and is scheduled to continue for 8 years with a total budget of about 350 MNOK, of which 120 MNOK is from the Research Council of Norway.

Research and innovation is carried out by the research partners in collaboration with the industry partners. The industry partners, numbering 50 in total, cover the full value chain of the Norwegian wind industry including developers and energy companies, supply industry and service companies.

The activities are industry-oriented, with research focused to bring innovations to a Technology Readiness Level (TRL) equivalent to the laboratory testing stage. We have an active strategy to transfer the results from NorthWind to the industry so that they can be further developed and come to practical use. This includes engagement in user cases and preparation of spin-off projects. Our PhD programme and educational activities at bachelor and master level, carried out by the university partners, provide an excellent pool of highly qualified candidates for the industry. We communicate our results actively through meetings, webinars, conferences, and publishing, bringing value to the industry and society in general.

A floating wind turbine's tower is being assembled at Gulen, in Western Norway.

VISION AND GOALS

SINTEF Research Scientist Marte Gammelsæter prepares the end cut of a model high voltage cable for later analysis at SINTEF Energy Lab, in Trondheim.

The vision of NorthWind is expressed through our slogan: "Turning wind R&D into a sustainable industry". The overall goal is to bring forward research and innovation to reduce the cost of wind energy, facilitate its sustainable development, create jobs and grow exports.

The research is carried out in five work packages (WPs) addressing these specific research challenges:

- Structure and integrity: De-risk concept selection and enable cost-effective design and fabrication of support structures through reduced uncertainty and novel methods.

- Marine operations and logistics: Develop methods and tools for efficient and safe marine operations and logistic planning for installation and maintenance of offshore wind farms.

- Electrical infrastructure and system integration: Develop reliable and cost-effective electric power components and system solutions for connecting large-scale offshore wind farms.

- Digital twin and asset management: Develop methodologies to elevate the capability level of digital twins of wind farms and components from descriptive to prescriptive or autonomous.

- Sustainable wind development: Develop tools and insights for the sustainable development of wind energy to resolve environmental and societal conflicts.

Our mission is to accelerate the green transition.

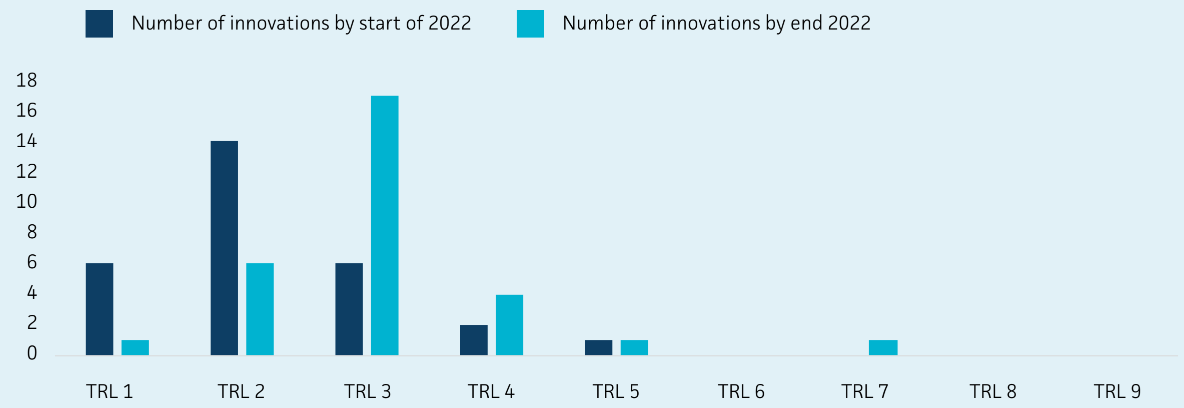
NORTHWIND BY NUMBERS

55 partners

8 years

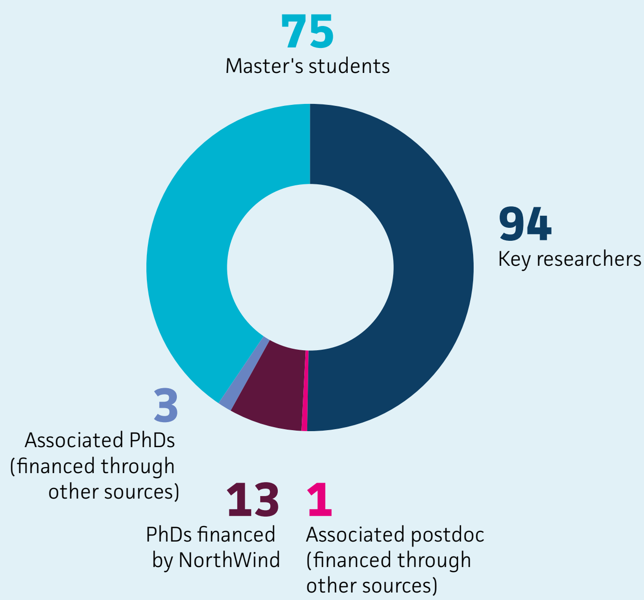
350 MNOK

Development of innovations

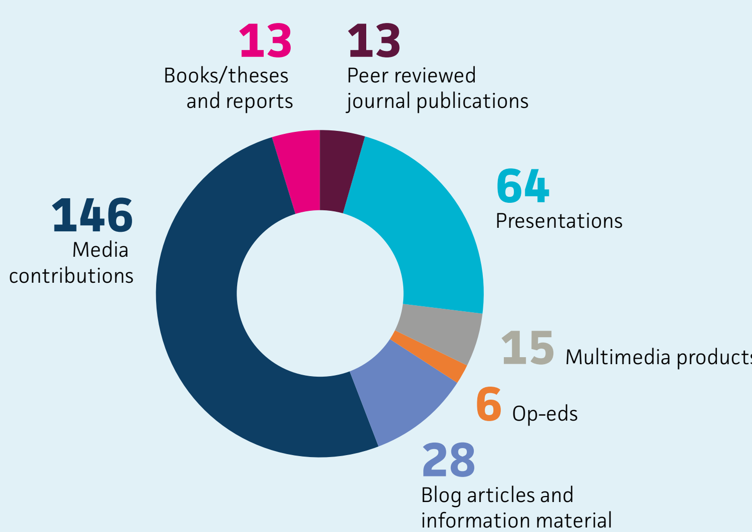


TRL 1 Basic principles observed
TRL 2 Technology concept formulated
TRL 3 Experimental proof of concept
TRL 4 Technology validated in lab
TRL 5 Technology validated in relevant environment
TRL 6 Technology demonstrated in relevant environment
TRL 7 System prototype demonstration in operational environment
TRL 8 System complete and qualified
TRL 9 Actual system proven in operational environment

People



Communication and dissemination*



* Numbers shown are accumulated totals since the beginning of Centre activities.

OFFSHORE WIND ON THE FAST TRACK

Message from the Centre Director

It is a privilege to work as Centre director with so many talented and extremely skilled colleagues. The engagement from both research partners and industry is truly inspiring, and I thank you all for the hard work and dedication that you have put into NorthWind in 2022. I feel that we are now really moving as a team and making a big positive impact. We deliver on plan, and we are on track to bring forward even more innovations and results in the years to come.

2022 has been rich in developments for wind energy, and in particular for offshore wind.

In January, the results of the auctions in Scotland awarding 16 GW of floating wind capacity were a clear sign of industry trust and of the start of a new era of accelerated development of floating wind. In February, the EU parliament adopted a new strategy on offshore renewables with a goal of 60 GW of offshore wind by 2030 and 300 GW by 2050. In May, Denmark, Germany, the Netherlands and Belgium announced that they would jointly install 150 GW of capacity before 2050, and the Norwegian government announced a goal of 30 GW of offshore wind.

More recently, Norway's first – and currently the world's largest – floating offshore wind farm, Hywind Tampen, started production. In December, the Norwegian government announced an initiative on offshore wind to increase industry exports to 85 billion NOK by 2030, and they revealed that the first Norwegian offshore areas, Sørlige Nordsjøen II and Utsira Nord, will be put to tender in early 2023.

These exciting developments demonstrate the relevance of NorthWind. The Centre is in demand and growing. During 2022, Kongsberg Digital, Hydro and Oceaneering joined as industry partners, and World Wide Wind joined as a network partner, so NorthWind now gathers 50 industry and network partners. This is excellent but considering that the Norwegian offshore wind ambitions have increased markedly since NorthWind was launched in 2021, I expect and welcome further growth in NorthWind's activities and number of partners in the years to come.

The 30 GW offshore wind target corresponds to a doubling of the Norwegian power system, with investments totalling 1000 billion NOK in the coming 2-3 decades. This will give Norway access to large amounts of emissions-free and affordable energy, ensure progress towards climate targets and bolster value creation. To succeed, however, our efforts on education, research and innovation must be enhanced. This is necessary to enable efficient, safe and sustainable construction and operation of the 30 GW of offshore wind farms in Norway, and to increase Norwegian export of components and services to the international offshore wind market.

Substructures, marine operations, HVDC stations, cables, connectors, market solutions, asset management, digital twin technology, and environmental design are examples of these exports. By taking 10 % of the global market, Norway could generate export revenues of upwards of 85 billion NOK by 2030. To this end, the National Export Council

John Olav Giæver Tande is the director of the NorthWind research centre, and a pioneer in floating offshore wind energy. He is Chief Scientist and Research Manager at SINTEF Energy Research. From 2009 to 2017, he was the Director of NOWITECH (Norwegian Research Centre for Offshore Wind Technology). Both NorthWind and NOWITECH have been funded by the Research Council of Norway (RCN) and national/international industry. In 2019, John Olav Giæver Tande received the Mission Innovation Champion Award at the fourth Mission Innovation ministerial meeting in Vancouver, Canada.

Centre director John Olav Tande (SINTEF) and chair of the NorthWind Board Elling Rishoff (DNV)

prepared a report with 25 specific recommendations. The main message is that a concerted effort is needed. Specific measures include reinforcement of NorthWind with more public funding to be on level with other FMEs within important areas for Norway; the establishment of a European Centre of Excellence on offshore wind; and bilateral research programmes with selected markets outside Europe (such as Japan, South Korea and USA). Investment in education, research and innovation is paramount for a successful offshore wind development and may reap enormous benefits down the road.

Considering that the technology and solutions for offshore wind farms are still at a relatively early stage of development, it is reasonable to assume that significant cost savings can be achieved through research and innovation. As an example, a modest 5 % reduction in capex would mean a 50 billion NOK saving to realise the 30 GW offshore wind ambition for Norway. In reality, the cost of floating wind would need to be reduced by 50 % or more, though not all cost reductions can be accredited to research and innovation. Industrialisation and series production are indeed very important steps to reduce costs, though they must be based on the best knowledge and models to be effective. On top of the savings in capex comes the value of the technology and solutions that can be applied in developing wind farms outside of Norway and as an export commodity.

THE UNIQUE ROLE OF NORTHWIND

Message from the Chair

In the time since the last NorthWind Annual Report, we have experienced a series of challenges to the stability and prosperity of our society and environment. Russia's brutal attack on Ukraine has amplified the need for less dependency on gas supply from Russia to EU markets. At the same time, there is increasing political willingness to fulfil the obligations of the Paris Agreement. This nexus of forces has put major focus on the need for securing the European energy supply.

Both Statnett and DNV's forecasts predict a shortage of electricity in the years to come (2026-2030) and the need for more clean power is recognised by most actors in the energy market. Norway's offshore wind consultation process was initiated in 2022 and is a prerequisite to deliver on Norway's ambition of 30 GW of wind power in 2040. In addition, the National Export Council issued their plan for developing a strong Norwegian supply industry, with an aim to reach 10 % global market share by 2030, corresponding to NOK 85 billion in exports by the supply industry.

Consequently, the Norwegian offshore wind industrial challenge is threefold:

- Supply more clean energy to Norwegian industries and households
- Develop a sustainable wind power supply industry
- Develop trustworthy co-existence and biodiversity policies

The 2022 macro-observations include:

- An excellent outlook for major markets (US, UK, EU, Korea, Japan etc.)
- Wind industry turbine manufacturers are experiencing losses, mainly due to high inflation
- A series of unresolved supply chain challenges, lacking construction facilities and insufficient harbour capacity
- A global scarcity of talent
- Somewhat unclear energy market rules
- A need for improved planning and build-out of grid and infrastructure, on a large scale

To master and manage a greener future will require a holistic approach with decisive action that will shorten the time to clean energy. The key question we must address at NorthWind is how we contribute needed knowledge and stay relevant.

The unique role of NorthWind is to operate at a holistic national level. The work will contribute to innovation, progress, and conformity of the Norwegian offshore wind adventure. Among NorthWind's 2023 ambitions, the FME will focus on holistic design by reporting progress on: technology readiness level (TRL), digital capability level (DCL) and sustainability readiness level (SRL). Already many of NorthWind's activities have deliverables in the TRL 3-6 range. And the ability to manage the "development mix" across the TRL, DCL and SDG scale is one of the main assets of NorthWind. As such, industry and research partners at all levels should work with us, so that together we are able to find a firm balance between innovation and industrialisation.

Elling Rishoff holds an M.Sc. in Naval Architecture and Ocean Engineering from NTNU (1987). He has over 30 years' experience with technology leadership in the marine and technical software fields with a strong know-how in digital transformations. His previous experience includes CEO of DNV Software and DNV Group CIO. He has engaged with the Offshore wind software industry since 2008. He currently holds the position of Senior Vice President Incubation Offshore Wind at DNV in Norway.

ORGANISATION

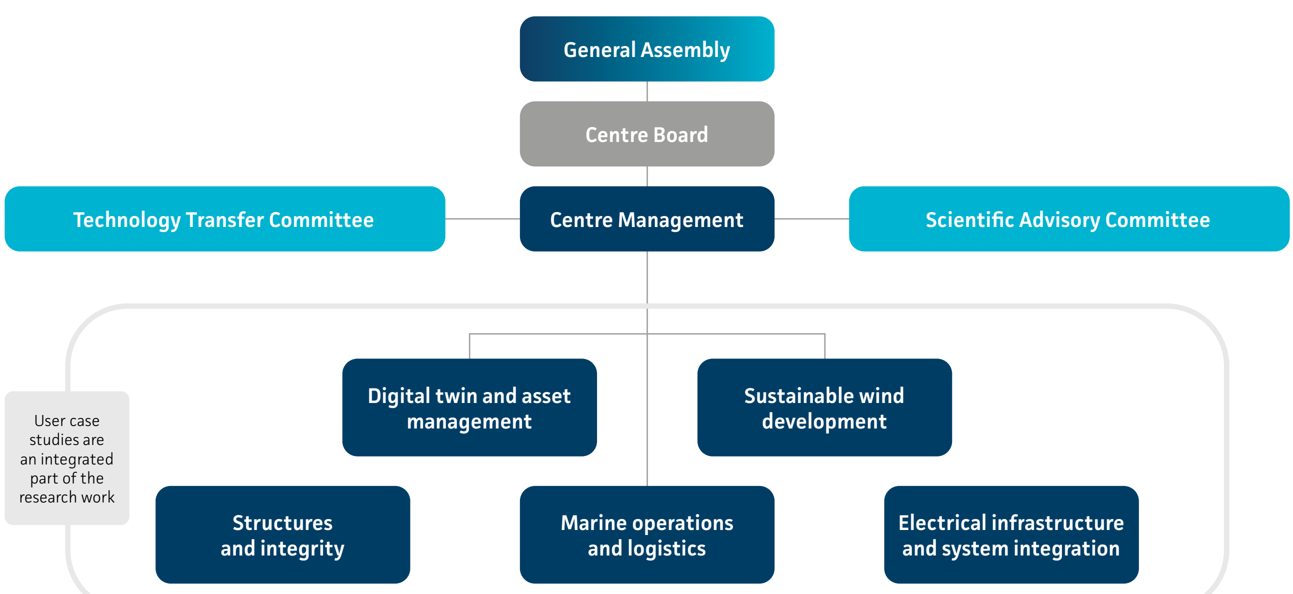
NorthWind is composed of a strong team of research and industry partners with complementary expertise and roles. The Centre is organised like a company with a General Assembly, a Board, and a Centre Management Group (CMG) for daily operation. Research work is carried out in the work packages (WPs) that each have a lead and a deputy. The Scientific Advisory Committee (SAC) enhances the academic programme and the Technology Transfer Committee (TTC) enhances the interaction with industry.

The CMG consists of a Centre director, a manager, an administrator, a communication manager, and the heads of the WPs, the SAC and the TTC.

Board

The Board consists of 11 members of which 8 are from industry and 3 are from the research partners. They were elected as part of the startup of the Centre in 2021 for a two-year period. During 2022 they had two meetings, one at Gulen in June and one on the occasion of the Annual Innovation Forum in Trondheim in December. The Board oversees the progress of NorthWind, and approves workplans and budgets, but is first and foremost a forum for strategic discussions and advice.

- Elling Rishoff (Chairperson), DNV
- Geir Olav Berg, Aker Offshore wind
- Jan-Kristian Haukeland, DOF
- Ole J. Nordahl, Equinor
- Håkon Hallem, Force Technology



- Torunn Lund Clasen, Nexans
- Björn Mo Östgren, Statkraft
- Anne Brisset, Total Norge
- Norunn Myklebust, NINA
- Johan Einar Hustad, NTNU
- Petter Støa, SINTEF

Scientific Advisory Committee

The Scientific Advisory Committee (SAC) is responsible for developing, in collaboration with the Centre Director and WP leaders, a top-quality PhD and postdoc programme. This includes having an active recruitment strategy, inviting international experts to give lectures, organising scientific colloquia and seminars, and exposing scholars to industry and leading international research groups. The Committee also liaises with the associated research partners and gives advice on the scientific content and progress of the Centre.

