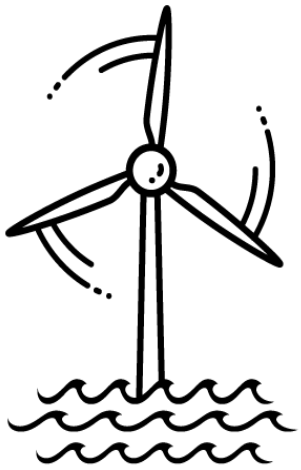
BERGEN OFFSHORE WIND CENTRE (BOW) ANNUAL REPORT 2021

UNIVERSITY OF BERGEN

BOW – our vision and mission



BOW's vision:

Provide new knowledge for sustainable development of offshore wind energy

BOW's mission:

To be a resource centre contributing research and education at a high international level.

We address aspects related to resources, environment and technical solutions, as well as legal, economic and social aspects of offshore wind energy. We provide professional support and advice to the industry, authorities and society at large, as well as mobilizing and making UiB's multi-disciplinary competence more visible.

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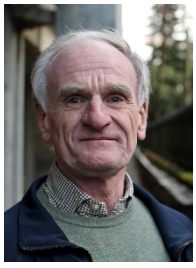


Foreword

In 2021 the goals for offshore wind energy production in EU's Green Deal have been more clearly defined. The EU expects a massive upscaling of offshore wind energy, from 12 GW in 2019 to 300 GW in 2050, the UK not included. In addition, the UK have great ambitions on its own and outside Europe we observe that USA and several Asian countries, in particular China, Japan and South-Korea, also have ambitious plans for offshore wind development.

These great ambitions confirm that the cross-disciplinary approach of BOW is important, and the research and educational activities must be intensified. To succeed with such a great upscaling a focus on wind turbine technology alone is not sufficient. Characterization of the wind field up to 300 m above sea level becomes essential, as well as understanding of the interaction between the wind turbines and adjacent wind farms. Furthermore, our knowledge of the impact on marine life within a wind farm must be improved. What is the impact of, for instance, the operational noise, the reef effect, and trawl free areas? The impact on marine life and interaction effects between wind farms also poses several legal challenges. Do we have a suitable legal framework for the projected scale-up of offshore wind energy? These are among the topics BOW are addressing. You can read more about them in this report.

In 2021 we have strengthened our research staff with both permanent personnel and postdoc. and PhD candidates. Our new Associate Professor, Cristian Gebhardt represents new and important competence to BOW. You will find more about him and his visions in the section where we introduce new staff.

We have been awarded several new projects in 2021, ranging from wind field - structure interaction, via decommissioning to competence building in industry. We are now seeing the benefits of our multidisciplinary competence to the challenges of offshore wind energy.

Despite the challenges related to the Corona pandemic, we have actively disseminated our results, both through scientific publications, conference presentations and in the media and public debates. We now see the results from a long-term focus on being visible in the public domain: we are frequently consulted to provide input to strategies and plans as well as providing our insight to politicians. We try to do this with our vision "Provide new knowledge for sustainable development of offshore wind energy" in mind.

In this year's report you can also read about the industrial perspectives by Jan Fredrik Stadaas, member of our Scientific Advisory Committee (SAC). How can we learn from the past in moving forward? He discusses the interaction between technology and legal framework as well as the environmental impact and coexistence with other users of the sea.

Associate Professor at the Law Faculty, Ignacio Herrera Anchustegui reflects about "2021 – the missed year" and status of the legal framework. He writes about missing details of the present regulatory framework, and the expectations for 2022.

Pleasant reading!

Finn Gunnar Nielsen, Director of Bergen Offshore Wind Centre (BOW)

Offshore wind: learn from the past – prepare for the future

Jan-Fredrik Stadaas, Corporate Strategy Manager Equinor
Member of BOW's scientific advisory committee

Offshore wind is on everyone's lips these days: Huge interest by the media, discussed by politicians, attractive for investors and increased interest from the public. All this triggers a lot of questions in terms of what offshore wind can offer, where should it be built, what impact it will it have on the energy market but also physically in our surroundings. Looking back in history, there has always been uncertainty when new technologies have become an integral part of our society and lives. Typical past examples are the introduction of cars, electrical infrastructure, the railroad, as well as more recent ones such as the internet, district heating and aquaculture. They have all come with consequences, change, and opportunities. So then, what about offshore wind – what should we expect, how should we work to take full advantage of the new energy offering/technology while reducing potential negative impacts? I don't have all the answers to these questions but will elaborate a bit on what we have learned over the last decade and shed some light on what we should expect in the coming years.

Having worked with offshore wind internationally the last 10 years in the UK, Europe, and Asia, I have learned how technology, regulatory systems and markets have worked together to develop a new industry. Starting with small turbines and small wind farms in shallow waters based on technology and solutions inherited for other industries, offshore wind has grown into a global industry. It has developed its own made products, standards, and methods suitable for the marine environment and established efficient supply chains. Typically, a wind turbine has tripled in size, as has the wind farms delivering electricity to millions. The yield, the installation time and operational efficiency have been optimized, resulting in a drop in cost of electricity of more than 60% in less than 10 years. Another huge impact on the business has been the reduction of risk associated with the industry. The risk level has dropped significantly, allowing for low-cost capital and reasonable insurance cost to be available for offshore wind investments. Another important element that should be mentioned is the regulatory changes. In the early days, the regulatory system gave the developers a high degree of freedom due to unclear rules and regulations. This has changed dramatically, and the regulators have become much more professional and confident about how to develop the sector. During this period of almost 15 years, the industry installed around 30 GW of offshore wind. A key question now is what will happen the next decade when this number increases to about 200 GW?

First of all, I think the industrialization of offshore wind will continue driving the cost down even lower making it even more competitive to alternatives and opening up new markets.

Secondly, we will see more global supply chains emerge on key components, taking advantage of scale production. On the other hand, local content and value-creation will also play an increasing role. The public, regulators and politicians will demand local jobs, industrial development, and infrastructure investments which will drive local partnerships and need for local presence by the developers.

Thirdly, I foresee an increased focus on sustainable growth taking in the impact offshore wind will have on the energy system, the local environment and need for coexistence with other users of the sea. This will come with policy, law, regulations & planning and will have a

huge impact on the freedom to operate, the value creation potential and the need for cooperation.

Lastly, I think we will see an increasing demand for a closer integration with the energy system to handle the volatile and unpredictable nature of offshore wind electricity production. How this will be solved is still unclear and we might see many different solutions. All in all, this development will trigger the need for further research, piloting and validation carried out in cooperation between academia, developers, supply chains, regulators, and policy makers. If we, by working together, find sustainable solutions that stand the test of time, there will be a great future for offshore wind's role in the energy transition, making energy affordable, sustainable, and reliable for all.