The Committee is composed of members from the research partner organisations and the associated research partner organisations. It is led by professor Trond Kvamsdal (NTNU). The associate research partners (DTU, TNO, Fraunhofer, University of Strathclyde, NREL, NCEPU and Florence School of Regulation) are internationally acclaimed and strengthen the Centre. They participate by providing advice on the open research and academic programme of NorthWind to ensure efficiency and quality at the highest international level. The Committee operates with a national core group that meets on a quarterly basis or more frequently as required, and a full committee with the international associate partners that meets twice per year – physically in January in connection with the EERA DeepWind conference and digitally in the spring. In 2022, because of Covid-19 restrictions, EERA DeepWind was organised as a digital event only. The SAC did not meet then, but met digitally in May. The first physical meeting of the full Committee took place during the EERA DeepWind 2023 conference. It consisted of a review of NorthWind's activities on co-existence, environmental impact and large-scale integration.

The Scientific Advisory Committee held a meeting during the EERA DeepWind conference, in January of 2023. Left to right: Jørn Vatn, NTNU; Michael Muskulus, NTNU; Amir R. Nejad, NTNU; Trond Kvamsdal, NTNU; Olimpo Anaya-Lara, University of Strathclyde; Arno van Wingerde, Fraunhofer; Amy Robertson, NREL; Peter Eecen, TNO; Erin Bachynski-Polić, NTNU; Ignacio Martí, DTU; John Olav Tande, SINTEF.

Technology Transfer Committee

The Technology Transfer Committee (TTC) has a specific responsibility to bring results towards commercial use, including linking with SINTEF TTO, NTNU TTO, industry partners' business development and corporate venture units, industry clusters, Innovation Norway and Enova. The Committee is led by Inger Marie Malvik (SINTEF). It held two meetings in 2022. In 2023, the TTC will also hold dedicated meetings with energy companies participating in NorthWind to bring innovations from research institution and suppliers faster forward. This fits well with the goal to facilitate the process for further development and maturation of innovations through new funding like IPNs, JIPs, etc. An important focus area for the Committee in 2022 has been following up on the 30 innovations of NorthWind with TRL spanning from 1 to 4. This work will be strengthened through 2023.

Research partners

Centre lead

Industry partners

Associates

How we work together

The Centre is set up to generate value for the industry and society in general. We strive on the one hand to accomplish research at the highest academic level, and on the other hand to create results and innovations that have practical applications for the industry. We do this through collaboration between partners, leveraging our complementarity with distinct roles and expertise. SINTEF, NGI and NINA do industry-oriented research within their distinct areas of expertise. NTNU and UiO carry out the more academic research with the PhD and postdoc programme, as well as education at master and bachelor level. The industry partners are engaged through a set of activities:

- taking lead or participating with in-kind in user case studies addressing specific challenges
- participating in WP meetings and in direct interaction with the researchers
- being co-advisors for PhDs, masters and bachelors
- engaging in the Board with strategic discussions and advice

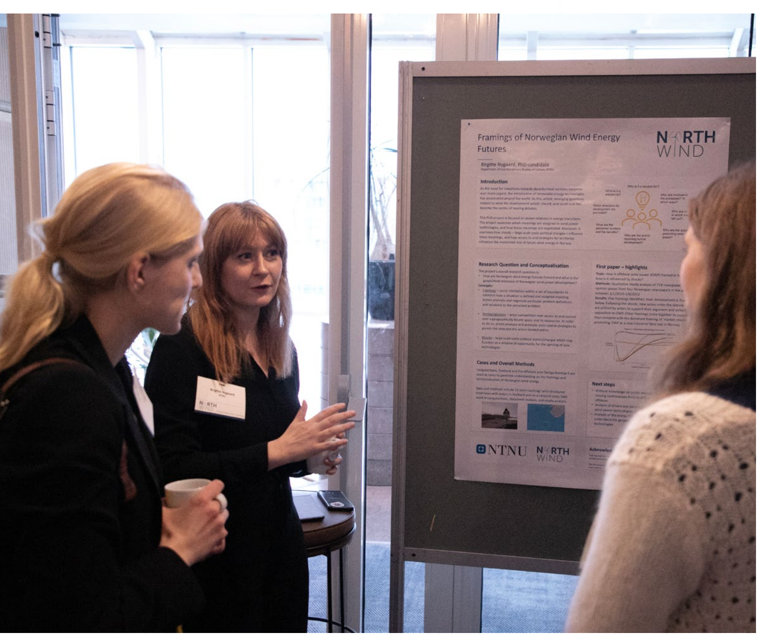
Recurring events and activities at Northwind

- taking part in webinars, the Annual Innovation Forum and other overarching Centre activities
- following up innovations and developing spin-off projects

The work is carried out with monthly meetings of the Centre Management Group for coordination of and follow up on the day-to-day activities. The WPs each have at least two meetings annually with the industry partners; one in the spring and one in the fall. These meetings are for reporting progress of works, getting feedback and preparing workplans. Each workplan covers a two-year period and is approved by the Board in December of the preceding year. There are also ad-hoc meetings with smaller groups to address specific issues.

Annual Innovation Forum

NorthWind's very first in-person Annual Innovation Forum was held in 2022. This is an occasion for scientists and representatives from the industry to update each other about Centre activities, and wind power in general. The programme featured a series of keynote speeches by members of the industry, and several scientific poster presentations. Scientists from each of the work packages were also on hand to provide an update of the work being done in their work package.



PhD candidate Birgitte Nygaard (NTNU) presents her work with a poster titled "Framing of Norwegian Wind Energy Futures".

Odd Erik Gundersen, from Aneo, talks about the potential of using digital technologies for predictive maintenance of wind turbines.

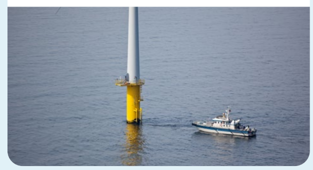
Webinar series

The Technology Transfer Committee continued its successful webinar series in 2022, with 11 events organised. Webinars were arranged covering a range of interesting topics from all of NorthWind's WPs.
The webinars' titles are listed below:

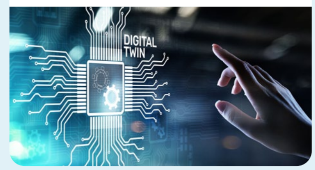
HSE/Safety and regulations for offshore wind

Integrity in soil conditions, fabrication and operation

Efficient operation and maintenance of offshore wind



Digital twin for cost-effective operation of offshore wind



Load capacity of cables in the electric network

IEA Wind – and why you should get involved

Presentation of Scotwind plans

Installation of offshore wind turbines

Offshore infrastructure and large-scale integration of wind power

From idea to development/research to innovation and commercialization

Sustainability readiness levels – Are you ready for sustainable wind energy development

The energy crisis in Europe: Energy production and use in Norway (together with NTRANS)

Co-creating sustainability readiness levels – How to get ready for sustainable wind energy development (workshop)

Presentations from the webinars can be found on the "**Events**" page of the NorthWind website.

First row: John Olav Tande, Centre director, Vigdis Olden (WP1), Eirill Bachmann Mehammer (WP3), Rita V. D'Oliveira Bouman (WP5), Norunn Sæther Myklebust (Board - NINA), Inger Marie Malvik (Head of TTC). Second row: Petter Støa (Board - SINTEF), Kjetil Johannessen (WP4), Elling Rishoff (Board – DNV), Hans Christian Bolstad (Centre Manager). Third row: Trond Kvamsdal (Head of SAC), Björn Mo Östgren (Board – Statkraft), Henning Braaten (WP2), Audun Johanson (Nexans), Geir Olav Berg (Board – Aker Offshore Wind), Katrine Wyller (Research Council of Norway).

Workshop and Board meeting at Gulen

NorthWind organised a workshop and Board meeting at Gulen in June. Participants visited the Hywind Tampen floating wind turbine assembly site and got a very interesting tour of the facilities by the Wergeland Group. Hywind Tampen, which started production in November, will have an installed capacity of 95 MW when completed, making it the largest floating offshore wind farm in the world.

A very large crane slowly positions the top part of the tower during the assembly of the sixth Hywind Tampen floating wind turbine.

EERA DeepWind CONFERENCE 2023

EERA DeepWind celebrated its 20th edition this year with a record event in terms of participation: Over 80 presentations, 125 scientific posters and 300 participants. The annual conference has gathered the foremost experts on offshore wind from around the world since 2004.
Like last year, NorthWind took an active role in organising it.

SINTEF NTNU EERA European Energy Research Alliance

The conference was officially opened by State Secretary for the Norwegian Ministry of Petroleum and Energy, Elisabeth Sæther, who outlined the government's plans for offshore wind in the coming years. Another keynote speaker, University of Bergen professor Finn Gunnar Nielsen, reminded the audience that cost reductions in offshore wind power can only come through development. "You need to think not in terms of years but in terms of gigawatts of capacity installed when considering what actually makes cost reductions happen," he said.

EERA DeepWind Science and Innovation Award

Later during the conference, professor Nielsen was awarded the very first EERA DeepWind Science and Innovation Award, for his outstanding contribution to offshore floating wind technology.

Professor Nielsen participated in the very first DeepWind conference, in 2004, and was central to the success of the research and development leading to the very first full-scale floating wind turbine, Hywind Demo.

The programme included presentations by top specialists in the field, addressing the following topics:

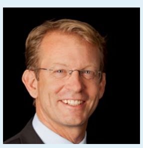
- New turbine and generator technology
- Grid connection and system integration
- Met-ocean conditions
- Operation & maintenance
- Installation and sub-structures
- Marine operations and logistics
- Wind farm optimisation
- Experimental testing and validation
- Wind farm control systems
- Societal impact and controversies
- Environmental impact
- Legal and regulatory framework

The papers submitted for the conference are now in peer-review for publication in the Journal of Physics: Conference series. These are expected to be online with open access by the fall of 2023.

The conference presented a top roster of keynote speakers:

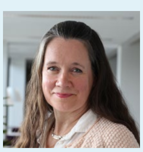
Elisabeth Sæther
State Secretary,
Norwegian Ministry of Petroleum and Energy

Alexandra Bech Gjørv
CEO, SINTEF

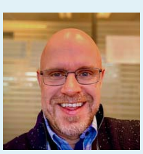


Jon Dugstad
Director Wind,
Norwegian Energy Partners (NORWEP)

Finn Gunnar Nielsen
Professor,
University of Bergen

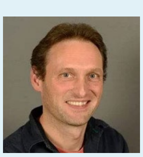


Hannele Holttinen
Operating Agent,
Grid Integration task 25 of IEA Wind



Kristian Holm
Technology Director,
Equinor

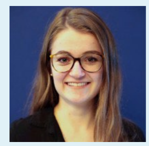
Charlotte Bay Hasager
Professor, Technical University of Denmark (DTU)



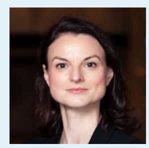
Roel May
Senior Researcher,
Norwegian Institute for Nature Research (NINA)

Ignacio Martí
Director, EERA JP Wind

Jacob Edmonds
Deputy Co-chair ETIP Wind and Senior Director Ørsted

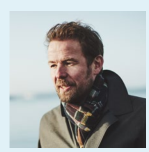


Joanna Ines Martin
Graduate Wind Farm Engineer, Ørsted



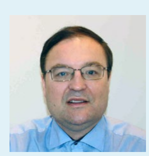
Catherine Banet
Professor, University of Oslo

Jose Luis Domínguez García
Group Leader of Power Systems, IREC



Knut Vassbotn
CEO, Deep Wind Offshore

Geir Olav Berg
CTO and SVP engineering,
Aker Offshore Wind



Trond Kvamsdal
Professor, NTNU,
head of NorthWind SAC
and co-chair of EERA DeepWind

John Olav Tande
Chief Scientist at SINTEF,
director of NorthWind
and chair of EERA DeepWind

MARK YOUR CALENDARS:
The next EERA DeepWind conference will take place in Trondheim, 17-19 January 2024.

Most of the work for the planning and arrangement of the conference took place in 2022.
We have therefore elected to include it in the report for 2022, although the conference itself took place in January of 2023.

Photo: Smidesang & Lyng

VALUE FOR INDUSTRY PARTNERS

Senior Technician Morten H. Danielsen at work at SINTEF Industry's Welding laboratory.

- Excellent research with significant budget and duration, directed towards industry needs
- First-rate recruitment opportunities from strong master's, PhD, and post-doctoral programmes
- First access to detailed results for business development
- Access to an international network and strategic positioning in important European forums
- Knowledge and innovations reducing the cost of energy from offshore wind farms, and reducing the environmental and societal impacts
- Collaboration through user case studies proposed by the industry

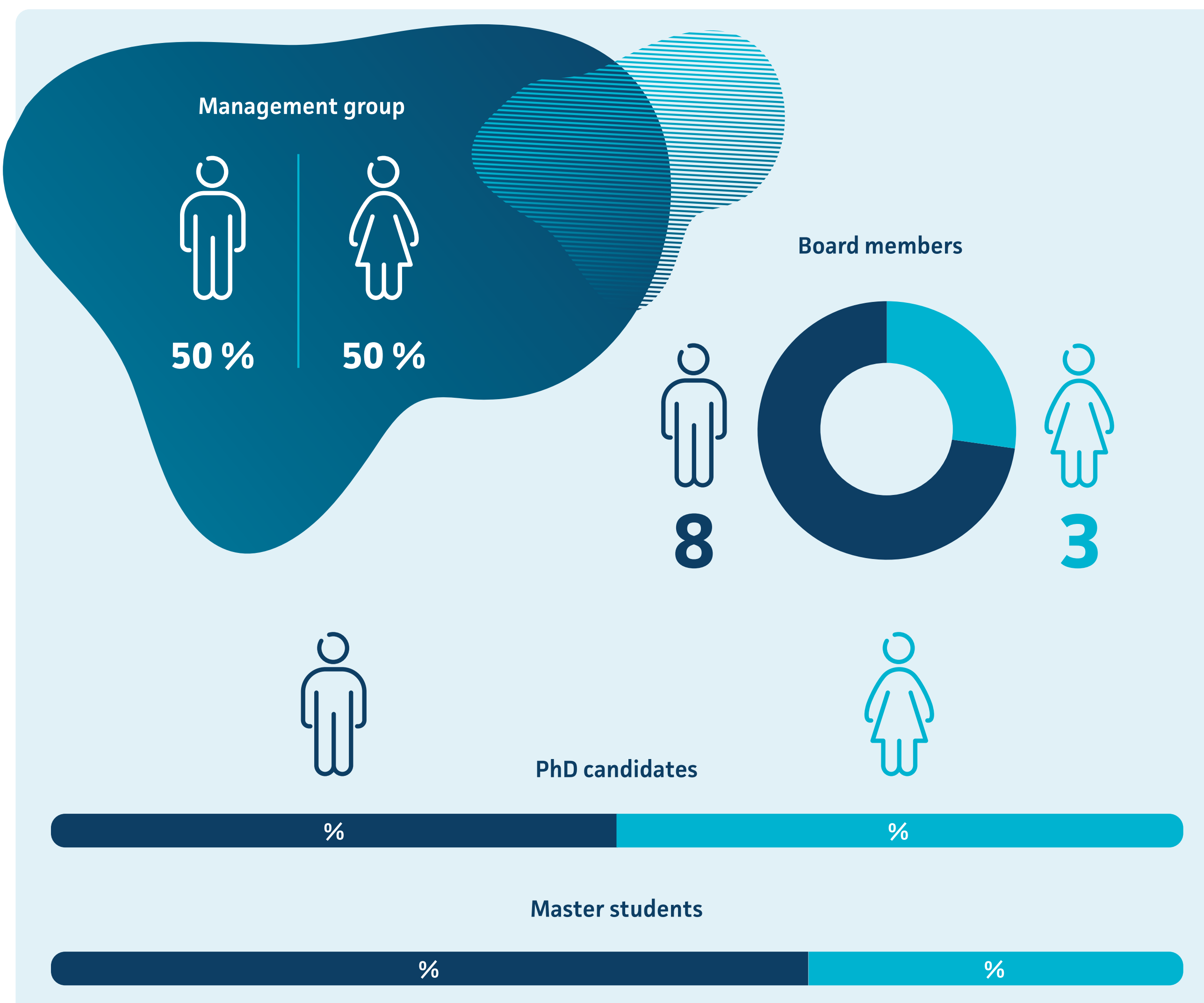
User case studies

The purpose of the user case studies is for experts from across NorthWind's work packages to address specific challenges in collaboration with industry partners. We expect at least 20 such studies to be carried out as part of NorthWind. The case studies are led by industry partners, to ensure that their focus is calibrated to the needs of the industry. You can read descriptions of selected user case studies on which work has started in the Research and results section of this report.

GENDER EQUALITY

NorthWind's management group has good gender balance (50/50). Women were encouraged to apply to our PhD programme, and 6 out of 13 of the funded PhD candidates are women. On the MSc front, 33% of the candidates who completed in 2022 are women.

The gender balance on the board is skewed: 3 out of 11 members are women. A new vote will be held to pick board members in 2023, and improving the gender balance will be in focus.



OUR CONTRIBUTION TO A MORE SUSTAINABLE WORLD

NorthWind's research in more efficient and sustainable wind energy contributes to reaching the UN's Sustainable Development Goals. Here are three of them that we consider as the most relevant and where we hope to achieve significant impact through our research.

Working to enable the massive deployment and integration of wind energy into the energy system at a competitive cost addresses goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all.

The anticipated increase in the market share of cost-competitive on- and offshore wind energy by 2030 is one of the most important drivers for reaching emissions reduction targets, and targets goal 13: Take urgent action to combat climate change and its impacts.

Work on sustainable solutions for offshore wind energy development targets goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development.

Photo: Shutterstock

INTERNATIONAL COOPERATION

NorthWind's Scientific Advisory Committee has representatives from DTU (Denmark), TNO (Netherlands), Fraunhofer (Germany), Florence School of Regulation (Italy), NREL (United States) and NCEPU (China). These collaborators contribute at their own expense with advice and input to the Centre, particularly the PhD programme and other activities linked to the sharing of open results. We invited these partners to join the Scientific Advisory Committee because they are leaders in their field, and because the Centre's research partners already have an extensive and productive collaboration with them. This includes cooperation associated with EU projects and network organisations, cooperation in the Norway-China programme and cooperation through the IEA in the wind power area.

In 2022, the research partners were involved in several relevant EU projects, such as MaRINET2, WATEREYE, FarmConners, TotalControl, UPWARDS, DACOMAT and SetWind. New projects that started at the end of 2022 include Scarlet and Wendy.

Network activities through EERA JP Wind[1] and ETIPWind[2] reinforce the European cooperation. FME NorthWind partners are active in these organisations. SINTEF Ocean's Vibeke Stærkebye Nørstebø leads the EERA JP Wind subprogramme Planning & Deployment, social, environmental and economic issues while SINTEF Energy Research's John Olav Tande leads the subprogramme on Offshore Balance of Plant, with support from Konstanze Kölle (also from SINTEF Energy Research). John Olav Tande is also a member of ETIPWind's Steering Committee.

The international cooperation aspect of NorthWind is strengthened by the fact that several of the Centre's partners are involved in the International Energy Agency Wind Technology Collaboration Programme. This strengthens networking possibilities and helps ensure that NorthWind partners are up to date with the latest developments on the international research front.

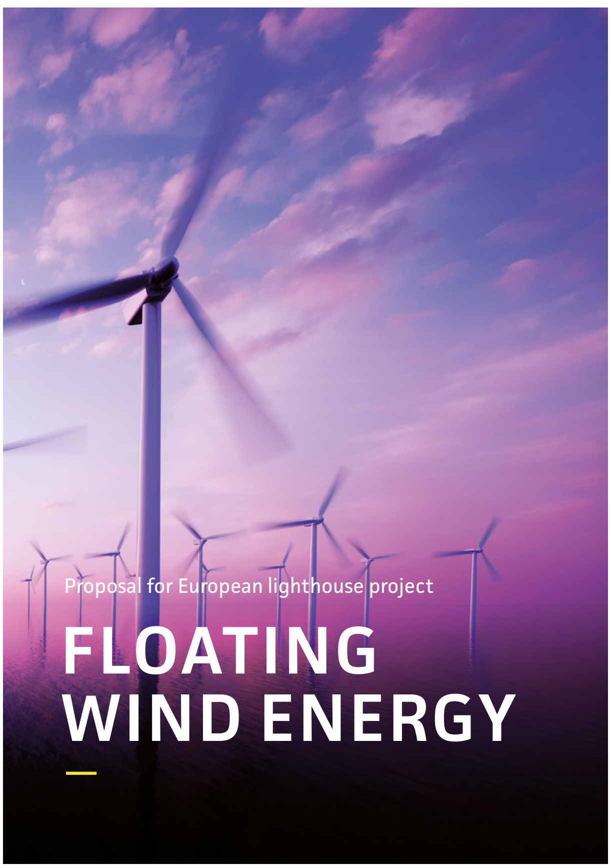
Cooperation countries outside the EU

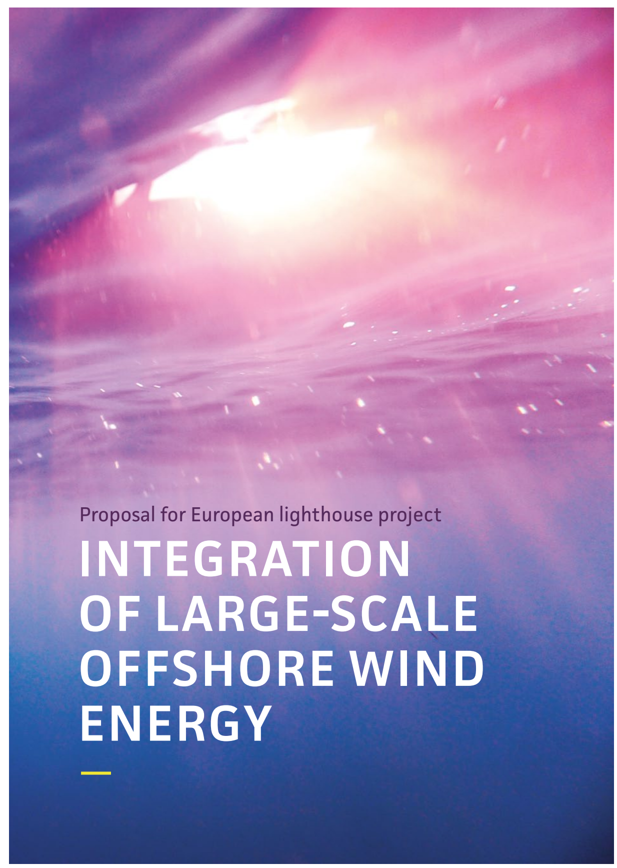
Norway's cooperation countries outside of the EU/EEA, namely Brazil, Canada, India, Japan, China, South Africa, the United States and South Korea, are all relevant with regards to collaboration in the field of wind power.

The Norway-China collaboration currently has one active project: CONWIND (2020-2023). The potential is enormous to start similar projects with the other countries in the list. Japan, the United States and South Korea have all announced big plans in floating offshore wind and stand out as relevant partner countries, both in terms of research and opportunities for industrial projects and exports.

European Centre of Excellence

NorthWind has been engaged with EERA JP Wind to promote the establishment of a European Centre of Excellence on wind energy, with research on floating wind and large-scale integration of offshore wind as two important elements. A Centre of Excellence can be seen as a kind of European-scale NorthWind, and would be co-financed by European partners. It would accelerate progress through a more efficient use of resources in areas with potential for innovation, added value and increased exports. Norway has the credibility to take a leading role in such a centre. It would help creating a European "home market" for Norwegian offshore wind-related technology, expertise and products. The market is huge: The European goal of 300 GW of offshore wind by 2050 will require investments of about 1000 billion EUR.





[1] EERA JP wind: European Energy Research Alliance joint programme on wind energy

[2] ETIP wind: European Technology and Innovation Platform on wind energy

COLLABORATION WITH OTHER FMEs

Arendalsuka

Arendalsuka is a large political gathering that is held annually in Arendal, Norway. The event's mission is to strengthen the belief in political empowerment and democracy through open debate and involvement. NorthWind collaborated with other FMEs in providing recommendations about the use of the North Sea as a solution to the climate and energy crises. These recommendations were presented at Arendalsuka on 15 August, together with a report prepared by research centres LowEmission, FME NCCS, FME HYDROGENi, FME NTRANS and FME NorthWind.

The report highlights ways in which the North Sea can become a hub for new climate technologies and green jobs – in areas like CO_2 storage, the electrification of the oil and gas industry, the North Sea network, offshore wind, energy islands and hydrogen.

Energy crisis workshop

On 13 May, NorthWind participated in and co-organised a workshop on the theme "Energy production and use in Norway". The event was part of FME NTRANS's series of workshops about the energy crisis. NorthWind scientists Eirill Bachmann Mehammer and Magnus Korpås held presentations about offshore wind and the energy system.

NTNU Energy Transition Conference

NorthWind director John Olav Tande held a keynote presentation at the NTNU Energy Transition Conference, which is co-organised by NTNU and a number of FMEs, including NorthWind.

Policy brief

A policy brief was co-published by FME NorthWind and FME NTRANS, on the topic of Stakeholder and citizen participation in offshore wind development.

PhD seminar

NorthWind and FME CINELDI held a PhD and Postdoc seminar on innovation on 23 September. The event was led by Ida Fuchs, who is the innovation manager for *Electrification and digitalization* at the Department of Electric Power Engineering at NTNU. Participants from both research centres took part in the two-hour workshop.

Ida Fuchs holds a presentation for NorthWind and CINELDI PhDs and postdocs.

RESEARCH AND RESULTS

The primary objective of FME NorthWind is to bring forward outstanding research and innovation to reduce the cost of wind power and facilitate its sustainable development, which will grow exports and create jobs.

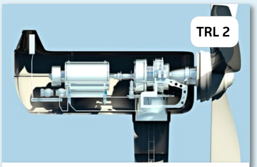
The secondary objectives are to:

- De-risk critical aspects for concept selection and enable cost-effective design and fabrication of support structures through reduced uncertainty and application of novel methods (WP1).
- Develop methods and tools for efficient and safe marine operations and logistic planning for installation and maintenance of offshore wind farms (WP2).
- Develop reliable and cost-effective electric power components and system solutions to enable profitable large-scale deployment of offshore wind energy in the North Sea (WP3).
- Develop methodologies to elevate the capability level of digital twins from 0-2 to 3-5 (WP4).
- Develop tools and insights for sustainable development of wind energy to create a successful export industry, reduce cost and uncertainty, and resolve environmental and societal conflicts (WP5).

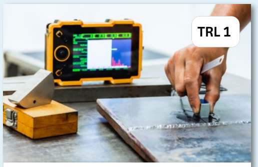
Innovations

In 2022, we structured our work with innovations, and the interplay between research and industry. We identified 30 innovations, classified according to their Technology Readiness Level (TRL). The innovations are within fields that are important for Norway's offshore wind efforts, and where we have leading industry partners who can put them to use. This includes offshore wind foundations, marine operations, electrical infrastructure, digital solutions for monitoring and control, and sustainable development. At the start of the year, most of the innovations were at TRL 2 (concept formulated). They are now mostly all at TRL 3 (experimental proof of concept) or 4 (validated in lab). As they develop, the innovations will be adopted as user cases or spin-off projects, led by one or several industry partners, and brought into practical use for the benefit of the industry and society in general.

Improved estimation of fine contents in silty sands from CPT measurements

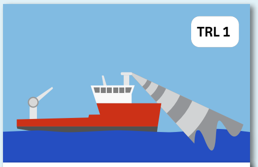


Digital twin of gear system based on more accurate material and damage data



Acoustic emission for laser welding process monitoring

New procedures to identify operational limits more efficiently

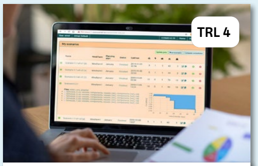


Methodology for wave and motion feedforward control for wind turbine blade installation

Reliability-based structural design

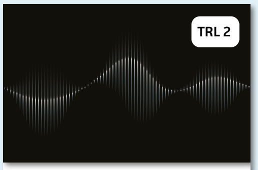
Additive manufacturing technology for repair and maintenance of offshore wind structures

Optimised power cable installation for coupled tension-torque behaviour



COSMO – Computer tool for optimisation and simulation of marine opersations

New method for thermal-electrical cable analysis including power variation and utilising accurate loss calculation

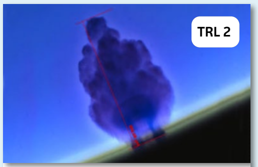


Increased sensitivity and accuracy in health monitoring of bearings by using Acoustic Emission

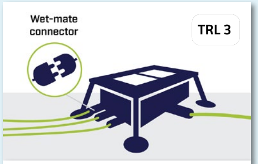
Laser-arc hybrid welding (LAHW)

Improved understanding of GBS installation

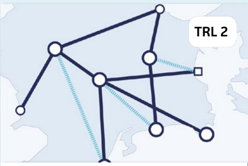
SMARTMOW – Logistics decision support tool for predictive maintenance at offshore wind farms



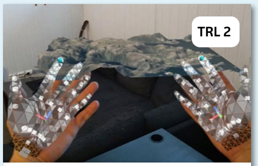
New models for degradation and lifetime assessment of HVAC insulation systems



Wet-mate connectors for >66 kV



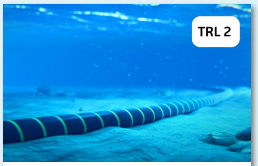
Industry-oriented tools for transient analysis and stability assessments in multivendor offshore grids



Holo Lens digital twin application

Online park design/optimisation tool

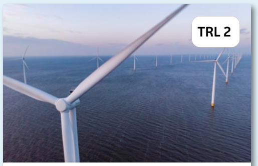
AviSite – Online application for assessing life cycle impacts on avian diversity for siting of offshore wind farms



New material model for power cables, including effects of hysteretic damping and coupling to torque, axial force and pressure

Advanced ancillary services from wind farms

HAM as a new paradigm in modelling



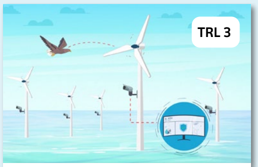
Reduced order model for wakes

Diffusion and innovation models for offshore wind technology

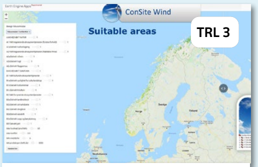
Combined testing and multiscale characterisation procedure for high and very high cycle fatigue

Comprehensive framework for optimising offshore grid design and operation

Fast multisvale modelling from global > meso > micro wake scales



SKARV – Bird collision avoidance system



Consite Wind – Consensus-based siting of onshore wind energy development

WORK PACKAGE 1
STRUCTURES AND INTEGRITY

WP LEADERS
Vigdis Olden, SINTEF
vigdis.olden@sintef.no
+47 982 30 434

Ana Page, NGI
ana.page@ngi.no
+47 406 98 328

Objective

De-risk critical aspects for concept selection and enable cost-effective design and fabrication of support structures through reduced uncertainty and application of novel methods.

Main results from 2022

Numerical simulation of cone penetration tests in silty sands

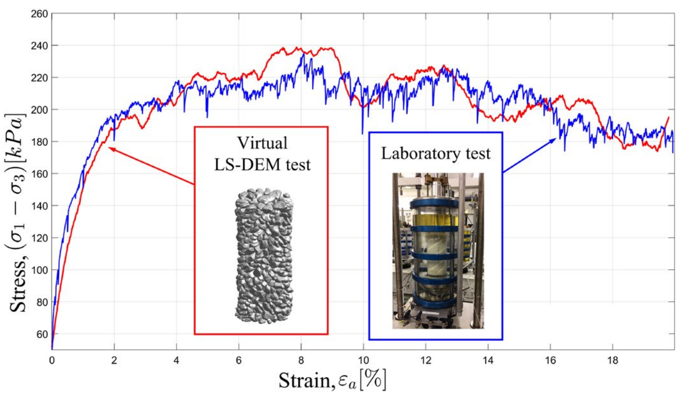
The offshore wind industry relies heavily on the Cone Penetration Test (CPTu) to measure the in-situ soil conditions and characterise large areas. However, the accuracy of CPT data interpretation depends on generic correlations. While these correlations work well for sands with limited fine particles, they are less reliable for soils with higher fines content, like silty sands, partially due to the lack of understanding on how the presence of fine particles affects the measured CPTu response. To address this issue and analyse the influence of fines and drainage on the tip resistance and developed pore pressure in CPTu, researchers in WP1 have combined two known numerical techniques: large-deformation finite element analyses with the "zipper technique" and coupled consolidation analyses. The results from applying this technique have been compared against CPTu measurements from two locations at an offshore wind farm site, providing good agreement, and indicating that this technique may help improving the understanding of the effect of fines content on CPTu response.

Establishing a sand database

The limited capacity of site investigation vessels and laboratories to process and test soil samples remains a significant bottleneck in the offshore wind industry, causing delays in the deployment of new offshore wind sites. To address this challenge, researchers in WP1 have taken the initiative to compile a database of typical sand properties. The primary objective of this database is to provide access to data on typical soil behaviour for offshore sites. This will facilitate the development of offshore wind projects, especially in cases where there are no site-specific laboratory test results available. Our approach involved a combination of existing laboratory tests and newly generated virtual sand tests to enhance the coverage of the database. To conduct virtual tests, we used the recently developed Level-Set Discrete Element Method (LS-DEM). This method models the interactions between individual sand grains in an assembly of grains, generating a continuum stress-strain relationship similar to that derived from traditional laboratory tests (see the figure on next page).

Nonlinear hydrodynamic loads

In numerical fluid dynamics simulations, three methods were used to examine hydrodynamic loads on the INO WINDMOOR floater in regular waves. The simulations



Comparison of the stress- strain curves from a virtual LS-DEM test and a triaxial laboratory test for Øysand sand.

revealed the effect of the free surface on local drag forces and demonstrated the effectiveness of different approaches for modelling the platform motion. The findings have significant implications for the optimisation of floating offshore wind turbines. Results are presented in a poster at EERA DeepWind 2023 and will be submitted as a paper for the same conference.