Jan-Fredrik Stadaas presenting at the Science Meets Industry conference in the University Aula. © Kjersti Boge Christensen

A year in review: Where is the legal framework standing for offshore wind in Norway after 2021?


© André Kvalvågnes

Ignacio Herrera Anchustegui – Associate Professor, Faculty of Law (UiB)
Member of Bergen Offshore Wind Centre

Full speed ahead? - 2020 created great expectations in the offshore wind community. Most of us assumed that this was the year that kickstarted, for real, the rapid development of offshore wind in Norway. The year began with the approval and construction of Hywind Tampen,[1] and its state aid funding.[2] This was revolutionary for engineering – electrifying oil and gas fields directly – as well as in law as an alternative in the energy transition.[3] Hywind Tampen was authorized not as an offshore wind farm project but as a modification to an oil and gas license.

Further, the Solberg government announced in June 2020 that two areas were to be opened for a license to develop wind projects starting 1 January 2021.[4] These are Utsira Nord and Sørlige Nordsjø II; the first one is outside the coast of Haugesund, and the second one is right at the border to Denmark in the Norwegian Exclusive Economic Zone. This announcement came with a legal addition: the Government adopted the Regulation to the Offshore Energy Act, also entering into force 1 January 2021.[5] Shortly after, everyone was ready for the first of

[1] EFTA Surveillance Authority, ESA greenlights aid to floating offshore wind farm (11 March 2020): https://www.eftasurv.int/newsroom/updates/esa-greenlights-aid-floating-offshore-wind-farm

[2] Herrera Anchustegui, Ignacio, "Is Hywind Tampen's State Aid Approval a Kickstart for the Norwegian Offshore Wind Industry?", European State Aid Law Quarterly, Volume 19 (2020), Issue 2, p. 225-231, Available at SSRN: https://ssrn.com/abstract=3646956.

[3] Herrera Anchustegui, Ignacio and Glapiak, Aleksander, Wind of Change: A Scandinavian Perspective on Energy Transition and the 'Greenification' of the Oil and Gas Sector (April 19, 2021). Available at SSRN: https://ssrn.com/abstract=3829455.

[4] Regjeringen, Opner områder for havvind i Noreg (16 June 2020), https://www.regjeringen.no/no/dokumentarkiv/regjeringen-solberg/aktuelt-regjeringen-solberg/oed/pressemeldinger/2020/opner-omrader/id2705986/

[5] Forskrift til havenergilova (havenergilovforskrifta), FOR-2020-06-12-1192.

January 2021. Not to celebrate the new year, but to read the different license applications submitted for Utsira Nord and Sørlige Nordsjø II.

A much-needed piece of regulation, but a missed opportunity? – Among the legal community, there was no doubt about the need for complementing the Offshore Energy Act of 2010 ("OEA").[6] The OEA is a framework regulation with few details. It is a starting point towards licensing sea areas in Norway's Economic Exclusive Zone and its Territorial Sea beyond the baselines. However, its content is rather thin.

Not surprisingly, as nothing else was in place leading to a regulatory vacuum, no projects proposals were submitted in 2021. As I have said elsewhere, "ingen juss, ingen havvind".[7] Further guidance on how to conduct the licensing process was much needed.

The Regulation to the OEA that entered into force in 2021 could have been the solution. However, while it has undoubtedly improved the status quo, it is insufficient to set things in motion. The Regulation builds upon the structure of the equivalent instrument for energy licenses in Norway, especially the regimes of offshore oil and gas fields and onshore wind farms. Most of its content is directed towards describing and setting parameters related to the licensing process. Yet, despite progress, it is still insufficient.

A new turn of tides? Energi til arbeid and the Notice – One year after the opening of areas, in June 2021, the Solberg Government issued the Energy White Paper "Energi til arbeid".[8] This policy instrument set forward the energy development priorities for Norway for the decade to come. In it, offshore wind had an important role – unsurprisingly so. It was named as an important factor towards the electrification of Norway and as a vehicle to develop renewable energy through a new industrial sector in the country.[9] The White Paper highlighted four major issues: i) Norway has a significant potential for offshore wind electricity production; ii) offshore wind may be an engine for national industrial development; iii) projects ought to be built with little or no government support (subsidies); and iv) regulatory barriers were still not addressed.

Along with the White Paper, a "Guidance Notice" was announced and opened to comments from all interested stakeholders.[10] The Notice developed in extenso the rules connected to the licensing process for offshore wind in Norway. This non-binding proposal shifted the focus of the licensing, moving from a more developer-led project towards a more government-controlled regime. It described in major but still insufficient detail, in my view, different options to conduct the licensing selection. Either through energy auctions (where the price of electricity produced was the main deciding factor) or based on the quality of the project/licensees. Which system to use is left entirely to the discretion of the government. The Notice also opens the possibility of dividing a licensing area into sub-zones.

Too slow, too complex, and no one happy? Shortly after, the legal community commented on the Notice. The Oil and Energy Ministry received almost a hundred replies. Nearly all of them stressed the very lengthy, cumbersome, and complex process that the Regulation and the Notice would create. Estimates vary, but a wind farm would be constructed between 7 to 10 years after the start of the licensing process.. If all goes according to plan. The reactions

[6] Lov om fornybar energiproduksjon til havs (havenergilova), LOV-2010-06-04-21.

[7] Juristen, – Ingen juss, ingen havvind – Interview with Ignacio Herrera Anchustegui: https://juristen.no/nyheter/2021/02/%E2%80%93-ingen-juss-ingen-havvind. This translates roughly to: «no law, no offshore wind».

[8] Olje og Energidepartement, Energi til arbeid – langsiktig verdiskaping fra norske energiressurser, (Meld. St. 36 (2020-2021).

[9] Energi til arbeid – langsiktig verdiskaping fra norske energiressurser, p. 84 to 103.

[10] Regjeringen, Høring - Veileder for arealtildeling, konsesjonsprosess og søknader for vindkraft til havs, og forslag til endringer i havenergilova og havenergilovforskrifta (11 June 2021), https://www.regjeringen.no/no/dokumenter/horing-veileder-for-arealtildeling-konsesjonsprosess-og-soknader-for-vindkraft-til-havs-og-forslag-til-endringer-i-havenergilova-og-havenergilovforskrifta/id2860575/

have made the Ministry reconsider aspects of the Notice, delaying its adoption, even though it was expected to have done so before or in December 2021.