Uncertainty analysis of hydrodynamic experiments of floating wind turbines

A numerical study was conducted to evaluate uncertainties in the mooring system of the 12MW INO WINDMOOR semisubmersible floating wind turbine based on the KPN WINDMOOR hydrodynamic experiment. The study investigated uncertainties in the mooring system and their effect on outputs such as mooring line tension and platform responses. Two different approaches were used for the uncertainty analysis: the Taylor Series Method and the Monte Carlo Method. The results will be presented at OMAE2023 in June 2023 and provide valuable insights into the uncertainties associated with the mooring system modelling and its impact on hydrodynamic testing of floating wind turbines.

Materials integrity in the drive train

A state-of-the-art report on design, operation, failures and lifetime of main bearings and gears has been written. Considerable effort to get hold of failed drive train components and relevant material for study of failures and laboratory rolling fatigue experiments have taken place without success. We hope that this can be solved in collaboration with the industry partners in 2023.

How efficient is laser-arc hybrid welding?

Laser-arc hybrid welding (LAHW) is an efficient and promising welding technology for manufacturing offshore wind substructures. Inspired by the quest for finding efficient fabrication methods, we performed an initial comparison study in a laboratory to show how efficient LAHW can be compared to conventional welding methods. We found that LAHW may offer 5-24 times higher productivity than conventional arc welding (see the figure above) with half the energy consumption.

Despite the economic and productivity advantages of LAHW, there are challenges with the quality of welds, e.g., cracking at weld centreline and poor microstructure. Improvement of the stability of LAHW process is the key to achieve defect-free welds. Therefore, we have started to investigate the potential of using acoustic emission (AE) technique for LAHW process monitoring. A state-of-the-art review has been performed. The first testing will start in 2023.

INNOVATION

Laser-arc hybrid welding (LAHW)

The innovation LAHW has been further developed in 2022 in terms of optimising process parameters, improving process stability, and reducing defects in the weld. Some improvement has been achieved; however, the innovation is still at a low TRL (2-3).

User cases

Generic sites (lead: 4Subsea)

The purpose of this user case is to compile site and environmental properties relevant for the Norwegian offshore wind lease sites as a common basis for research within and outside FME NorthWind, and to support the industry's need for data during early site development phases. The industry partners have started identifying and retrieving relevant site data from open access data sources.

Next generation condition monitoring (lead: Kongsberg Maritime)

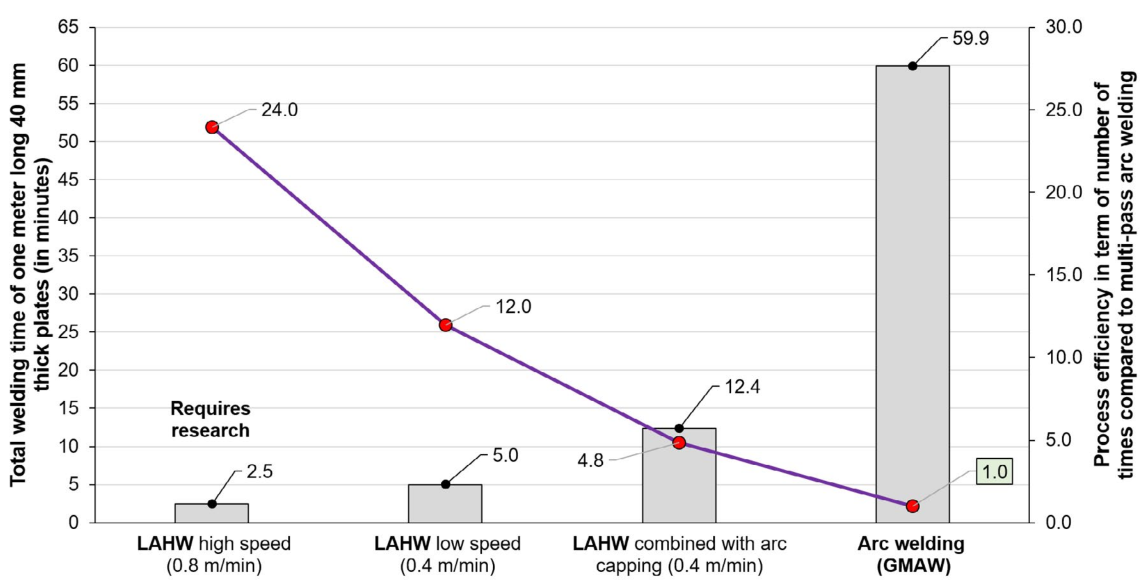
This user case explores Acoustic Emission as a tool to improve sensitivity and accuracy in health monitoring. The objective is the development of predictive models for fatigue and environmental degradation supporting models for remaining useful lifetime and mitigation strategies. The user case is connected to Task 1.3: Lifetime, performance, and integrity. A central activity in 2022 has been to initiate monitoring of the gear box in turbines at Unitech Zephyros (offshore) and Bessakerfjellet/Aneo (onshore).

Cost effective manufacturing (lead: Aker Offshore Wind)

The goal of this user case is to develop high-efficiency manufacturing technologies for mass production of substructures. The user case is led by Aker Offshore Wind and several other industry companies have contributed to its development as well. In 2022, four tasks have been defined and will be focused: 1) to compare different welding methods and define optimal process parameters; 2) to develop LAHW process; 3) to develop a robotic non-destructive testing (NDT) method and 4) to develop a manufacturing digital twin (in collaboration with WP4).

Aluminium in offshore wind (lead: Hydro Aluminium)

This new proposed user case introduced in 2022 aims to explore the potential of aluminium for offshore wind applications, e.g., nacelle parts, cooling parts, turbines, taking advantage of aluminium as a material for lightweight design, increased recyclability, and anticorrosive solutions.



Comparison of productivity, LAHW vs. arc welding.

WORK PACKAGE 2
MARINE OPERATIONS AND LOGISTICS

WP LEADERS
Henning Braaten, SINTEF
henning.braaten@sintef.no
+47 915 74 682

Zhen Gao, NTNU
zhen.gao@ntnu.no
+47 917 51 114
(outgoing)

Svein Sævik, NTNU
svein.savik@ntnu.no
+47 735 95 173
(incoming)

Objectives

Develop methods and tools for efficient and safe marine operations and logistic planning for installation and maintenance of offshore wind farms.

Main results from 2022

Installation and replacement operations

- PhD candidate working on "An approach for safe and cost-effective installation of offshore wind power cables".
- Report on "Installation and replacement of offshore wind turbine blades".
- Mapped potential innovations when it comes to installation of GBS (gravity-based structures). Work to be finished and presented in 2023.

Service Operation Vessel (SOV) for offshore wind turbines

- Developed procedures to be able to perform operability studies and identify operational limits more efficiently.

Optimisation models for planning marine logistics operations

- PhD candidate working on "Predictive maintenance planning at offshore wind farms".
- Issued report on "Predictive maintenance logistics for offshore wind farms".
- Further developed COSMO – A decision support tool for planning the maritime logistics of the installation of large offshore wind farms.

INNOVATION

An approach for safe and cost-effective installation of offshore wind power cables

For offshore wind turbine installations, the grid of subsea power cables represents a critical infrastructure for transporting the electric energy to the market. This includes both dynamic cables connecting the bottom-fixed/floating wind turbines to the seabed and sections of static cables linking each turbine to the grid and each wind farm to the market.

During installation, the power cable is exposed to vessel motions and forces from local wave kinematics. The cable motion and structural response is influenced by several other factors such as water depth, vessel heading, cable-soil interaction, tension-torque coupling and internal friction of the power cables.

Illustration: Shutterstock

According to current design practice, the weather window in terms of acceptable sea state parameters allowing cable installation is established before the operation takes place and is based on simplified global dynamic models. It is noted that vessel availability is a cost driver. To reduce installation cost, it is necessary to explore non-linear cable behaviour in more detail.

Through the work at NorthWind, we plan to develop the methodology from TRL 1 to TRL 3.

Outcomes from NorthWind:

- Improved FE-models for simulating cable behaviour during installation. The model has been developed and shall be implemented in general FE-software suitable for dynamic simulation of offshore power cable installation.
- Improved evaluation criteria for combined cable loads, i.e. combinations of tensions (compression), torque and bending moment by use of suggested interaction formulas. These interaction formulas are suitable to judge load severity in a typical power cable subjected to combined tension (compression), bending and torque loading. These are in a format suitable to evaluate and make explicit the combined loads experienced and seen in dynamic simulation of installation operations.

WORK PACKAGE 3
ELECTRICAL INFRASTRUCTURE & SYSTEM INTEGRATION

WP LEADERS
Eirill Bachmann Mehammer, SINTEF
eirill.mehammer@sintef.no
+47 405 51 236 (outgoing)

Marte Gammelsæter, SINTEF
marte.gammelsaeter@sintef.no
+47 951 02 147 (incoming)

Magnus Korpås, NTNU
magnus.korpas@ntnu.no
+47 970 42 009

Objectives

Develop reliable and cost-effective electric power components and system solutions to enable profitable large-scale deployment of offshore wind energy in the North Sea.

Main results from 2022

Electrical Infrastructure

- Conference paper on electro-thermal cable models published in Journal of Physics: Conference Series
- Conference paper on power electronics converters and architecture for modular HVDC wind generators published in POWERCON
- Journal paper on steel armour modelling submitted to IEEE Trans. Power Delivery
- Conference paper on models for degradation and lifetime assessment submitted to EERA DeepWind 2023
- Two spin-off projects: KSP SeaConnect and KSP NewLifT

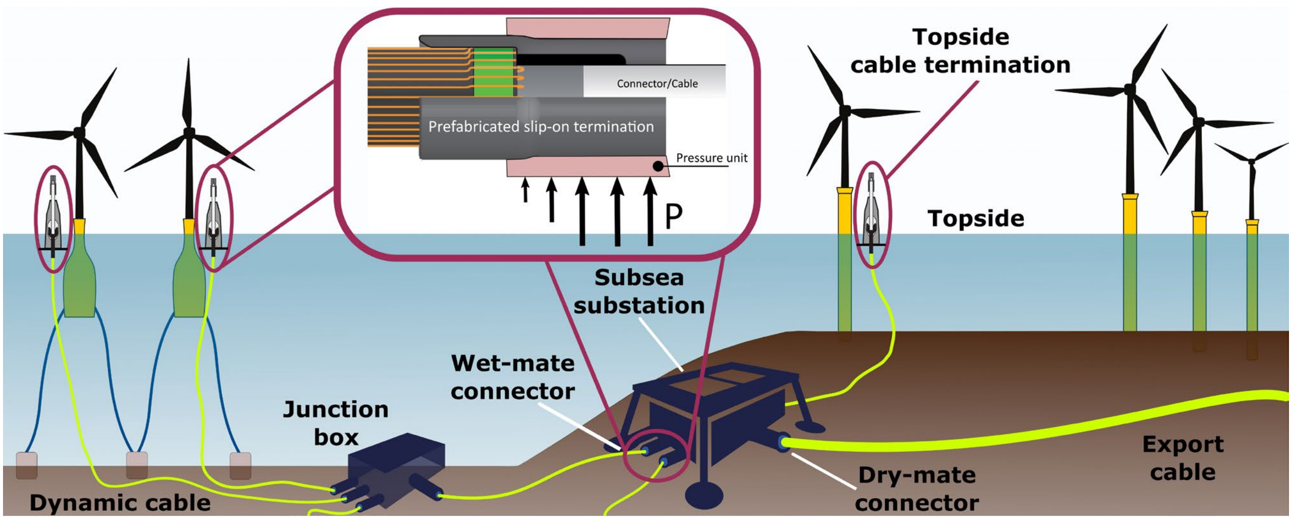
System integration

- Conference paper on models to identify economically robust offshore grid configurations submitted to EERA DeepWind 2023
- Journal paper on advanced ancillary services provision from wind farms submitted to the IEEE journal
- Conference paper on market challenges for 100 % renewable power systems submitted to the International conference on the European energy market (EEM22)
- Newspaper op-ed on "30 GW wind power timeseries analysis" (Dagens Næringsliv)
- Memo on Small-Signal State-Space Model MATLAB tool for interconnected AC/MTDC grids completed (in-kind from MODULATOR)

INNOVATION

Subsea connectors for large-scale floating wind farms

Floating wind in deep waters offers a huge energy production potential but is still at an early stage of development. For far-from-shore floating wind farms, the transmission costs including inter-array cabling account for almost half of the total costs. Improved and innovative power components are therefore key to reduce the levelized cost of energy (LCOE) of floating wind.



At deep waters, a conventional substation on a bottom-fixed structure starts to become impractical. Floating foundations are competitive with the bottom-fixed foundations at water depths of about 50 m and more feasible than bottom-fixed solutions at waters deeper than 60 m based on the future cost prognosis performed by Multiconsult in an optimistic scenario[3]. The alternative is to have a floating substation, or to use subsea technology. By locating the substation at the seabed, the costs are reduced, and the robustness is increased compared to floating substations. Existing subsea technology from the offshore oil and gas sector can be adapted to floating wind applications, on the condition that the costs are reduced, and the capabilities are extended.

Subsea connectors are the key technology needed to enable subsea substations and must be developed to a higher voltage level than what exists on the world market today. Laboratory testing of subsea connector models during load variations have been performed in NorthWind's WP3, in collaboration with the LowEmission Centre. The main purpose was to examine the effect of increased interfacial pressure levels and insulating liquid types on the partial discharge inception of a silicone rubber slip-on type cable termination and to study whether higher voltage ratings can be achieved by introducing additional radial pressure around the termination without changing the design and dimension of the components.

The current TRL of this innovation is 3. The development will continue in the spin-off project KSP SeaConnect (High voltage subsea connections for resilient renewable offshore grids), where Equinor, TotalEnergies and NKT are among the partners.

[3] Multiconsult 2012, Fagrapport til strategisk konsekvensutredning av fornybar energiproduksjon til havs – teknologi og kostnadsutvikling.

WORK PACKAGE 4
DIGITAL TWIN AND ASSET MANAGEMENT

WP LEADERS
Adil Rasheed, NTNU
adil.rasheed@ntnu.no
+47 902 91 771

Kjetil Andre Johannessen, SINTEF
kjetil.johannessen@sintef.no
+47 913 45 314

Objectives

Develop methodologies to elevate the capability level of digital twin from 0-2 to 3-5.

Main results from 2022

Digital Twin adapted for wind energy

Data consolidation: The Bessaker wind farm and Zefyros wind turbine data have been acquired and pre-processed to build standalone, descriptive, and predictive digital twins, accurately representing operation, and providing insights into future performance. The following databases have been established.

- Data collected from the Bessaker Wind farm, cleaned, and utilised in building a standalone and descriptive digital twin.
- Data for the Zefyros case collected, cleaned, and utilised in building a standalone and descriptive digital twin.

Novel modelling paradigm: This work involved developing a novel modelling paradigm, hybrid analysis and modelling (HAM), that combines the strengths of both physics-based modelling and data-driven modelling. Two approaches have recently been developed, known as Non-Intrusive Reduced Order Models (NIROM) and Corrective Source Term Approach (COSTA). NIROM employs Long Short-Term Memory (LSTM) networks to accelerate computational fluid dynamics (CFD) simulations of turbulent flows, while COSTA models elasticity problems in the presence of incomplete physics, uncertainty in physical parameters, and simplifying assumptions. This work has resulted in the following manuscripts:

- A paper titled: Hybrid deep-learning POD-based parametric reduced order model for flow around wind-turbine blade published in the Journal of Physics: Conference Series
- A masters' thesis titled “Corrective source term approach for improving physics-based models” was completed and a journal article based on the thesis is under review

Asset Management

Predictive maintenance and decision support for wind energy applications: Offshore wind turbines (OWTs) are important for wind power generation due to their high electricity output and low land use. However, the harsh environment and remote locations in which they are installed mean maintenance is difficult, making predictive maintenance (PdM) a compelling strategy. PdM relies on failure prognostics, which predict an asset's remaining useful life (RUL) based on condition monitoring (CM). This work presents a systematic review of failure prognostic models for wind turbines, categorising them into data-driven, model-based, and hybrid models. The findings suggest that developing hybrid models that combine the advantages of data-driven and model-based models is promising. Meanwhile, a separate investigation examines offshore wind turbine failures and proposes four hypotheses on failure features. The work is compiled in the form of the following papers:

- Statistical analysis of offshore wind turbine failures, Submitted to ESREL 2023
- A paper titled "A review of failure prognostics for predictive maintenance of offshore wind turbines" published in the Journal of Physics: Conference Series, 2022

Informed public engagement

Development of tools for visualising datasets:
A generalised and extendable virtual reality-based digital twin framework has been developed to demonstrate its standalone, descriptive, and predictive capabilities in the context of an onshore wind farm and an offshore wind turbine. The work will appear in the proceedings of the following conferences.

- Standalone, Descriptive, and Predictive Digital Twin of an Onshore Wind Farm in Complex Terrain, Deep Wind 2023
- Demonstration of a standalone and descriptive digital twin of a floating offshore wind turbine, Accepted in OMAE 2023

User cases

Onshore wind farm (User: Aneo)

This user case involves the creation of digital twins for an onshore wind farm located in complex terrain at three capability levels. First, a standalone digital twin is created using openly available data on the environment and turbines, which is implemented with a 3D interface that is virtual-reality-enabled. Second, real SCADA data from the wind farm is utilised

to enhance the digital twin to the descriptive level. In addition to SCADA data, weather forecasts from a microscale model, nested into openly available weather forecasts, are also used to instil further realism. The wind resources are visualised in the VR, and hourly power production predictions for up to sixty hours ahead are inferred from the weather data.

Offshore wind turbine (User: Sustainable Energy Norwegian Catapult Center)

In this user case, we introduce the digital twin concept and capability level scale in the context of wind energy. We demonstrate the development of three different

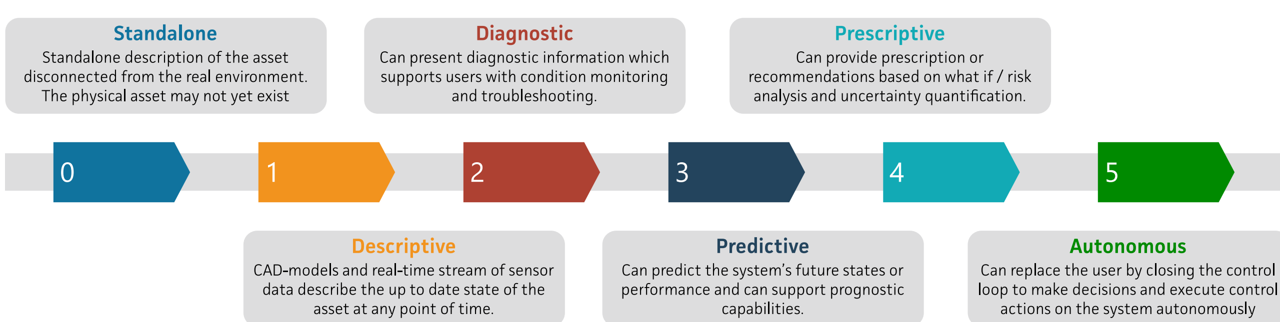
types of digital twins for an operational floating offshore wind turbine: standalone, descriptive, and prescriptive. The standalone digital twin provides a virtual representation of the wind turbine and its operating environment, which can be used during the planning, design, and construction phases. The descriptive digital twin enhances the standalone digital twin with real data from the turbine and visualises all the data in virtual reality to aid informed decision-making. In addition, the descriptive digital twin serves as a basis for diagnostic, predictive, prescriptive, and autonomous tools. The predictive digital twin is created by utilising weather forecasts, neural networks, and transfer learning.

Optimal wind farm layout design (lead: Norconsult)
This is a new relevant user case proposed in 2022. Optimising the layout of a wind farm involves many factors, including wake losses, cabling costs, and environmental survey costs. The stability of operations and maintenance efficiency also impact the overall lifespan costs of a wind farm. The wear-and-tear of turbines requires derating or yawing of the peripheral turbines, which further affects the layout optimisation. When there are over 30 or 40 design variables, effective optimisation relies on gradient-based methods. However, few such tools exist, and we aim to explore the FLOWFarm.jl tool from Brigham Young University's FlowLab, which has the potential to extend to include new features and go beyond local optima. In the short term, we will compare it with industry-standard tools like WindPro and the Jensen-model. Our long-term vision is to implement more of the factors mentioned above.

INNOVATION

Two HAM approaches: the NIROM and COSTA

The main innovation has been the development of the two HAM approaches: the NIROM and COSTA. These methods have demonstrated high accuracy, computational efficiency, and the ability to model the unknown while utilising existing knowledge to the maximum extent. Consequently, they are seen as powerful enablers for digital twin applications. Without this new family of models, realisation of realistic digital twins is challenging. TRL 2-3.



WORK PACKAGE 5
SUSTAINABLE WIND DEVELOPMENT

WP LEAD
Rita V. d'Oliveira Bouman (NTNU)
rita.bouman@ntnu.no
+47 942 60 455

Roel May (NINA)
roel.may@nina.no
+47 957 85 995

Objectives

Develop tools and insights for sustainable development of wind energy to create a successful export industry, reduce costs and uncertainty, and resolve environmental and societal conflicts.

Main results from 2022

The role of Norwegian wind in the sustainable energy transition

- PhD candidate working on "Circular business development of offshore wind energy"➔ Pankaj Ravindra Gode.
- PhD candidate working on "Harnessing Norwegian maritime industrial capabilities in the emerging US offshore wind industry" ➔ Julian Lahuerta
- A preliminary SDG impact analysis (poster presented at the Annual Innovation forum), combined qualitative literature and quantitative global value chain analysis
- Started developing a quantitative innovation-diffusion model, that relates cost and technology learning data of the different components of an offshore wind farm, with the diffusion/uptake of wind offshore. Here, we have the theoretical model implemented with some (partly dummy) data. In 2023, we'll collect information from industry.
- Outlined a qualitative SDG-interlinkage study: presented at the Annual Innovation forum, where we started recruiting experts for the focus group activities for 2023.

Environmental impacts and options for environmental design

- Above-water impacts: The work in 2022 was linked to design and preparations for applying for a permit from the Norwegian Food Safety Authority for year-round tracking of gulls (GPS precision, harness-mounted equipment), as well as the processing of tracking data of kittiwakes from Skudeneshavn/Karmøy.
- Below-water impacts: A literature review of reef effects for Scandinavia has been performed and is currently being finalised in a report. NINA has established collaboration with the Institute of Marine Research for taking eDNA samples at the Hywind Tampen area before construction starts; this will be followed up on in the coming years through the spin-off project WindSys.
- Onshore impacts: The AviSite LCA-mapping application has been developed, and is currently undergoing internal testing.
- Mitigation options: SINTEF performed a review of existing technology for bird detection and systems to prevent bird collisions. This has been published in a report "Review of technology for bird detection and collision prevention".
- Integrated siting tool: The ConSite tool has been established in a new cloud repository in NINA's Google Enterprise. So far, further development of the ConSite Wind web app includes additional maps, preference weights and new functionality to support

a traffic light planning approach. The beta version now operational. Development of the Online data catalogue is in progress.
- Two PhD candidates were hired in 2022 that will focus their work on *"Improved legal framework for impact assessment of wind parks"* and *"Life-cycle options for ecological restoration: construction to decommission"*, respectively.

Public engagement, participation and controversy
- PhD candidate working on "The framing of Norwegian wind energy futures – the cases of Svalbard and Sørlige Nordsjø II" ➔ Birgitte Nygaard
- Workshop with FME NTRANS on the Norwegian wind power controversy

Publications

- Journal paper: Afewerki, S. and Karlsen, A., 2022. Policy mixes for just sustainable development in regions specialized in carbon-intensive industries: the case of two Norwegian petro-maritime regions. European Planning Studies, 30(11), pp.2273-2292.
- Book chapter: Banet, C., 2022. Energy Planning Legal Requirements and Offshore Wind in Norway. In Fleming, Ruven; de Graaf, Kars; Hancher, Leigh & Woerdman, Edwin (Ed.), A Force of Energy - Essays in Energy Law in Honour of Professor Martha Roggenkamp. University of Groningen Press. ISSN 9789403429533. p. 191–203.
- Report: Garcia Rosa, P.: Review of technology for bird detection and collision prevention.

User cases

Sustainability Readiness Levels (SRL): Currently the outcomes from a stakeholder workshop on how to define SRLs are being analysed and synthesised. Literature regarding this approach and similar approaches and concepts has been collected for the development of a working framework.

INNOVATIONS

AviSite – Online application for assessing life cycle impacts on avian diversity for siting of onshore wind farms

AviSite has been developed as an online application that allows users to perform life cycle impact assessment (LCIA) screening of bird impacts during the early planning phase. It allows users to spatially visualise where impacts of avian diversity are expected to be highest and allow for locating sites with lowest conflict level per LCOE. The LCIA methodology has been developed, but the online application still needs to be constructed and validated. Currently the app is published internally for testing prior to public release. This innovation is currently at TRL 6.

ConSite Wind – Consensus-based siting of onshore wind energy development

ConSite Wind is a Spatial Multi-Criteria Decision Analysis toolbox (S-MCDA) that is useful to build consensus, optimise spatial planning and improve transparent decision-making processes during the planning and licensing phase of wind energy projects. ConSite is designed to perform a combination of modern multi-criteria evaluation and decision analysis techniques for optimal siting of wind-power plants based on ecological, societal and technological criteria. The toolbox has been developed through several earlier and ongoing research projects. So far, further development of the ConSite Wind web app includes additional maps, preference weights and new functionality to support a traffic light planning approach. The beta-version now operational. Development of the Online data catalogue is in progress. This innovation is currently at TRL 5.

SPIN-OFF PROJECTS

The following projects have been established or kicked off during the course of 2022. They arose entirely or partly as the result of work carried out at NorthWind. The projects are carried out with separate contracts, but are in alignment with the research agenda of NorthWind and provide added value.

Financed by the Research Council of Norway and other Norwegian sources

Ocean Grid (in Norwegian: Havnett) – This Green Platform project will develop new technology, knowledge and solutions to enable a profitable development of offshore wind on the Norwegian continental shelf. This includes how to connect the power from offshore wind to the existing grid. The project looks at both bottom-fixed and floating wind farms. It includes a KSP led by SINTEF Energy Research. Duration: 2022-2024. Project lead: Equinor.

FutureCare – This IPN project looks at the future design of high-voltage subsea AC (HVAC) cables for offshore renewable energy, with a view to develop the lead-free cables of the future. The project develops modelling tools and carries out testing to ensure the development of wet-design, lead-free cables with high reliability and long service life. Such wet-design cables are crucial to the continued development of floating renewables such as offshore wind, solar, wind hydrogen and wave power. Duration: 2021-2023 Project lead: Nexans.

VisAviS – This KSP project develops a bird migration visualisation tool to facilitate impact assessments of coastal and offshore wind projects, with a view to support a sustainable development of these projects. Duration: 2022-2026. Project lead: NINA.

SeaConnect – This KSP looks at high-voltage subsea connections for resilient renewable offshore grids. It will develop new materials and designs for the subsea components that currently have the highest risk of failure in the offshore power grid. It also aims at increasing the breakdown voltage and service life for subsea cable terminations and connectors. Duration: 2022-2026. Project lead: SINTEF Energy Research.

NewLifT – This KSP examines new insulation liquids for transformers, with better thermal properties. It aims at providing new knowledge and models to precisely establish the thermal performance of alternative dielectric liquids for transformers. This will reduce risk and uncertainty and facilitate the use of the next generation of insulation liquids, in both new and old transformers. Duration: 2022-2026. Project lead: SINTEF Energy Research.

WindSys – This KSP will assess the impact of floating wind farms on marine life, also look at co-existence with the fisheries industry. The focus is on pelagic fish, looking at the impacts of the placement of wind turbines at sea. Duration: 2022-2025. Project lead: NINA.

WindBarge – This IPN supports the development and commercialisation of the WindBarge floating structure, which enables floating wind turbines in water depths of 40 to 100 metres. The overarching goal is to improve the utilisation of existing bottom-fixed wind farms, and their connected infrastructure. Duration: 2022-2025. Project lead: GMFS AS.

AdaPfab – This IPN aims at developing a sustainable and cost-effective prefabrication process to enable the mass production of offshore wind substructures. Duration: 2022-2025. Project lead: Aker Solutions.

Financed by the EU

SCARLET – Superconducting cables for sustainable energy transition: This EU Horizon Europe project joins 15 partners from 7 countries, working to design and manufacture superconducting cables that will enable cheaper and more efficient power transmission from renewable sources. Project lead: SINTEF Energy Research. Project duration: 2022-2027

Wendy – Multicriteria analysis of the technical, environmental and social factors triggering the PIMBY principle for Wind technologies: This EU Horizon Europe project examines the PIMBY (Please in my backyard) principle, and how it can be triggered for wind power technology. Norwegian partners involved are NINA and the METCENTRE. Project lead: CIRCE. Project duration: 2022-2025

EDUCATION AND RECRUITMENT

Research scientist training constitutes a significant part of NorthWind's activities, and is provided by NTNU and UiO, in collaboration with the associate research partners. The centre's educational programme will fund 27 PhD and postdoc grants, including 10 in-kind grants by NTNU and UiO. So far, 13 PhDs have already started (11 at NTNU and 2 at UiO).

In addition, 3 PhDs and 1 postdoc are associated with NorthWind, but financed through other sources. There is also an effort to have more bachelor and master students at NTNU and UiO specialising in wind energy. In total 83 MSc students presented theses related to wind energy at NTNU in 2022. This represents a unique recruitment base for our industry partners.

Collaboration

An individual research plan is developed for each PhD candidate based on the Centre's research needs. Collaboration groups between PhD students, supervisors, SINTEF researchers and relevant industry partners maximise synergy and integration at task level. Research addresses scientific and technical knowledge gaps to achieve the Centre's goals. PhD students and their supervisors present their research at leading international conferences and annual NorthWind meetings and seminars.

International Academic Networks

The Centre will facilitate and fund PhDs to stay abroad with collaborating universities. Industry partners will provide short-term internship positions for innovation case studies. International exchange of research personnel with academic networks and internship arrangements with the Centre's industry partners will contribute to knowledge exchange between the academic communities and the industry.

New course by NTNU

NTNU was at work in 2022 preparing a new, free continuing education course titled "Introduction to offshore wind". The course is financed by the Norwegian Directorate for Higher Education and Skills and was launched in February of 2023.

Photo: Maxime Landrot/NTNU

Our PhD candidates

Veronica Liverud Krathe (WP1)

Affiliation: NTNU
Nationality: Norwegian
Supervisor: Prof. Erin Bachynski-Polić (NTNU), Prof. Amir R. Nejad (NTNU), Dr Jason Jonkman (NREL)
Period: 2021-2024
Thesis: Multiscale/-fidelity wind turbine dynamics models for structural design and control

Afolarinwa David Oyegbile (WP1)

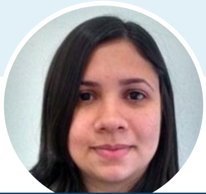
Affiliation: NTNU
Nationality: Nigerian
Supervisor: Prof. Michael Muskulus (NTNU), Prof. Gudmund Eiksund (NTNU), Senior Researcher Anand Natarajan (DTU), Dr. Amy Robertson (NREL)
Period: 2021-2024
Thesis: Reliability- and data-based structural design under industrial constraints

Torfinn Ottesen (WP2)

Affiliation: NTNU, SINTEF Ocean
Nationality: Norwegian
Supervisor: Prof. Svein Sævik (NTNU), Prof. Zhen Gao (NTNU), Senior Research Scientist Janne Gjøsteen (SINTEF Ocean)
Period: 2021-2025
Thesis: An approach for safe and cost-effective installation of offshore wind power cables

Vibeke Hvidegaard Petersen (WP2)

Affiliation: NTNU
Nationality: Danish
Supervisor: Prof. Magnus Stålhane (NTNU)
Period: 2022-2025
Thesis: Predictive maintenance of offshore wind turbines



Lorrana Faria da Rocha (WP3)

Affiliation: NTNU
Nationality: Brazilian
Supervisor: Pål Keim Olsen (NTNU),
Co-supervisors: Hendrik Vansompel (UGent),
Elisabetta Tedeschi (NTNU), Erik Grøndahl (SGRE)
Period: 2021-2024
Thesis: Power electronics architecture and control methods for a HVDC generator for offshore wind

Arkaitz Rabanal Alcubilla (WP3)

Affiliation: NTNU
Nationality: Spanish
Supervisor: Elisabetta Tedeschi (NTNU).
Co-Supervisors: Salvatore D'Arco (Sintef Energy),
Nicolaos Cutululis (DTU), Pål Keim Olsen (NTNU)
Period: 2021-2024
Thesis: Energy Storage for Grid Services in HVDC Connected Offshore Wind Farms

Ingvild Ånestad (WP3)

Affiliation: UiO
Nationality: Norwegian
Supervisor: Prof. Catherine Banet (UiO)
Period: 2023-2027
Thesis: The regulatory framework for the development of offshore grid infrastructure in the North Sea, primarily focusing on Norway

Florian Stadtmann (WP4)

Affiliation: NTNU
Nationality: German
Supervisor: Prof. Adil Rasheed (NTNU),
Prof. Trond Kvamsdal (NTNU), Prof. Omer San (OSU), Kjetil André Johannessen (SINTEF)
Period: 2021-2024
Thesis: Enabling Technologies for Digital Twins

Wanwan Zhang (WP4)

Affiliation: NTNU
Nationality: Chinese
Supervisor: Prof. Jørn Vatn (NTNU),
Prof. Adil Rasheed (NTNU)
Period: 2021-2024
Thesis: Predictive Maintenance and Decision Support for Asset Management

Gullik-André Fjordbo (WP5)

Affiliation: UiO
Nationality: Norwegian
Supervisor: Prof. Ivar Alvik (UiO),
Associate Prof. Katrine Broch Hauge (UiO)
Period: 2022-2026
Thesis: Impact assessments of wind power plants

Pankaj Ravindra Gode (WP5)

Affiliation: NTNU
Nationality: Indian
Supervisor: Prof. Arild Aspelund (NTNU), Ass. Prof. Øyvind Bjørgum (NTNU)
Period: 2021-2025
Thesis: Circular Business Development of Offshore Wind Energy

Julian Lahuerta (WP5)

Affiliation: NTNU
Nationality: Norwegian
Supervisor: Prof. Asbjørn Karlsen (NTNU)
Period: 2021-2024
Thesis: Harnessing Norwegian maritime industrial capabilities in the emerging US offshore wind industry

Birgitte Nygaard (WP5)

Affiliation: NTNU
Nationality: Danish
Supervisor: Prof. Tomas Moe Skjølsvold (NTNU), Ass. Prof. Robert Næss (NTNU)
Period: 2021-2024
Thesis: The framing of Norwegian Wind Energy futures – the cases of Svalbard and Sørlige Nordsjø II

Nikki Luttikhuis (WP5)

Affiliation: SINTEF Industry & NTNU
Nationality: Dutch
Supervisor: Øyvind Bjørgum (NTNU), Kirsten Wiebe (SINTEF)
Period: 2021-2025
Thesis: Technology impacts on the Sustainable Development Goals, an interlinkages approach

PhDs associated with NorthWind but financed through other sources

Øyvind Torgersrud (WP1)

Affiliation: Laboratoire 3SR, Université Grenoble Alpes & NGI
Nationality: Norwegian
Supervisor: Gioacchino Viggiani (3SR), Hans Petter Jostad (NGI), Jose E Andrade (Caltech), Edward Ando (EPFL)
Period: 2021-2024
Thesis: Numerical and experimental analysis of fabric evolution in granular soil under cyclic loading

Yannick Cyiza Karekezi (WP3)

Affiliation: NTNU
Nationality: Norwegian
Supervisor: Pål Keim Olsen.
Co-supervisors: Robert Nilssen (NTNU), Hendrik Vansompel (UGent), Erik Grøndahl (SGRE)
Period: 2021-2024
Thesis: Novel Modular HVDC Generator for Offshore Wind

COMMUNICATIONS

NorthWind continues to enjoy significant media coverage as the result of the sustained efforts of its communications team.