The red-green coalition and the cables – A governmental change seems to have shifted the energy priorities in Norway. In the Støre Government, much of the offshore wind discussion has been linked to 'hybrid projects': parks connected to the Norwegian grid and export power. Parts of the governing coalition and its Parliamentary allies are against the concession of permits for new export cables.[11] This opposition has been exacerbated because of the rise in electricity prices. If anything, debate and uncertainty have increased in the past months, and not a single license application has been submitted after the government shift.

Way forward? With 2021 going amiss, will 2022 be the year for offshore wind in Norway? This is the question that floats the air as well as public discussion. Everyone expects a response from the Ministry concerning the Notice and whether changes to shorten/simplify the process will be taken. In the meantime, it seems that much will be decided during the Spring. Further delays, however, are the source of concern among the industry, politicians, and even us in academia.[12] Political indecisions, a vague regulatory framework, and controversy over the use of power have offshore wind, for the time being, flowing low in Norway.

Off-the-radar fly other regulatory and legal research challenges not openly discussed in 2021. The Norwegian offshore wind story exemplifies how regulatory solutions lag far behind technological changes. Could this experience serve us to promote novel ways to create a more parallel development between law and technology in Norway? Additionally, the controversy and lack of governance instruments we have had in offshore wind are a good starting point to reflect on the need for comprehensive, flexible, and holistic governance frameworks balancing the tradeoffs brought by offshore wind. More research and cooperation are needed. May 2022 be a good year for this too.

A hybrid meeting at UiB when the White paper was launched © Ragnhild H Nyheim

[11] Aftenposten, SV åpner for hybridkabler. Sp sier blankt nei. I vår må de finne en løsning (8 January 2022), https://www.aftenposten.no/norge/politikk/i/dnprLw/sv-aapner-for-hybridkabler-sp-sier-blankt-nei-i-vaar-maa-de-finne-en-loe

[12] Finn Gunnar Nielsen and Ida Marie Solbrekke, Norge kan bli utkonkurrert (Dagbladet, 12 January 2022).

Summary of 2021

BOW's multidisciplinary approach within offshore wind energy has continued in full strength in 2021. The COVID-19 pandemic has haltered some of the outreach activities as well as delayed some project activities, but recruitment of new staff has continued according to plan. The multidisciplinary profile has gained attention, also at an international level. The connection between science and law has earned particular interest. If offshore wind will get the dominating status within the European electricity supply that The International Energy Agency (IEA), among others, assume, we think this is the right way to go. One needs to take a comprehensive approach in terms of planning and development. This involves understanding wind resources, technology, environmental aspects and having a proper legal framework.

Projects

Some of the projects in 2021 are:

Large Offshore Wind Turbines (LOWT). Structured design accounting for non-neutral wind conditions

PI at BOW: Joachim Reuder Joachim.reuder@uib.no

Funded with 12MNOK via the NFR FRIPRO program

© Kristin Guldbrandsen Frøysa

The aim of this project is to gain knowledge and develop models to improve the design for large floating offshore wind turbines (>12MW). Standards for design of wind turbines are developed based on the assumption that the atmosphere is neutral. However, during the winter the atmosphere above the sea surface is often unstable when the air is colder than the sea. The atmosphere is, however, often stable in the summer when the air is warmer than the sea. A stable, neutral, or unstable atmosphere has an impact on how the wind changes according to the altitude above the sea surface. To design cost efficient large floating offshore wind turbines, it is important to have appropriate models for the wind profiles above the ocean. Effective wind and turbulence models are also essential for cost efficient designs of larger floating wind farms.

Data-Driven Methodologies in Offshore Wind Energy

PI at BOW: Cristian Guillermo Gebhardt Cristian.Gebhardt@uib.no

The research activities related to this project pursue digitalization as an innovative tool in the field of offshore wind energy research. Special emphasis is set but is not limited to fluid-induced loads due to wind fields and ocean waves as well as dynamics by means of the of the data-

driven computational mechanics. The duration of the project is from 2022 to 2025: 1 postdoc position over 4 years funded by GFI

PRE-DÉCOR PI at BOW Ignacio Herrera Anchustegui Ignacio.Herrera-Anchustegui@uib.no In 2021 this project was financed by the NFR (325,000 NOK). This little project on the importance of understanding the realities of decommissioning offshore structures had lots of activity. The end result was a large interdisciplinary report on the law and economics of decommissioning in the North Sea, freely available here: https://ssrn.com/abstract=3882821. Our project findings were presented in many fora in and out of Norway and this project has served as a launching pad for other initiatives related to decommissioning and repowering of offshore energy structures.

Personnel

In 2021 BOW has strengthened its staff. Worthy of mention is the hiring of associate professor Cristian Gebhardt who is enhancing BOW's competence in terms of dynamic analysis of wind turbines. For a more in-depth presentation on Cristian Gebhardt and his vision for BOW, please see below.

Thanks to the support of the AkademiaAvtalen we obtained funding (800,000 NOK) to hire as Prof. II the world-known expert, **Prof. Leigh Hancher**. Leigh is now affiliated with the Faculty of Law at UiB and with her expertise in the field of energy law she will boost our ability to produce high quality research and develop a network. Already this collaboration has given some fruits with an upcoming Handbook on Energy and Competition Law to be edited by Prof. Hancher and Ass. Prof. Herrera Anchustegui and to be published in 2023 by Elgar.

The affiliated personnel of BOW constitute of 22 professors/associate professors, 8 researchers/postdoctoral fellows, 4 Adjunct professors, 14 PhD students and 1 administrative position.

Table 1: BOW scientific affiliated personnel. GFI: Geophysical Institute, PHYS: Physics and Technology, BIO: Biology, GEO: Earth Science, SOC SC: Social Sciences and Geography.

	GFI	PHYS	INF	BIO	GEO	SOC SC	LAW	SUM
Prof. / Assoc. Prof.	6	1	3	1	3	2	3	**19**
Researchers/ post docs	6	1		1				**8**
PhD students	10	1			1	1	1	**14**
SUM	**22**	**3**	**3**	**2**	**4**	**3**	**4**	**41**

Publications and dissemination work

BOW has had several publications and presentations in 2021. We had fewer publications than in 2020, but more presentations at conferences.

Table 2: Publications in 2021 by category. Details are given in Appendix B.

Publication category	Number
Peer reviewed research articles	11
Chapters in books	3
Reports	3
Poster presentations	7
Conferences, oral presentations	30
Popular presentations	6
Debate contributions (News)	9

BOW has contributed to several reports in 2021, where one of them is on offshore Hydrogen production in Sørlige Nordsjø II This report discusses the current situation in terms of offshore wind and hydrogen production in Norway and Europe, in addition to addressing the legal framework in Norway.