The starting phase of the Centre's activity saw significant communications efforts expended towards establishing a brand and a communications platform, namely the NorthWind website and the newsletter. These efforts are already paying off and will do so to an even greater extent as the Centre evolves and produces even more results and innovations.

Why communications matter for NorthWind

The success of NorthWind relies in large part on efficiently communicating both its objectives and results to the industry, the research community, the government and its various agencies, and the general public.

By sharing knowledge and information and contributing to an informed debate about wind energy, the Centre can help foster public acceptance, and ensure the political and industrial willingness necessary for the continued development of wind energy. Communication is therefore a core strategic activity of NorthWind.

Strategic communication efforts

NorthWind took part in Arendalsuka, together with several FMEs and the LowEmission research centre. The Centres prepared a report highlighting ways in which the North Sea can become a hub for new climate technologies and green jobs – in areas like CO_2 storage, the electrification of the oil and gas industry, the North Sea network, offshore wind, energy islands and hydrogen.

NorthWind also supported international organisations such as EERA JP Wind in their push for a European Centre of Excellence on wind energy. The Centre is also an active member of a collaboration forum about offshore wind organised by the Norwegian Ministry of Petroleum and Energy. Centre director John Tande heads a working group within the forum about research, technology and competence.

Website and newsletter

The website performed very well during 2022, with 30 134 pageviews from 1 January to 31 December – which are good results for a site of that nature. The site is intended as a central hub for all external communication, provides information about the Centre and its partners, and disseminates research results and progress. The website was also successfully used to promote various events such as the webinar series, the Annual Innovation Forum and the EERA DeepWind conference.

The news section of the website is intended as a content hub that serves a dual purpose as a communications platform for the centre and a public engagement tool about wind energy. As such, it contains articles not only about Centre activities and results, but also about wind energy in general.

The newsletter has over 400 subscribers. Anyone visiting the website can subscribe to it. In total, 19 newsletters were sent in 2022, to promote events and share news.

Internal newsletter

In addition to the external newsletter, to which anyone can subscribe, NorthWind management has launched, with the support of the communications team, an internal newsletter aimed at keeping project partners up to date with information.

A fact-based approach

In a context where debate about wind energy is often emotionally charged, the communications team adopts a fact-based approach for its efforts directed at the general public. In this spirit, the website shares new developments in the world of wind power, as well as articles highlighting areas of concern. On a few occasions, articles were written that debunk myths about wind power.

One of those was an op-ed by Professor Magnus Korpås, from NTNU, who wrote an article stating that wind power and hydro power are indeed a good match, in reply to another op-ed that stated wind turbines produced energy when it was needed the least.

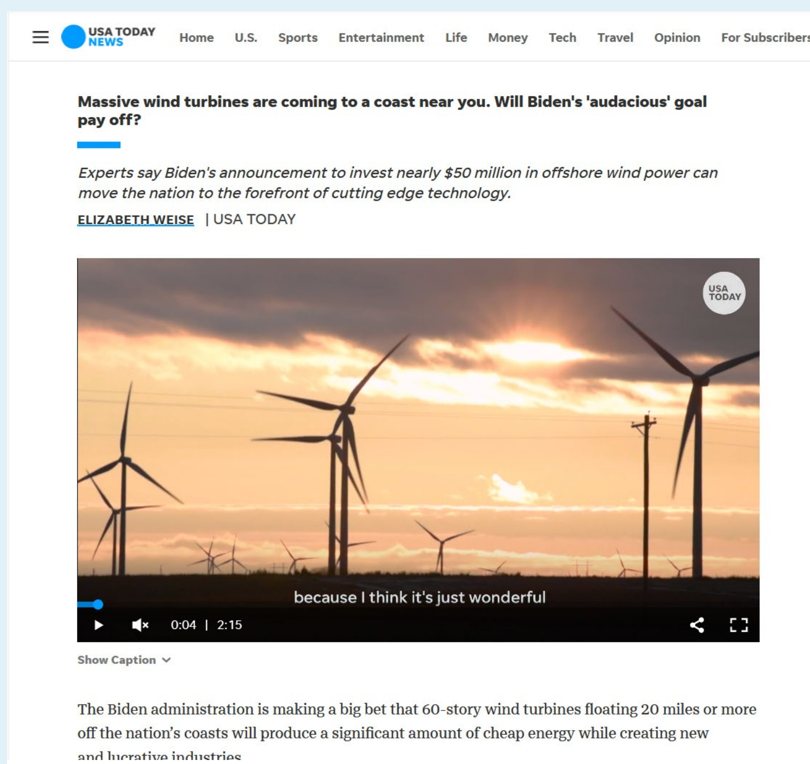
Support was also given to fact-checking website faktisk.no, which sought help from NorthWind on three occasions[4] to assess the accuracy of claims about wind power that were circulating on social media.

On 14-15 March, NorthWind was one of five research centres to be invited to hold a presentation at a communications conference organised by SINTE Energy Research, entitled *Skal fakta ha makta* (Should facts have power).

Appearances in the media

NorthWind scientists penned four op-eds that were published in Norwegian newspapers Dagens næringsliv, Aftenposten and Stavanger Aftenblad. They appeared in seven podcast episodes or radio interviews. Centre director John Olav Tande was also featured in American daily newspaper USA Today, in an article about president Biden's announcement of an investment of 50 million USD in offshore wind power.

In total, NorthWind appeared in 68 articles in business media.


USA TODAY NEWS | Home | U.S. | Sports | Entertainment | Life | Money | Tech | Travel | Opinion | For Subscribers

Massive wind turbines are coming to a coast near you. Will Biden's 'audacious' goal pay off?

Experts say Biden's announcement to invest nearly $50 million in offshore wind power can move the nation to the forefront of cutting edge technology.

ELIZABETH WEISE | USA TODAY

Show Caption

The Biden administration is making a big bet that 60-story wind turbines floating 20 miles or more off the nation's coasts will produce a significant amount of cheap energy while creating new and lucrative industries

Blog articles

Six blog articles were published by NorthWind during the course of the year. Looking forward, we expect this number to gradually increase as progress is made in the various work packages.

Webinar series

The communications team supported the Technology Transfer Committee in the organisation of its popular webinars, particularly with respect to promoting the events and facilitating registration. More webinars are planned for 2023.

Annual Innovation Forum

The first in-person Annual Innovation Forum took place in December. This annual event is a golden opportunity for partners to learn about the research and innovation activities in the Centre, and an excellent occasion for networking among consortium members. Based on the very positive feedback from participants, the event will be extended with dedicated work package meetings and more poster presentations.

EERA DeepWind conference

NorthWind is a major participant in the international offshore wind R&I conference EERA DeepWind (see pages 20-22). The conference is an international event aiming to present the best ongoing research and innovation related to deep sea offshore wind farms, both bottom-fixed and floating.

Social media

The NorthWind LinkedIn page experienced significant growth in 2022, with the number of followers going from 239 at the beginning of the year to 630 on 31 December. LinkedIn has proven an efficient social media channel for sharing scientific news and results, and we anticipate the number of followers to continue growing as the centre publishes more results. Project partners are encouraged to share NorthWind news, events and blog articles on their own social media channels to amplify their reach.

[4] https://www.faktisk.no/artikler/z5x7g/dette-vet-vi-om-mikroplast-fra-vindturbiner
https://www.faktisk.no/artikler/zw8ll/nei-vindturbiner-produserer-ikke-strom-bare-4-av-12-maneder-i-aret
https://www.faktisk.no/artikler/z419v/nei-klimagasser-fra-vindmoller-gir-ikke-mer-drivhuseffekt-enn-flytrafikk

FINANCIAL STATEMENT

Costs (in 1000 NOK)	Amount
Host institution (SINTEF Energi)	7111
Research partners	31974
User partners	9301
Equipment	
Total	**48386**

Funding (in 1000 NOK)	Amount
Research Council of Norway	21128
Host institution (SINTEF Energi)	1483
Research partners	8396
User partners*	17379
Total	**48386**

*Excess User partner funding transferred to 2023

PERSONNEL

Key researchers

Name	Institution	Area
John Olav Tande	SINTEF Energi	WP0, WP3, WP4
Hans Christian Bolstad	SINTEF Energi	WP0
Trond Kvamsdal	NTNU	WP0, WP4, WP5
Inger Marie Malvik	SINTEF Energi	WP0, WP5
Vigdis Olden	SINTEF Energi	WP0, WP1
Ana Page	NGI	WP0, WP1, WP2
Henning Braaten	SINTEF Ocean	WP0, WP2
Petter A. Berthelsen	SINTEF Ocean	WP0, WP1, WP2
Zhen Gao	NTNU	WP0, WP2
Eirill Bachmann Mehammer	SINTEF Energi	WP0, WP3
Magnus Korpås	NTNU	WP0, WP3, WP5
Adil Rasheed	NTNU	WP0, WP 4
Kjetil Johannessen	SINTEF Digital	WP0, WP4
Marianne Ryghaug	NTNU	WP0, WP5
Sara Heidenreich	NTNU	WP0, WP5
Roel May	NINA	WP0, WP5
Michael Muskulus	NTNU	WP1
Xiaobo Ren	SINTEF Industri	WP1
Erin Bachynski-Polic	NTNU	WP1
Ivan Bunaziv	SINTEF Industri	WP1
Magnus Eriksson	SINTEF Industri	WP1
Martin Gutsch	SINTEF Ocean	WP2
Lars Magne Nonås	SINTEF Ocean	WP2
Svein Sævik	NTNU	WP2
Anne Bruyat	SINTEF Ocean	WP2
Halgeir Ludvigsen	SINTEF Ocean	WP2
Elin Espeland Halvorsen-Weare	SINTEF Ocean	WP2
Halvor Lie	SINTEF Ocean	WP2
Magnus Stålhane	NTNU	WP2
Yauheni Kisialiou	SINTEF Ocean	WP2
Pål Olsen	NTNU	WP3
Catherine Banet	UiO	WP3, WP5

Name	Institution	Area
Salvatore D'Arco	SINTEF Energi	WP3
Elisabetta Tedeschi	NTNU	WP3
Øystein Hestad	SINTEF Energi	WP3
Harald Svendsen	SINTEF Energi	WP3
Espen Eberg	SINTEF Energi	WP3
Bjørn Gustavsen	SINTEF Energi	WP3, WP4
Atle Pedersen	SINTEF Energi	WP3
Dag Linhjell	SINTEF Energi	WP3
Antonio Alvaro	SINTEF Industri	WP3
Anette Brocks Hagen	SINTEF Industri	WP3
Janne Gjøsteen	SINTEF Ocean	WP3
Jørn Vatn	NTNU	WP4
Balram Panjwani	SINTEF Industri	WP4
Valentin Chabaud	SINTEF Energi	WP3, WP4
Olimpo Anaya-Lara	SINTEF Energi	WP3
Svein Magne Hellesø	SINTEF Energi	WP3
Andrzej Holdyk	SINTEF Energi	WP3
Sverre Hvidsten	SINTEF Energi	WP3
Martin Høyer-Hansen	SINTEF Energi	WP3
Emre Kantar	SINTEF Energi	WP3
Hans Helmer Sæternes	SINTEF Energi	WP3
Kristian Thinn Solheim	SINTEF Energi	WP3
Torbjørn Ve Andersen	SINTEF Energi	WP3
Mandar Tabib	SINTEF Digital	WP4
Iver Bakken Sperstad	SINTEF Energi	WP4
Jon Vegard Venås	SINTEF Digital	WP4
Florian Stadtmann	NTNU	WP4
Wanwan Zhang	NTNU	WP4
Daniel Wennstrøm	NTNU	WP4
Sondre Sørbø	NTNU	WP4
Sebastien Gros	NTNU	WP4
Ole Øiseth	NTNU	WP4

Name	Institution	Area
Kirsten S. Wiebe	SINTEF Industri	WP5
Asbjørn Karlsen	NTNU	WP5
Arild Aspelund	NTNU	WP5
Asgeir Tomasgaard	NTNU	WP5
Øyvind Bjørgum	NTNU	WP5
Ruud Egging	NTNU	WP5
Fabian Rocha Aponte	SINTEF Industri	WP5
Børge Moe	NINA	WP5
Signe Christensen Dalsgaard	NINA	WP5
Carolyn Rosten	NINA	WP5
Johanna Järnegren	NINA	WP5
Elisabet Forsgren	NINA	WP5
Diego Jordán-Pavón	NINA	WP5
Bård Stokke	NINA	WP5
Katrine B. Hauge	UiO	WP5

Name	Institution	Area
Ole K. Fauchald	FNI	WP5
Ola Mestad	UiO	WP5
Ivar Alvik	UiO	WP5
Knut Kaasen	UiO	WP5
Bente Graae	NTNU, IBI	WP5
Dagmar Hagen	NINA	WP5
Ana Silva	NINA	WP5
Paula Garcia Rosa	SINTEF Energi	WP5
Frank Hanssen	NINA	WP5
Jiska van Dijk	NINA	WP5
Robert Næss	NTNU	WP5
Tomas M. Skjølsvold	NTNU	WP5
Christian Klöckner	NTNU	WP5
Vibeke S. Nørstebø	SINTEF Ocean	WP5

Associated postdoc

(financed through other sources)

Name	Nationality	Period	Gender	Topic
Alex X. Jerves	USA	2021-2023	M	Characterising sand behaviour from Level-Set Discrete Element Method (LS-DEM) simulations

PhD students

PhD candidate	Nationality	Period	Gender	WP	Topic
Veronica Liverud Krathe	Norwegian	2021-2024	F	1	Multiscale/-fidelity wind turbine dynamics models for structural design and control
Afolarinwa David Oygbile	Nigerian	2021-2024	M	1	Reliability- and data-based structural design under industrial constraints
Torfinn Ottesen	Norwegian	2021-2025	M	2	An approach for safe and cost-effective installation of offshore wind power cables
Vibeke Videgaard Petersen	Danish	2022-2025	F	2	Predictive maintenance planning for offshore wind farms
Lorrana Faria	Brazillian	2021-2024	F	3	Power electronics architecture and control methods for a HVDC generator for offshore wind
Arkaitz Rabanal Alcubilla	Spanish	2021-2024	M	3	Energy Storage for Grid Services in HVDC Connected Offshore Wind Farms
Ingvild Ånestad	Norwegian	2023-2027	F	3	The regulatory framework for the development of offshore grid infrastructure in the North Sea, primarily focusing on Norway
Florian Stadmann	German	2021-2024	M	4	Enabling Technologies for Digital Twins

PhD candidate	Nationality	Period	Gender	WP	Topic
Wanwan Zhang	Chinese	2021-2024	F	4	Predictive Maintenance and Decision Support for Asset Management
Gullik-André Fjordbo	Norwegian	2022-2026	M	5	Impact assessment of wind power plants
Pankaj Ravindra Gode	Indian	2021-2024	M	5	Circular Business Development of Offshore Wind Energy
Julian Richard Lahuerta	Norwegian	2021-2024	M	5	Harnessing Norwegian maritime industrial capabilities in the emerging US offshore wind industry
Birgitte Nygaard	Danish	2021-2024	F	5	The framing of Norwegian Wind Energy futures – the cases of Svalbard and Sørlige Nordsjø II

PhD students with financial support from other sources

PhD candidate	Nationality	Funding	Period	Gender	WP	Topic
Øyvind Torgersrud	Norwegian	NGI	2021-2024	M	1	Numerical and experimental analysis of fabric evolution in granular soil under cyclic loading
Yannick Cyiza Karekezi	Norwegian	NTNU	2021-2024	M	3	Novel Modular HVDC Generator for Offshore Wind
Nikki Luttikhuis	Dutch	SINTEF	2021-2025	F	5	Technology impacts on the Sustainable Development Goals, an interlinkages approach

Master's students

Name	Gender	Topic
Bendik Peter Løvøy Alvestad	M	Simulate the effect of yaw misalignment/floater motion on the wake dynamics of large-scale wind turbines (12-15MW) in the non-neutral atmosphere
Leon Fevang-Gunn	M	Simulate the effect of yaw misalignment on wake dynamics in the uniform flow using high fidelity models
Marte Austenå	F	Wind Power on Frøya: From Controversy to Decision-Making (Use of knowledge in wind power controversies and decision-making processes)
Tina Berntsen Flobak	F	Stillest vann har dypest grunn: Skjær i sjøen for Norges industrieventyr. En kvalitativ studie av verdiforståelse som en kilde til utfordringer for fremtidens energiomstilling i Norge. (Hvilke typer næringsinteresser kan påvirke ulike aktører I utbyggingen av flytende havvindkraft ved Utsira?)
Taohong Liao	F	Comparison of Environmental impact of Hydropower and Wind Power
Eivind Jamessen	M	Economical Optimisation of Wind Powered Pump Hydro Storage Systems in Norway
Florian Saberniak	M	Offshore Wind Turbine Modelling State of the Art and future development
Trygve Thomas Aamodt	M	Gone With the Wind? Offshore Wind Data Management in the North Sea
William Hyggen VIken	M	A method for evaluating the potential for retrofitting Wind Assisted Ship Propulsion from a ship owner perspective
Helen Abraham	F	A Feasibility Study of a Renewable Energy Supply for an Offshore Oil and Gas Installation (med Tvedt)
Amund Garsrud Tvedt	M	A Feasibility Study of a Renewable Energy Supply for an Offshore Oil and Gas Installation (med Abraham)
Amirashkan Haghshenas	M	Predictive Digital Twin of Wind Farm
Fredrik Opdal	M	Design of a Hybrid Winding PM Machine for Electric Aviation
Elias Holmboe Skår	M	An Assessment of the Global Warming Potential of Marine Operations Related to Decommissioning of Offshore Wind Farms
Harald Osland Haugli	M	Numerical Modeling and Simulation of the Single Blade Installation for a Spar Wind Turbine Inside a Floating Dock
Marianne Helno Jahren	F	On Reduced Order Drivetrain Model Integrated with Wind Turbine and Wind Farm Simulation Tools

Name	Gender	Topic
Manjeri Ramakrishnan, Kaushik Shiva	M	Numerical Analysis of Mooring Systems for Floating Wind Turbines
Ane Bakken Hodt, June Bakken	F	Real Options Approach to Analyse the Attractiveness of Different Grid Solutions for Offshore Wind Projects: A Case Study from Norway
Maren Andrine Teien	F	Combining offshore wind power and hydrogen production – Assessment of storage requirements and energy utilization for different configurations
Mihhail Afanasjev	M	Broken Ice Loads on Floating Wind Turbine
Sebastian Kaasa	M	Bottom-Fixed Steel Jacket Substructures for the IEA-15-MW 240 Reference Wind Turbine in the Southern North Sea II
Saravanan Bhaskaran	M	Operational Limit Assessment of Offshore Wind Turbine Blade Mating Process Using Response-Based Criteria
Finn Lorange	M	Performance analysis of Flettner rotor installations
Mathias Tomren	M	Design and Numerical Analysis of Mooring Systems for Floating Wind Turbines – Comparison of Concepts for European Waters
Rikke Olsen Fredheim	F	Tower design for very large floating wind turbines
Ingvild Mariannedatter Solheim	F	Effect of Stockbridge Dampers on the Vibration Response of Suspension Bridge Hangers
Vignesh Balasubramaniyan	M	Load transfer from coupled analysis to structural design of FWTs
Martin Widding	M	Quantifying the capacity value of wind power in composite power systems
Stian Ekerhovd Boge Daniel Wergeland	M	A Hydro-Aerodynamic Analysis of a Floating Offshore Wind Turbine to Assist in Floater Selection
Trond Markus Tutturen Jørgen Solli-Nyhus	M	Towards Plug-and-Play Control of Wind Power Systems: Scalable stability certificate guaranteeing large signal stability for entire wind parks
Torbjørn B. Nilsen	M	Assessment of environmental impacts in the Norwegian licencing process for wind power
Lisa Chanel Lien	F	Combined models for optimization of routing and maintenance scheduling for offshore wind farms
Ali Hassan Qureshi	M	Dynamic process modelling of topside systems to evaluate power consumption and coupling with periodic power supply from renewables
Yu Ma	M	Novel Modeling and Fatigue Analysis for Early-phase Design of a 15-MW FOWT
Lucia Hanh Tran Vu	F	Analysis Of Floater Supported Offshore Wind Turbines
Magnus Kornelius Sæland Øystein Morken	M	Estimating modal damping due to hysteric soil behaviour and its effect on fatigue response of offshore wind structures on jackets and monopiles
Kirsten Kristine Biering Mohr	F	Temperatures in the mesosphere and lower thermosphere and the viability of using non-continuous time series to derive tides
Casper Leonard Klop	M	Forces and vibrations in a Modular HVDC Generator
Lars Thaulow Bremnes	M	PSCAD Simulations of Distance Protection Performance in a Grid with high Wind Power Penetration
Kooshiar Nasrollahi	M	Study on the Variable Frequency Transformer's Operation and Frequency Range
Marie Tyssen Bruu Lea Bakkevig Thorsen	F	Optimizing the Design of Charter Contracts for Installation Vessels at Offshore Wind Farms using Branch-and-Price
Claysius Dewanata Widjaja	M	Impedance Modelling and Stability Analysis of Virtual Synchronous Machine-based Wind Energy Conversion System
Siren Huse	F	Floating wind turbine mooring chain stress and fatigue analysis- Comparison between different solutions
Fredrik Håland	M	Combining fully coupled analysis and linear potential theory time domain analysis to obtain cross sectional loads in the substructure of a floating offshore wind turbine
Simon B. Aaland	M	Process simulation-based life cycle assessment of a subsea compression system: identifying the largest influences on environmental impact

Name	Gender	Topic
Haakon Lyngstad Jørgen Engelsen	M	Hybrid modelling for mooring system monitoring - A digital twin framework for floating wind turbines
Mikkel Nærby	M	Towards zero-emission power systems – A generation expansion study of the North Sea region 2040
Paul E. Seifert	M	The Value of Large-Scale Offshore Distribution Islands
Joey Hu	M	Preliminary Design Methodology Of Concrete Gravity-Based Foundations For Offshore Wind
Emil Jenssen	M	Position Control and Locking of Permanent Magnet Synchronous Motor for Propeller Drives in Drones
Gonzalo Sanfeliu Moreno	M	Feasibility study of floating solar panels on a hydropower reservoir with winter ice.
Helle Mortenesen Gråberg	F	Towards Physics-Informed Neural Networks for Urban Wind Flow Prediction
Eva Armstrong Sundsøy Støver, Marte Haugen	F	Rain Intrusion Through Horizontal Joints in Façade Panel Systems - Experimental Investigation
Domenica Janeth Naranjo Orrico	F	How do lichens, willow shrubs, meadow, and heath plant communities affect microclimate?
Jørgen Mikal Benum	M	Autonomous saildrone simulation and motion control
Poya Sherzad	F	Earthquake response of offshore wind turbines including nonlinear soil-structure interaction
Bendik Åshaug Holm	M	Path planning for wave-powered unmanned surface vehicle based on electronic navigational charts and weather data
Samson Bergesen	M	Design and Manufacturing of a Twin Harmonic Machine with Counter-rotating Rotors
Fatemeh Katal	F	The numerical simulation of different power plants by multi-criteria assessment methods for optimizing the efficiency and load demand in order to future use purposes
Alen Bhandari	M	Adaptation of Deep Learning based large object detection models to Tiny Object Detection
Einar Ingmar Skirdal Frøhaug	M	Design and Control of a Local Offshore Network for a Multi-Use Offshore Platform
Therese Tjeldflåt	F	Konflikter i vinden
Andreas Johannesen Fredrik Shaughnessy	M	Risk Premia in the German Electricity Forward Market: The Impact of Variable Renewable Energy Sources
Sofie Helene Råen Wettre	F	Numerical and Experimental Investigation of a Floating Offshore Wind Turbine Foundation with a Moonpool and Inner and Outer Skirts
Tonje Aasheim Nymark	F	Micro cracks in wind turbine bearings Investigation of microstructural characteristics and nanomechanical properties in White Etching Cracks (WEC)
Gjermund Smedsland	M	Fatigue Estimation of Offshore Structure by Monitored Data and Machine Learning
Sofie Barmen Stein	F	DC insulation materials for a modular HVDC generator
Tina Berntsen Flobak	F	Stille vann har dypest grunn: Skjær i sjøen for Norges nye industrieventyr. En kvalitativ studie av verdiforståelse som en kilde til utfordringer for fremtidens energiomstilling i Norge.
Marius Hofgaard Tage Ringstad	M	Determinants of Variable Renewable Energy Developers' Financial Performance
Stina Bjørgo Fimreite	F	Fluid Structure Interaction Analysis of Abnormal Wave Slamming Events
Eirik Anda	M	Numerical Study of Potential and Viscous, Nonlinear, Effects for Wave Drift Loads on Offshore Structures
Magnus Bøe	M	Future Design of Subsea High Voltage Cables for Offshore Renewables - Effect of Static Mechanical Stresses on the Insulation Lifetime
Kristen Bernhard Holtaas Sandaas	M	Implementing Renewable Electrification: Forecasting Requirements for Global LIB ESS Deployment
Torben Solvold Dahl	M	Fra Vann til vind, Et paradigmeskifte innenfor norsk energiutbygging. En analyse av to konsesjonsprosesser frem til vedtak på 2000-tallet.
Daniel Weldai Mesgena	M	Future Operation and Control of Power Systems-Laboratory Models and Real-Time Simulation

PUBLICATIONS

Peer reviewed journal publications

Search criteria: *sub-category:* Academic article *sub-category:* Academic literature review *sub-category:* Short communication *All publishing channels*

1. **Banet, Catherine.**
   Energy Planning Legal Requirements and Offshore Wind in Norway.. I: *A Force of Energy - Essays in Energy Law in Honour of Professor Martha Roggenkamp*. Groningen: University of Groningen Press 2022 ISBN 9789403429533. s. 191-203. UiO
2. **Deveci, Muhammet; Pamučar, Dragan; Cali, Umit; Kantar, Emre; Kölle, Konstanze; Tande, John Olav Giæver.**
   Hybrid q-Rung Orthopair Fuzzy Sets Based CoCoSo Model for Floating Offshore Wind Farm Site Selection in Norway. *CSEE Journal of Power and Energy Systems (JPES)* 2022 ;Volum 8.(5) s. 1261-1280. NTNU ENERGISINT
3. **Høyer-Hansen, Martin; Hellesø, Svein Magne; Solheim, Kristian Thinn; Mehammer, Eirill Bachmann; Eberg, Espen; Pedersen, Per Atle.**
   Optimisation of power cable ampacity in offshore wind farm applications. *Journal of Physics: Conference Series (JPCS)* 2022 ;Volum 2362. ENERGISINT
4. **Kölle, Konstanze; Göcmen, Tuhfe; Eguinoa, Irene; Alcayaga Roman, Leonardo Andres; Aparicio-Sanchez, Maria; Feng, Ju; Meyers, Johan; Pettas, Vasilis; Sood, Ishaan.**
   FarmConners market showcase results: wind farm flow control considering electricity prices. *Wind Energy Science* 2022 ;Volum 7.(6) s. 2181-2200. ENERGISINT
5. **Kölle, Konstanze; Göcmen, Tuhfe; Garcia Rosa, Paula Bastos; Petrovic, Vlaho; Eguinoa, Irene; Vrana, Til Kristian; Long, Qian; Pettas, Vasilis; Anand, Abhinav; Bartlas, Thanasis K.; Cutululis, Nicolaos A.; Manjock, Andreas; Tande, John Olav Giæver; Ruisi, Renzo; Bossanyi, Ervin.**
   Towards integrated wind farm control: Interfacing farm flow and power plant controls. *Advanced Control for Applications* 2022 ;Volum 4.(2). ENERGISINT
6. **Korpås, Magnus; Holttinen, Hannele; Helisto, Niina; Kiviluoma, Juha; Girard, Robin; Koivisto, Matti; Frew, Bethany; Dobschinski, Jan; Smith, J. Charles; Vrana, Til Kristian; Flynn, Damian; Orths, Antje; Soder, Lennart.**
   Addressing Market Issues in Electrical Power Systems with Large Shares of Variable Renewable Energy. I: *2022 18th International Conference on the European Energy Market - EEM*. Institute of Electrical and Electronics Engineers (IEEE) 2022 ISBN 978-1-6654-0896-7. NTNU ENERGISINT
7. **MacKinnon, Danny; Afewerki, Samson; Karlsen, Asbjørn.**
   Technology legitimation and strategic coupling: A cross-national study of floating wind power in Norway and Scotland. *Geoforum* 2022 ;Volum 135. s. 1-11. OCEAN NTNU
8. **Merz, Karl Otto.**
   Towards a particle-flow framework for uncertainty quantification, with applications in wind plant system dynamics and control. *Journal of Physics: Conference Series (JPCS)* 2022 ;Volum 2362. ENERGISINT
9. **Tabib, Mandar; Tsiolakis, Vasileios; Pawar, Suraj; Ahmed, Shady E.; Rasheed, Adil; Kvamsdal, Trond; San, Omer.**
   Hybrid deep-learning POD-based parametric reduced order model for flow around wind-turbine blade. *Journal of Physics: Conference Series (JPCS)* 2022 ;Volum 2362. s. - NTNU SINTEF
10. **Vardaroglu, Mustafa; Gao, Zhen; Avossa, Alberto Maria; Ricciardelli, Francesco.**
    Validation of a TLP wind turbine numerical model against model-scale tests under regular and irregular waves. *Ocean Engineering* 2022 ;Volum 256. s. - NTNU
11. **Wu, Mengning; Gao, Zhen; Zhao, Yuna.**
    Assessment of allowable sea states for offshore wind turbine blade installation using time-domain numerical models and considering weather forecast uncertainty. *Ocean Engineering* 2022 ;Volum 260. s. - NTNU
12. **Zhang, Wanwan; Vatn, Jørn; Rasheed, Adil.**
    A review of failure prognostics for predictive maintenance of offshore wind turbines. *Journal of Physics: Conference Series (JPCS)* 2022 ;Volum 2362. s. - NTNU

Presentations

Search criteria: *From:* 2022 *To:* 2022 *Main category:* Conference lecture and academic presentation *All publishing channels*

1. **Banet, Catherine.**
   Legal framework for electricity market design with offshore wind.. EERA DeepWind Conference 2023; 2023-01-20 - 2023-01-20. UiO

2. **Egeland, Ane Sydnes; Fjordbo, Gullik-André.**
Krav til utredning av miljøvirkninger av akvakultur. Havbruksretts-klubb; 2023-02-07 - 2023-02-07. UiO
3. **Gutsch, Martin; Ludvigsen, Halgeir.**
Investigation towards efficient walk-to-work (W2W) operability simulations. EERA DeepWind Conference; 2023-01-18 - 2023-01-20. OCEAN
4. **Jagite, George; Gao, Zhen; Braaten, Henning.**
On the installation of offshore wind turbines: Challenges and future perspectives. EERA DeepWind Conference 2023; 2023-01-18 - 2023-01-20. OCEAN NTNU
5. **Kvamsdal, Trond; Bachynski-Polić.**
Floating Wind Turbines: State of the art
Arctic Circle 2022, Reykjavik, Iceland; 2023-10-13 - 2022-10-16
6. **May, Roelof Frans.**
The Nature of Offshore Wind. EERA DeepWind Conference; 2023-01-18 - 2023-01-20. NINA
7. **Petersen, Vibeke; Guericke, Daniela; Stålhane, Magnus.**
Optimizing jack-up vessel chartering strategies to support maintenance tasks at offshore wind turbines. EERA DeepWind 2023; 2023-01-18 - 2023-01-20. NTNU

Books/theses and reports

Search criteria: *From:* 2022 *To:* 2022 *Main category:* Report/thesis *sub-category:* Encyclopaedia *sub-category:* Reference material *sub-category:* Popular scientific book *sub-category:* Textbook *sub-category:* Non-fiction book *All publishing channels*

1. **Bruu, Marie Tyssen; Thorsen, Lea Bakkevig.**
Optimizing the design of charter contracts for installation vessels at offshore wind farms using branch-and-price. Norges teknisk-naturvitenskapelige universitet 2022 88 p. NTNU
2. **Garcia Rosa, Paula Bastos.**
Review of technology for bird detection and collision prevention. Trondheim, Norway: SINTEF Energy Research 2022 15 p. ENERGISINT
3. **Halvorsen-Weare, Elin Espeland; Nonås, Lars Magne.**
Predictive maintenance logistics for offshore wind farms. : SINTEF Ocean 2022 (ISBN 978-82-14-07927-2) 18 p. OCEAN
4. **Heidenreich, Sara; Skjølsvold, Tomas Moe; Dankel, Dorothy Jane.**
Havvind: Areal, sted og sameksistens. Trondheim: FME NTRANS 2022 (ISBN 978-82-93863-23-6) 4 p.
UiB NTNU
5. **Heidenreich, Sara; Skjølsvold, Tomas Moe; Vasstrøm, Mikaela; Richter, Isabel.**
Havvind: strategier for et bedre offentlig ordskifte. Trondheim: FME NTRANS 2022 (ISBN 978-82-93863-18-2) 4 p.
NTNU UIA
6. **Petersen, Vibeke Hvidegaard.**
Optimization of maintenance schedules for offshore wind turbines. Danmarks Tekniske Universitet, DTU 2022 53 p.
NTNU
7. **Skjølsvold, Tomas Moe; Heidenreich, Sara.**
Fire samfunnsutfordringer for havvind. Trondheim: FME NTRANS 2022 (ISBN 978-82-93863-15-1) 4 p. NTNU
8. **Skjølsvold, Tomas Moe; Heidenreich, Sara; Linnerud, Kristin; Moe, Espen; Skjærseth, Jon Birger.**
Havvind: Tempo, politisk dynamikk og storpolitikk. Trondheim: FME NTRANS 2022 (ISBN 978-82-93863-22-9) 5 p.
NTNU NMBU FNI HVL
9. **Skjølsvold, Tomas Moe; Heidenreich, Sara; Suboticki, Ivana.**
Havvind: deltakelse og involvering av interessegrupper og innbyggere. Trondheim: FME NTRANS 2022 (ISBN 978-82-93863-21-2) 4 p. NTNU
10. **Tande, John Olav Giæver.**
NorthWind Annual Report 2021. Trondheim: SINTEFI Energi 2022 60 p. ENERGISINT