BOW and people affiliated with BOW have received recognition in terms of awards in 2021. Cristian Gebhardt received the Heisenberg Award from the German Research Foundation, and at the EERA DeepWind conference in January BOW received the Poster Award with The potential of synthetic turbulence in large eddy simulation during stable conditions over ocean wind farms

In June 2021 the Norwegian government launched the White Paper "Energi til arbeid", which is a long term policy for energy development and employment in Norway. Offshore wind was highly emphasized in this report and there was a hybrid meeting at UiB in connection with the launch of the report.

As a follow up to this White Paper, BOW had a meeting with the politician Ruth Grung in August. At that point Ruth Grung was an MP in the energy and environment committee in the Norwegian parliament. Licenses, auctions, EEA-regulations, and decommissioning were some of the topics that were discussed.

Representatives from BOW meeting MP Ruth Grung © Ragnhild H Nyheim

Although there were many digital conferences and webinars in 2021, there were also some “on site” conferences, presented by a selected few here:

September 14th and 15th **The Ocean** Conference took place in Grieghallen in Bergen. BOW’s Finn Gunnar Nielsen had a presentation on Norwegian ocean based renewable energy and seabed minerals.

Finn Gunnar Nielsen at The Ocean conference © Kai Stoltz

BOW was heavily present at the **OTD Energy** conference in Stavanger in October with a stand that was shared with UiS and NORCE, presentations by Ignacio Herrera Anchustegui and Etienne Cheynet, and pitches by PhD candidates Ida Marie Solbrekke, Hannah Elizabeth Petrie and Mauro Ghirardelli.

BOW shared a stand together with UiS and NORCE at OTD Energy 2021 © Henrik Moksnes

November 10th BOW, GCE Ocean Technology and NORCE arranged the offshore wind conference **Science Meets Industry** in the University Aula at University of Bergen. The conference was opened by BOW's Finn Gunnar Nielsen who welcomed "friends of the wind". There were presentations by representatives from industry as well as academia. BOW's Professor Joachim Reuder and PhD student Ida Marie Solbrekke presented their research on drones, and wind map data respectively. The conference was finalized with a panel discussion on the legal challenges in offshore wind, which was moderated by PhD student Eirik Finserås, and Professor Sigrid E Schütz was one of the participants.

Discussion on legal frameworks in offshore wind at Science Meets Industry © Ragnhild H Nyheim

Education

There have only been three MSc-dissertations handed in at the Energy Masters level in 2023. The reason for this is that the largest classes of the integrated five-year Energy Master have not started their Masters. Similarly, there have not been any PhD dissertations in 2021, but several candidates are getting closer to their dissertation date.

The civil engineering Master in Energy had more than 50 students in the most recent classes and last year the students had internships in organizations in Bergen and the surrounding areas.

Education in offshore wind regulation has been promoted actively in the study of Law. 54 students took the course of the Law of the Sea and its Uses in the Law Faculty, in which offshore energy was a central topic. Further, offshore wind matters will be once again discussed in early 2022 with a new subject Energy Law: Hydrocarbons, Renewables and Energy Markets, starting this January. There have been Five MScs-dissertations in law related to Offshore Wind

NORREN Summer School

BOW's Finn Gunnar Nielsen had a presentation on offshore wind at the NorRen Summer School on energy production and consumption. NorRen unites PhD candidates from various disciplines, providing them with new insights and creating the basis for future collaborations in renewable energy. It is a collaboration between UiB, NTNU and UiB and in 2021 it took place in Bjørnafjorden south of Bergen.

Research Activity

External funding for offshore wind related research activity amounted in 2021 to 8,8 mill NOK. This is lower than planned. However, we see that the activity is gaining speed in 2022. The key resources of funding are the Research Council of Norway (RCN) and the Academia agreement with Equinor.

Five research project applications where BOW was a key actor was submitted in 2021. Three of them have been granted, one is being reviewed, and one was rejected.

The application **ImpactWind Sørvest** in which BOW is an important partner, received generous funding from the NFR (total 55 million NOK). In this 6 year-project BOW will focus on continuing education geared towards the industry in addition to research on wind resources, operation, and maintenance. The law department will research on how to accelerate and optimize the granting of offshore wind licenses. Among other tasks, they will study the effect of one wind park on another nearby and the legal consequences derived therefrom, as well as seeking ways to optimize the repowering and decommissioning of wind parks and contribute actively to training of wind experts.

Committee activities

Christian Gebhardt has been an Associate Member of the Collaborative Research Centre 1463 Megastructures at Leibniz Universität Hannover since 2021 and chair (together with Jason Jonkman, Raimund Rolfes and Erik Lund) of the Mini-Symposium “Coupled Dynamics and Optimal Design” of the EAWE Wind Energy Science Conference at Leibniz Universität in Hannover.

SAC dialogue meeting

On November 11th BOW had a dialogue meeting with the Scientific Advisory Committee (SAC). Representatives from BOW gave an overall presentation of BOW, followed by a presentation of projects and a discussion on how these will be developed further. The committee came with strategic advice, where they specifically emphasized BOW’s unique multidisciplinary approach, in particular the unique connection between the natural sciences and law and stressed that this should be strengthened and developed further.

IEA

UiB (GFI and IFT) have been accepted as partners together with Equinor in the International Energy Agency (IEA) network project on Erosion of Blades https://www.iea.org/. Bodil Holst has agreed to be co-leader of WP5: Erosion Mechanics and material properties.

EERA

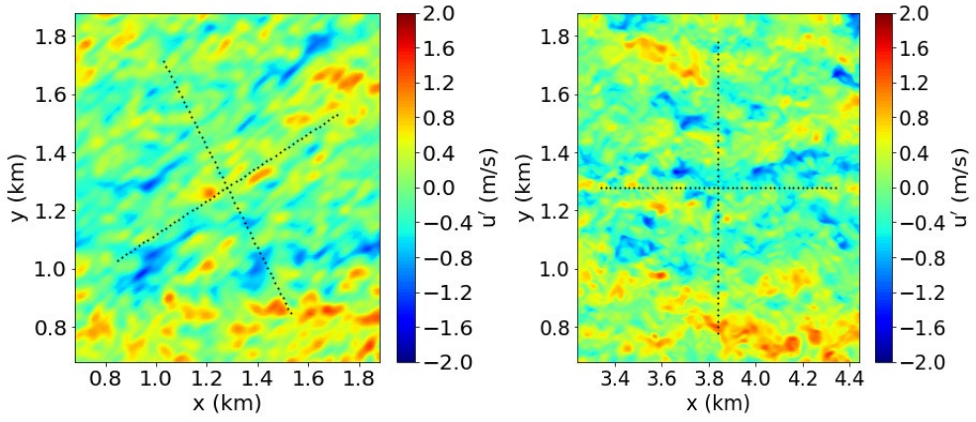
BOW has been represented on workshops and conferences, like EERA Deep Wind, by presentations and posters. Kristin Guldbrandsen Frøysa represents UiB in the EERA JP Wind Steering Committee.

Selected publications from 2021

Ignacio Herrera Anchustegui Ignacio.Herrera-Anchustegui@uib.no In **Distributive justice, community benefits and renewable energy: the case of offshore wind projects**,[1] I discuss the role, nature, and modalities of community benefits regarding offshore wind projects by using the North Sea as a case study. Community benefits are retributions/considerations given by project developers or the states to citizens that feel negatively affected by a wind farm (because it creates visual impact, noise, reduces the value of properties, or another type of nuisance, or impedes an activity they would have conducted otherwise, such as fishing). In this paper, I analyze how different countries adopt diverse approaches in a varied regulatory landscape and how new technological renewable energy solutions influence the benefits granted. I find that in most of the countries in the North Sea, there are both soft and hard law initiatives to increase community acceptance and decrease resistance, Norway being a notable but not positive exception. Benefits go from lump-sum payments, internships/scholarships, community funds, and even the right to co-own the facility. My study shows that despite wind farms are located further ashore, and sometimes are even invisible to the people living by the coast, community benefits are still granted as elements of energy justice and recognition of citizens' rights and expectations.

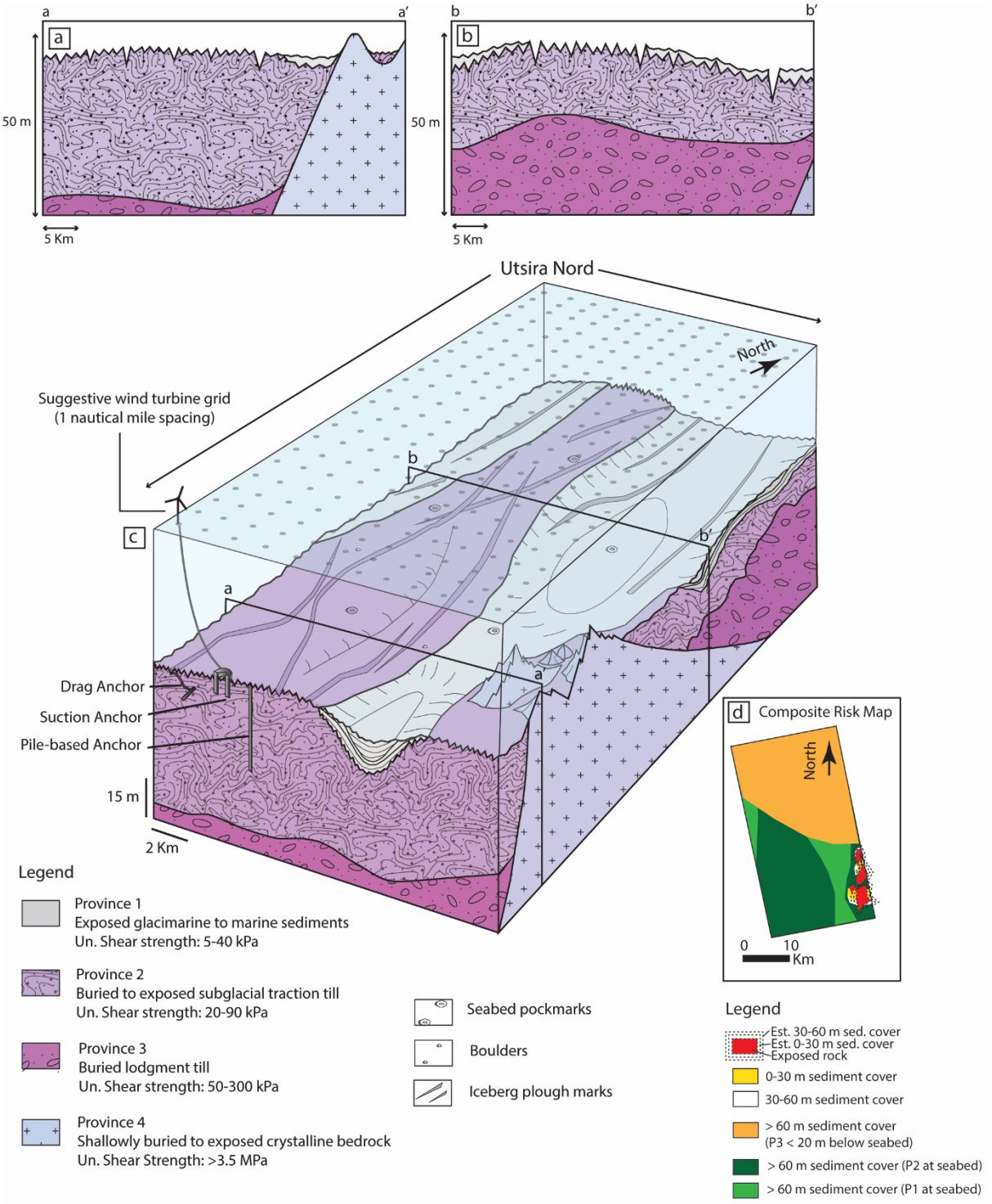
[1] Herrera Anchustegui, I. (2021). Distributive justice, community benefits and renewable energy: the case of offshore wind projects. In Fleming, Ruven, Huhta, Kaisa, Reins & Leonie (eds.). *Sustainable Energy Democracy and the Law* (Brill Publishers, 2021). A previous version of this chapter is freely available on: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3721147

XU Ning Xu.Ning@uib.no **Maria Krutova,** Maria.Krutova@uib.no, **and Mostafa Bakhoday Paskyabi** Mostafa.Bakhoday-Paskyabi@uib.no **Analysis of offshore wind spectra and coherence under neutral stability condition using the two LES models PALM and SOWFA** PALM and SOWFA are two of the most widely used large-eddy simulation tools in the community of wind energy. The aim of this work is to compare and investigate the features of these two models, which are based on different numerical schemes and discretization methods, in simulating the atmospheric boundary layer flows in neutral stability condition. The two models provided nearly identical profiles of wind speed, direction and turbulence intensity across the boundary layer and highly consistent estimates of the wind spectra and the coherence, showing good performance in resolving turbulent structures with a wide range of scales.