Multimedia products

Search criteria: *From:* 2022 *To:* 2022 *sub-category:* Multimedia product *All publishing channels*

1. **Garcia Rosa, Paula Bastos.**
SKARV bird collision avoidance system. SINTEF Energi AS 2022 ENERGISINT
2. **Tande, John Olav Giæver.**
Havvind kan dekke verdens energibehov flere ganger (video). SINTEF 2022. ENERGISINT
3. **Tande, John Olav Giæver.**
NorthWind, energiressursmelding og elektrisk skiløype. Energi-Norge 2022. ENERGISINT
4. **Tande, John Olav Giæver; Gardarsdottir, Stefania Osk.**
Hvordan kan vi kutte utslippene på norsk sokkel? (Video). SINTEF 2022. ENERGISINT

Op-eds

Search criteria: *From:* 2022 *To:* 2022 *sub-category:* Feature article *sub-category:* Editorial *All publishing channels*

1. **Eriksson, Magnus Carl Fredrik.**
Innlegg: Dette avgjør om Norge blir Europas hoffleverandør av havvindunderstell. *Dagens næringsliv* 2022. NTNU
2. **Karlsen, Asbjørn.**
Politikk for rettferdig bærekraftig omstilling i olje og gassregioner - For å lykkes med klimaomstilling trenger vi en helhetlig politikk som utnytter potensialet i utsatte olje- og gassregioner. *Gemini* 2022. NTNU

3. **Korpås, Magnus; Hustad, Johan Einar; Tomasgard, Asgeir.** Sol- og vindkraft er helt avgjørende for at vi skal kunne nå klima-målene. *Aftenposten (morgenutg. : trykt utg.)* 2022. NTNU
4. **Tande, John Olav Giæver; Svendsen, Harald Georg; Mehammer, Eirill Bachmann; Korpås, Magnus.** Null sammenheng mellom vind i nord og sør. Det er gull verdt for norsk havvind.. *Dagens næringsliv* 2022. NTNU ENERGISINT

Blogs and information material

Search criteria: *From:* 2022 *To:* 2022 *Main category:* Information material(s) *All publishing channels*

1. **Hestad, Øystein Leif Gurandsrud; Tande, John Olav Giæver.** "Hybrid cables" explained. ENERGISINT
2. **Hestad, Øystein Leif Gurandsrud; Tande, John Olav Giæver.** Hybridkabel enkelt forklart. ENERGISINT
3. **Mølnvik, Mona J.; Røkke, Nils Anders; Tande, John Olav Giæver; Gardarsdottir, Stefania Osk.** Nordsjøen som løsning på klima- og energikrisen. ENERGISINT
4. **Steenstrup-Duch, Anne.** Disse møter du fra SINTEF Energi på Arendalsuka. ENERGISINT
5. **Tande, John Olav Giæver.** EERA DeepWind: Spennende tider for havvind i Norge og Europa. ENERGISINT
6. **Tande, John Olav Giæver.** NorthWind - Fra forskning til bærekraftig industri. ENERGISINT
7. **Tande, John Olav Giæver.** NorthWind - From research to sustainable industry. ENERGISINT
8. **Tande, John Olav Giæver.** Offshore wind: the EU needs to invest now. ENERGISINT
9. **Tande, John Olav Giæver; Svendsen, Harald Georg.** Ulike vindforhold: Slik bør vi bygge 30 GW havvind i Norge. ENERGISINT

Media contributions

Search criteria: *From:* 2022 *To:* 2022 *Main category:* Media contribution *sub-category:* Popular scientific article *sub-category:* Interview journal *sub-category:* Article in business/trade/industry journal *sub-category:* Sound material *sub-category:* Short communication *All publishing channels*

1. **Bolstad, Hans Christian.** Sintef-forsker mener farten må opp. Fiskeribladet [Business/trade/industry journal] 2022-06-28. ENERGISINT
2. **Chabaud, Valentin Bruno.** Vegg av vindturbinar skal produsere kraft til havs. NRK [Internet] 2022-10-18. ENERGISINT
3. **Gardarsdottir, Stefania Osk; Tande, John Olav Giæver.** Hvordan kan vi kutte i utslippene på norsk sokkel? Podcast. SINTEF Smart forklart 2022. ENERGISINT
4. **Gardarsdottir, Stefania Osk; Tande, John Olav Giæver.** Smart forklart: Hvordan kan vi kutte utslippene på norsk sokkel?. SINTEF 2022. ENERGISIN
5. **Korpås, Magnus.** Norges store strømskvis. VG [Newspaper] 2022-09-17. NTNU
6. **Korpås, Magnus.** Tror regjeringens skattegrep kan hindre ny vindkraftutbygging. E24 [Internet] 2022-10-05. NTNU
7. **Korpås, Magnus.** Vindkraftbygging ebbet ut – kunne gitt strømprisfall. E24 [Internet] 2022-08-14. NTNU
8. **Tande, John Olav Giæver.** EERA 2022 Deep Wind conference – event roundup. PowerTechnology [Business/trade/industry journal] 2022-01-24. ENERGISINT
9. **Tande, John Olav Giæver.** First offshore wind power sites auctioned off California's coast. One day it could power 1.5M homes.. EL Sol [Newspaper] 2022-12-08. ENERGISINT
10. **Tande, John Olav Giæver.** First offshore wind power sites auctioned off California's coast. One day it could power 1.5M homes.. Daily magazine [Newspaper] 2022-12-10. ENERGISINT
11. **Tande, John Olav Giæver.** First offshore wind power sites auctioned off California's coast. One day it could power 1.5M homes.. USA TODAY [Newspaper] 2022-12-08. ENERGISINT
12. **Tande, John Olav Giæver.** Flytende havvind. TU [Business/trade/industry journal] 2022-08-23. ENERGISINT
13. **Tande, John Olav Giæver.** Forsker: - Vi hadde ikke hatt kraftkrise nå dersom vi hadde startet med havvind for ti år siden. Adresseavisen [Newspaper] 2022-01-31. ENERGISINT
14. **Tande, John Olav Giæver.** Global Offshore Wind Conference Showcases Best and Latest Research. TDAmeritrade [Business/trade/industry journal] 2022-01-11. ENERGISINT
15. **Tande, John Olav Giæver.** Global Offshore Wind Conference Showcases Best and Latest Research. Benzinga [Internet] 2022-01-11. ENERGISINT
16. **Tande, John Olav Giæver.** Global Offshore Wind Conference Showcases Best and Latest Research. Street Insider [Internet] 2022-01-11. ENERGISINT
17. **Tande, John Olav Giæver.** Global Offshore Wind Conference Showcases Best and Latest Research. AEVFN [Internet] 2022-01-11. ENERGISINT

18. **Tande, John Olav Giæver.**
Global Offshore Wind Conference Showcases Best and Latest Research. MarketScreener [Internet] 2022-01-11. ENERGISINT
19. **Tande, John Olav Giæver.**
Global Offshore Wind Conference Showcases Best and Latest Research. Investigate [Internet] 2022-01-11. ENERGISINT
20. **Tande, John Olav Giæver.**
Global Offshore Wind Conference Showcases Best and Latest Research. Yahoo finance [Internet] 2022-01-11. ENERGISINT
21. **Tande, John Olav Giæver.**
Global Offshore Wind Conference Showcases Best and Latest Research. Yahoo [Internet] 2022-01-11. ENERGISINT
22. **Tande, John Olav Giæver.**
Havvind. tv2 nyheter [TV] 2022-03-31. ENERGISINT
23. **Tande, John Olav Giæver.**
Havvind er i vinden, men konsekvensene for fiskeri er ikke med i diskusjonen. Fiskeribladet [Newspaper] 2022-01-17. ENERGISINT
24. **Tande, John Olav Giæver.**
Havvind-somling kan velte klimamålet. E24 [Newspaper] 2022-11-14. ENERGISINT
25. **Tande, John Olav Giæver.**
Havvind-somling kan velte klimamålet. Bergens Tidende [Newspaper] 2022-11-14. ENERGISINT
26. **Tande, John Olav Giæver.**
Internasjonal konferanse skal vise fram det fremste og nyeste innen havvindforskning. Elektronikknett [Business/trade/industry journal] 2022-01-12. ENERGISINT
27. **Tande, John Olav Giæver.**
Kan revolusjonere havvindindustrien: Vil bygge flytende vindturbiner med effekt på 40 MW. TU [Business/trade/industry journal] 2022-09-08. ENERGISINT
28. **Tande, John Olav Giæver.**
Kollisjon mellom fugler og vindmøller oppfinnelsen fra Sintef kan forhindre masse død av fugl. TV2 Nyhetskanalen [TV] 2022-06-20 ENERGISINT
29. **Tande, John Olav Giæver.**
Mangel på arbeidskraft, stål og sement er blant de største utfordringene for havvind. Kystens Næringsliv [Business/trade/industry journal] 2022-12-19. ENERGISINT
30. **Tande, John Olav Giæver.**
Massive wind turbines are coming to a coast near you. Will Biden's 'audacious' goal pay off?. NewsBreak [Newspaper] 2022-09-20 ENERGISINT
31. **Tande, John Olav Giæver.**
Massive wind turbines are coming to a coast near you. Will Biden's 'audacious' goal pay off?. yAHOO SPORTS [Internet] 2022-09-21 ENERGISINT
32. **Tande, John Olav Giæver.**
Massive wind turbines are coming to a coast near you. Will Biden's 'audacious' goal pay off?. DailyMagazine News [Newspaper] 2022-09-20. ENERGISINT
33. **Tande, John Olav Giæver.**
Massive wind turbines are coming to a coast near you. Will Biden's 'audacious' goal pay off?. USA TODAY NEWS [Newspaper] 2022-09-20. ENERGISINT
34. **Tande, John Olav Giæver.**
Mener havvind kan elektrifisere norsk sokkel før 2030. Adresseavisen [Newspaper] 2022-04-01. ENERGISINT
35. **Tande, John Olav Giæver.**
Nei, vindturbiner produserer ikke strøm bare 4 av 12 måneder i året. Faktisk.no [Business/trade/industry journal] 2022-06-09 ENERGISINT
36. **Tande, John Olav Giæver.**
Norge blir ikke med på historisk havvindsatsing i Nordsjøen. E24 [Newspaper] 2022-05-19. ENERGISINT
37. **Tande, John Olav Giæver.**
Norge sier nei til stort samarbeid i Nordsjøen. Bergens Tidende [Newspaper] 2022-05-22. ENERGISINT
38. **Tande, John Olav Giæver.**
Norwegian politics, Trygve Slagsvold Vedum. Archynewsy [Newspaper] 2022-05-25. ENERGISINT
39. **Tande, John Olav Giæver.**
NTNU Energy Transition Podcast #15. NTNU 2022 . ENERGISINT
40. **Tande, John Olav Giæver.**
Ocean Space Center utsettes: – Fikk kaffen i vrangstrupen. E24 [Business/trade/industry journal] 2022-05-14. ENERGISINT
41. **Tande, John Olav Giæver.**
'Offshore wind could supply 18 times the world's electricity demand from 2019'. future Net Zero [Business/trade/industry journal] 2022-02-16. ENERGISINT
42. **Tande, John Olav Giæver.**
Om noen år kan norsk havvindindustri få høyere eksportverdi enn sjømat. Fiskeribladet [Business/trade/industry journal] 2022-04-05. ENERGISINT
43. **Tande, John Olav Giæver.**
Pacific Coast offshore wind auction nets $757M in California. Pehal News [Newspaper] 2022-12-11. ENERGISINT
44. **Tande, John Olav Giæver.**
Rekordantall deltakere på den 20. globale havvindkonferansen. Energi Aktuelt [Business/trade/industry journal] 2022-12-22 ENERGISINT
45. **Tande, John Olav Giæver.**
Sintef-forsker mener havvind kan elektrifisere før 2030. NRK [Internet] 2022-03-31. ENERGISINT
46. **Tande, John Olav Giæver.**
Sintef-forsker mener havvind kan elektrifisere norsk sokkel før 2030. Varden [Newspaper] 2022-04-01. ENERGISINT

47. **Tande, John Olav Giæver.**
Sintef-forsker mener havvind kan elektrifisere norsk sokkel før 2030. Nationen [Newspaper] 2022-03-31. ENERGISINT
48. **Tande, John Olav Giæver.**
Sintef-forsker mener havvind kan elektrifisere norsk sokkel før 2030. Nettavisen [Newspaper] 2022-03-31. ENERGISINT
49. **Tande, John Olav Giæver.**
Sintef-forsker mener havvind kan elektrifisere norsk sokkel før 2030. Byggeindustrien [Business/trade/industry journal] 2022-03-31. ENERGISINT
50. **Tande, John Olav Giæver.**
Sintef-forsker mener havvind kan elektrifisere norsk sokkel før 2030. MN24 [Newspaper] 2022-03-31. ENERGISINT
51. **Tande, John Olav Giæver.**
Sintef-forsker mener havvind kan elektrifisere norsk sokkel før 2030. abc nyheter [Newspaper] 2022-03-31. ENERGISINT
52. **Tande, John Olav Giæver.**
Sintef-forsker mener havvind kan elektrifisere norsk sokkel før 2030. Dagsavisen [Newspaper] 2022-03-31. ENERGISINT
53. **Tande, John Olav Giæver.**
Sintef-forsker mener havvind kan elektrifisere norsk sokkel før 2030. Brønnøysund avis [Newspaper] 2022-03-31. ENERGISINT
54. **Tande, John Olav Giæver.**
Sjefforsker: Fornøyd med regjeringens havvindsatsing. Radio Nordkapp [Internet] 2022-05-11. ENERGISINT
55. **Tande, John Olav Giæver.**
Skal vise frem det nyeste innen havvindforskning. Ytringen [Newspaper] 2022-01-13. ENERGISINT
56. **Tande, John Olav Giæver.**
Skyhøye kraftpriser kan gjøre havvind lønnsomt. E24 [Newspaper] 2022-08-03. ENERGISINT
57. **Tande, John Olav Giæver.**
Slik kan norsk havvind avhjelpe europeisk kraftkrise. TU [Business/trade/industry journal] 2022-12-19. ENERGISINT
58. **Tande, John Olav Giæver.**
Slik skal forskerne hindre at fugl kolliderer med vindturbiner. tv2 nyheter [Newspaper] 2022-06-30. ENERGISINT
59. **Tande, John Olav Giæver.**
SSINTEF: Global Offshore Wind Conference Showcases Best and Latest ResearchINTEF: Global Offshore Wind Conference Showcases Best and Latest Research. FinanzNachrichten [Business/trade/industry journal] 2022-01-11. ENERGISINT
60. **Tande, John Olav Giæver.**
Statsministeren: – Det kan bli 1500 havvindmøller i løpet av de neste 20 årene. Avisen agder [Newspaper] 2022-05-11. ENERGISINT
61. **Tande, John Olav Giæver.**
Svensk vindkraft presser ned energiprisen med 35 øre per kWh. TU [Business/trade/industry journal] 2022-12-02. ENERGISINT
62. **Tande, John Olav Giæver.**
Tror på havvind før 2030. Klassekampen [Newspaper] 2022-03-31 ENERGISINT
63. **Tande, John Olav Giæver.**
Trur sokkelen kan elektrifiserast før. Nett.no [Internet] 2022-03-31. ENERGISINT
64. **Tande, John Olav Giæver.**
Utsetter omstridte hybridkabler. Adresseavisen [Newspaper] 2022-02-09. ENERGISINT
65. **Tande, John Olav Giæver.**
Venstrepolitiker: — Man kan ikke lage en fortelling om at forskning er jåleri og at man svir av milliarder helt ukritisk. Khrono [Newspaper] 2022-05-24. ENERGISINT
66. **Tande, John Olav Giæver; Svendsen, Harald Georg.**
Fersk vindanalyse er godt nytt for havvindutbygginga. Sunnmørsposten [Newspaper] 2022-11-29. ENERGISINT
67. **Tande, John Olav Giæver; Svendsen, Harald Georg.**
Sjekk kart: 29 år med vind-data viser hvor det er best å bygge havvindparker langs kysten. Kystens Nærligsliv [Newspaper] 2022-11-30. ENERGISINT
68. **Tomasgard, Asgeir; Korpås, Magnus; Hustad, Johan Einar.**
Sol- og vindkraft er helt avgjørende for at vi skal kunne nå klimamålene. Aftenposten [Newspaper] 2022-06-13. NTNU

Norwegian Centre for
Environment-friendly
Energy Research

www.northwindresearch.no