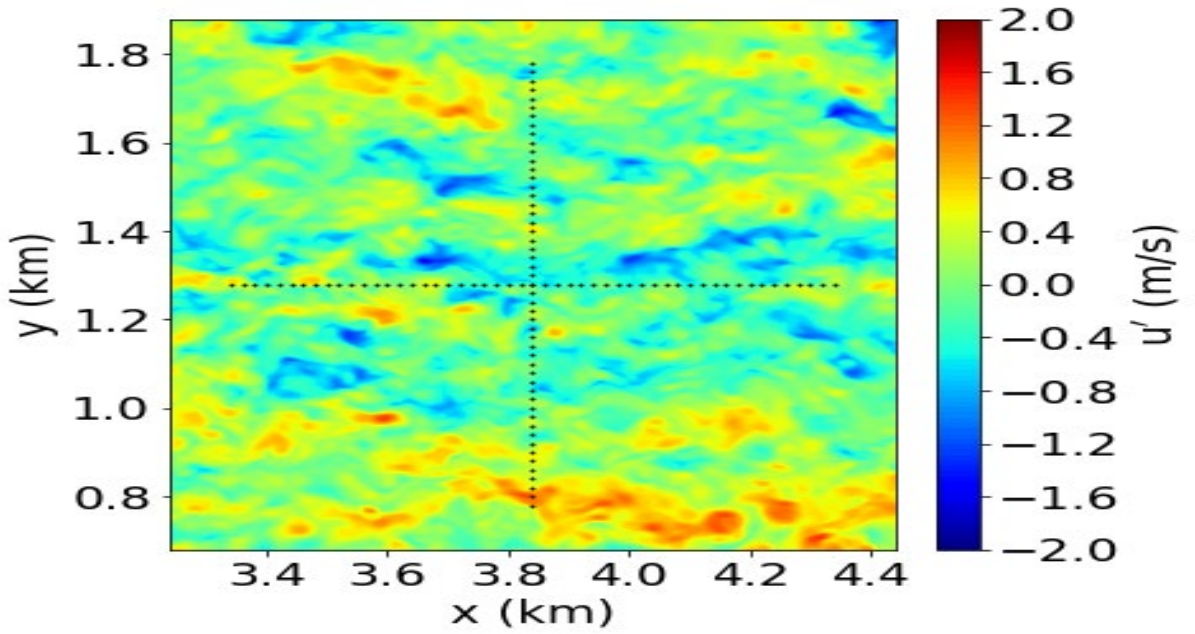
Snapshots of u-component fluctuating velocity at height of 100m from SOWFA and PALM.

Hannah E. Petrie Hannah.Petrie@uib.no, **Christian H. Eide** Christian.Eide@uib.no , **Haflidi Haflidason** Haflidi.Haflidason@uib.no **& Timothy Watton**, Equinor **A conceptual geological model for offshore wind sites in palaeo ice stream settings: The Utsira Nord site, North Sea (Extract from conclusions section of pre-print).** In this study, we demonstrate a method which can advance conventional “desktop studies” towards a more cross-disciplinary and powerful tool for understanding the key risks and uncertainties in the ground conditions at new offshore wind sites despite limited data availability. The conceptual geological model presented defines four main geotechnical provinces at the Utsira Nord floating offshore wind site: 1) exposed glacimarine to marine sediments suitable for suction-type anchors, 2) buried to exposed subglacial traction till suitable for suction-type anchors, 3) buried lodgment till with highly uncertain properties and likely boulders and 4) shallowly buried to exposed crystalline bedrock which will likely require a pile-based or novel anchoring solution of which approximately 10% of the site is estimated to comprise. The key provinces and their associated data acquisition requirements identified at Utsira Nord are of relevance to current and future offshore wind developments in other formerly glaciated marine areas such as the coastlines of Canada, the northern United States, the northern United Kingdom and the rest of the Norwegian coastline, particularly within paleo ice stream channels in these regions



Conceptual geological model for the Utsira Nord offshore wind site, based on geophysical and core data in the area.

Cheynet et al. Etienne.Cheynet@uib.no **The COTUR project: remote sensing of offshore turbulence for wind energy application**. The **COTUR** campaign explored the structure of wind turbulence above the ocean to improve the design of future multi-megawatt offshore wind turbines. Deploying scientific instruments offshore is both a financial and technological challenge. Therefore, lidar technology was used to remotely measure the wind above the ocean from instruments located on the seaside. The experimental setup is tailored to the study of the spatial correlation of wind gusts, which governs the wind loading on structures.



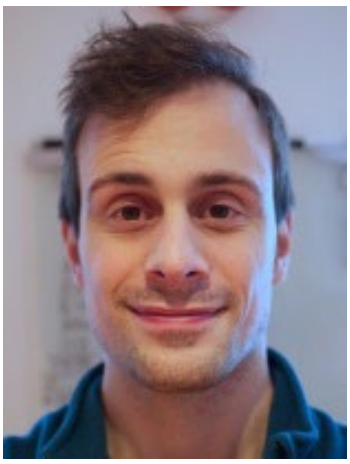
Along-beam velocity component recorded by two synchronized Lidar instruments (LidarW and LidarS) on 25-10-2019 from 13:35 to 14:25. The beams were nearly horizontal and aligned with the wind direction. The measurement location was above the ocean, 2 km away from the Norwegian coast and nearly 200 m above the sea surface. The correlation between these two time series can be measured and used to model the turbulent wind loading on an offshore wind turbine.

Meet our new researchers

Cristian Guillermo Gebhardt Cristian.Gebhardt@uib.no is Associate Professor for Offshore Wind Energy at GFI and Deputy Director of BOW since April 2021. He holds a diploma in mechanical and aeronautical engineering from *Instituto Universitario Aeronáutico* (2001-2005) and a doctoral degree in sciences of engineering from *Universidad Nacional de Córdoba* (2007-2012). In addition, he obtained his *Habilitation* for the field of statics and dynamics from *Leibniz Universität Hannover* (2015-2020). His research interests are quite broad ranging from applied mathematics to aeronautical, mechanical and civil engineering. The offshore wind energy represents the main application in his research portfolio, where he found a problem that is challenging enough to apply and to test the analytical and computational approaches he develops. Currently, he is working on theoretical foundations and computational procedures for data-driven computational mechanics. He expects, by adopting and further developing this new computing paradigm, to make possible capturing interactions among experimental data, that describe complex wind and/or sea states as well as material states, structure and fluids. He strongly believes that the resulting aero-hydro-elastic models based on this computing approach will take the analysis and design of offshore wind turbines to the next level.

Vision

At Bergen Offshore Wind Centre, we target at becoming a key player in the field of offshore wind energy at the local, national and international levels. Our approach to achieving such an ambitious goal relies on: carrying out outstanding and cross-disciplinary research; offering excellent and integrated education; and providing impartial and independent advice. In this way, we expect: bringing society, academia, industry and government around the table; facilitating the communication among all the stakeholders; identifying main issues and opportunities; bridging interests to enable multisectoral teamwork; training future professionals with a deep commitment; contributing to create feasible and perdurable solutions; and, co-designing a more environment- and people-friendly tomorrow. By doing so, we are going to make ourselves better known, to gain visibility and to further consolidate our still young, but fast-growing centre.



Mauro Ghirardelli mauro.ghirardelli@uib.no is a PhD student at GFI. He joined BOW in 2021. He has a BSc and a MSc in Physics from the Università Cattolica del Sacro Cuore, Brescia, Italy. Before moving to Bergen, he worked as a teaching assistant at Università degli Studi di Brescia - Faculty of Economics and Management. His work at BOW involves the development and test of an airborne measurement system consisting of a rotary blade UAV equipped with a sonic anemometer in order to investigate fine scale turbulence in offshore windfarms

Mohammadreza Penchah Mohammadreza.Penchah@uib.no is a postdoctoral research fellow at the GFI. He has a PhD in Meteorology. For his PhD, he studied planetary boundary layer simulations for wind resource assessment and used a coupled meso- and micro-scale modeling method to assess wind potential in his study area. Before moving to Bergen, he did some research on coupling atmosphere-ocean models for simulating wind filed over the sea and collaborated in preparing a mesoscale wind atlas of Iran. Here, his work is part of the HIPERWIND project, and he is working on accurate simulation of the atmospheric flow fields considering wave-wind interactions and data assimilation

Shokoufeh Malekhommadi Shokoufeh.Malekmohammadi@uib.no describes herself as a person who is obsessed with the clouds, wind and in general any sort of fluid motion in the atmosphere! She pursued her undergraduate studies in Aerospace Engineering and became more and more interested in fluid mechanics. As contributing to a green future was her personal goal, she decided to combine her interests and concerns and follow Renewable Energy Engineering focused on Wind Energy for her master's studies. Working on her master's thesis at EPFL university, she gained many skills in Wind Resource Assessment using Numerical Weather Prediction Models. And now she is just at the beginning of her journey as a PhD student continuing her research focused on the entrainment in the infinite size offshore wind farms using ship-based lidars. Her project aims to consider the effect of ship motion on the lidar measurements and compensate the corresponding induced error. She will investigate the turbulent vertical transport of kinetic energy entrained from the flow above into the wake of wind farm by measurement. She will have various measurement campaigns in different sites to provide a reliable dataset. For instance, she is joining the Nansen Legacy cruise towards the Arctic February 2022 to have a 20-day measurement campaign on the Norwegian Sea. She hopes to utilize her skills and knowledge from the past in the best way and is aware of the fact that there is still a lot to learn

Appendix A

Affiliated personnel 2021

Professors / associate professors:

- Finn Gunnar Nielsen (Geophysical Institute (GFI)), director
- Cristian Gebhardt (GFI), deputy director
- Joachim Reuder (GFI)
- Mostafa Bakhoday-Paskyabi (GFI)
- Nils Gunnar Kvamstø (GFI)
- Asgeir Sorteberg (GFI)
- Sigrid Eskeland Schütz (Faculty of Law (Law))
- Berte-Elen R. Konow (Law)
- Ignacio Herrera Anchustegui (Law)
- Dag Haugland (Department of Informatics (INF))
- Ahmad Hemmati (INF)
- Magne Haveraaen (INF)
- Haflidi Haflidason (Department of Earth Science (GEO))
- Christian Haug Eide (GEO)
- Tor Arne Johansen (GEO)
- Bodil Holst (Department of Physics and Technology (PHYS))
- Håvard Haarstad (Department of Geography (GEOG))
- Michael Robert Tatham (Dep. of Comparative Politics (COMP POL))
- Øystein Varpe (Department of Biological Sciences (BIO))

Researchers / Postdocs:

- Etienne Cheynet (GFI)
- Stephan Thomas Kral (GFI)
- Hai Bui (GFI)
- Mohammadreza Mohammadpour Penchah (GFI)
- Justas Zalieckas (PHYS)
- Dorothy Jane Dankel (BIO)

Adjunct professors / associate professors:

- Charlotte Bay Hasager (DTU)
- Birgitte Rugaard Furevik (MET)
- Marte Godvik (Equinor)
- Bjørn Maronga (Leibniz Univ. Hannover)

PhD students

- Ida Marie Solbrekke (GFI)
- Jan Markus Diezel (GFI)
- Astrid Nybø (GFI)
- Christiane Duscha (GFI)
- Maria Krutova (GFI)
- Mauro Ghirardelli (GFI)
- Shokoufeh Malekmohammadi (GFI)
- Mohammadreza Mohammadpour Penchah (GFI)
- Sai Wang (GFI)

- Xu Ning (GFI)
- Hannah Elizabeth Petrie (GEO)
- Carsten Peter Hinzmann (PHYS)
- Eirik Finserås (Law)
- Thea Johansen Gregersen (Dep. Of Psychosocial Science (PSYCHOL))

Administrative Personnel

- Torill Andersen Eidsvaag (GFI), Administrative coordinator
- Ragnhild Helle Nyheim (GFI) Administrative coordinator (substitute)
- Kristin Guldbrandsen Frøysa (GFI), Energy Director UiB

Scientific Advisory Committee (SAC):

- Christina Aabo, Head of R&D, Wind Power, Ørsted
- Henrik Bredmose, Professor, Danish Technical University (DTU) Wind Energy
- Bernhard Lange, Division Manager Wind Farm Planning and Operation, Fraunhofer Institute for Wind Energy Systems
- Thina Margrethe Saltvedt, Chief Analyst, Sustainable Finance Norway, Nordea
- Jan-Fredrik Stadaas, Corporate Strategy Manager, Equinor
- Jan Willem Wagenaar, R&D coordinator and project manager Wind Energy Systems, TNO

Steering Committee:

- Gunn Mangerud, vice dean, Climate and Energy transition, leader of the committee
- Karl Harald Søvig, dean, Faculty of Law
- Tor Eldevik, Head of Department, Geophysical Institute
- Aina Berg, Director of Energy, NORCE
- Jan Erik Askildsen, Dean, Faculty of Social Science
- Torill Eidsvaag, BOW (secretary)

Appendix B - Publications

Scientific publications

Cheynet, E., Flügge, M., Reuder, J., Jakobsen, J. B., Heggelund, Y., Svardal, B., Garfias, P.B., Obhrai, C., Daniotti, N., Bergen, J., Duscha, C., Wildmann, N., Onarheim, I., H. & Godvik, M. (2021). The COTUR project: remote sensing of offshore turbulence for wind energy application. *Atmospheric Measurement Techniques, 14* (9) (access)

Christakos, K., Björkqvist, J.V., Tuomi, L. Furevik, B. R. & Breivik, Ø. (2021). Modelling wave growth in narrow fetch geometries: The white-capping and wind input formulations. *Ocean Modelling, 157,* 101730. (access)

Daniotti, N., Jakobsen, J. B., Snæbjörnsson, J., Cheynet, E., & Wang, J. (2021). Observations of bridge stay cable vibrations in dry and wet conditions: A case study. *Journal of Sound and Vibration*, *503*, 116106. (access)

Hente, C., Gebhardt, C. & Rolfes, R. (2021). On the static analysis of nonlinear beam and shell structures with singular stiffness matrices due to redundant coordinates. *Thin-Walled Structures, 161*, 107496. (access)

Gebhardt, C. & Romero, I. (2021). On a nonlinear rod exhibiting only axial and bending deformations: mathematical modeling and numerical implementation. *Acta Mechanica, 232*, 3825-3847 (access)

Midjiyawa, Z., Cheynet, E., Reuder, J., Ágústsson. H. & Kvamsdal, T. (2021). Potential and challenges of wind measurements using met-masts in complex terrain for bridge design: Part I – Integral flow characteristics. *Journal of Wind Engineering & Industrial Aerodynamics, 211,* 104584. (access)

Midjiyawa, Z., Cheynet, E., Reuder, J., Ágústsson, H. & Kvamsdal, T. (2021). Potential and challenges of wind measurements using met-masts in complex terrain for bridge design: Part II- Spectral flow characteristics. *Journal of Wind Engineering & Industrial Aerodynamics, 211,* 104585. (access)

Ning, X., Krutova, M. & Paskyabi, M., P. (2021). Analysis of offshore wind spectra and coherence under neutral stability condition using the two LES models PALM and SOWFA. Journal of Physics: Conference Series (JPCS)

Nybø, A., Nielsen, F. G. & Godvik, M. (2021). Analysis of turbulence models fitted to site, and their impact on the response of a bottomed-fixed wind turbine. Journal of Physics: Conference Series (JPCS)

Nybø, A., Nielsen F.G. & Godvik, M. (2021). Quasi-static response of a bottom-fixed wind turbine subject to various incident wind fields. *Wind Energy, 24* (12) (access)

Solbrekke, I.M., Sorteberg, A. & Haakenstad, H. (2021). The 3 km Norwegian reanalysis (NORA3) - a validation of offshore wind resources in the North Sea and the Norwegian Sea. *Wind Energy Science, 6*, 1501-1519 (access)

Book chapters

Bange, J., Reuder, J. & Platis, A. (2021). Unmanned Air Vehicle Measurements. In Foken. T (Ed.), *Springer Handbook of Atmospheric Measuresments* (Chapter 48). Springer Nature Switzerland AG (access)

Gebhardt, C. (2021). Ein vereinheitlichter nichtlinearer Ansatz zur Strukturanalyse von Balken- und Schalentragwerken (In German). *Chapter for the yearbook 2020 of the Braunsweigische Wissenschaftliche Gesellschaft,* ISSN 978-3-7369-7423-4, Cuvillier, 2021

Herrera Anchustegui, I. (2021). Distributive justice, community benefits and renewable energy: the case of offshore wind projects. In Fleming, Ruven, Huhta, Kaisa, Reins & Leonie (eds.). *Sustainable Energy Democracy and the Law* (Brill Publishers, 2021)

Reports

Blått kompass (2021). Senter for hav og arktis. Multiple authors (access)

Optimal utnyttelse av energi fra havvind i Sørlige Nordsjø II, Greenstat (2021). Sæbø, A.O., Trøen, T.L, Synnevåg Sydness, G., Lerøy Shaefer, J.M, Baardsen, A. H. et. al (access)

Recommendation on the use of wind lidars Geophysical Institute and Bergen Offshore Wind Centre. University of Bergen (2021) Reuder, J., Cheynet, E, Clifton, A., van Dooren, M., F., Gottschall, J., Bogunovic Jakobsen, J. et. al

Understanding decommissioning of offshore infrastructures: A legal and economic appetizer, Institutt for samfunnsøkonomi, Norges Handelshøyskole (2021). Herrera Anchustegui, I., Eskeland, G., Skjeret, F. A, Melnychenko. M., Lødøen, J. et. al (access)

Awards

Cristian Gebhardt. Heisenberg Award. *Deutsche Forschungsgemeinschaft*, Germany 2021

Judith Boekee Eera Deepwind 2021. Poster award The potential of synthetic turbulence in large eddy simulation during stable conditions over ocean wind farms

Appendix C - Ongoing projects and expected activity

Project	BOW - responsible	Topic	2021	2022	2023	2024
COTUR II	Joachim Reuder	Analysis of the data from COTUR I	650	350		
CONWIND	Mostafa Bakhoday-Paskyabi	Wind farm control. BOW focuses on wind prediction (nowcasting) and wind farm control. Norwegian-Chinese collaborative NFR funded project, led by NORCE	1530	2557	756	
HIPERWIND	Mostafa Bakhoday-Paskyabi	HIghly advanced Probabilistic design and Enhanced Reliability methods for high-value, cost-efficient offshore WIND. BOW: Multiscale flow modelling, a Horizon2020 project, led by DTU	948	1833	1582	
Equinor support	Joachim Reuder	Consultancy by BOW experts for Equinor	100	100	100	100
Leading edge erosion on wind turbine blades	Bodil Holst (IFT) / Joachim Reuder (GFI)	Developing nano diamond coatings resistant to erosion. Analysis and modelling of environmental conditions relevant for wind turbine blade erosion, an Akademia agree ment project.	1443	1476	647	
Integrated marine geological characterization	Haflidi Haflidason	An integrated geological characterization of marine ground conditions for offshore wind foundations in the North Sea, an Akademia agreement project.	20	1400		
DeWindSea	Sigrid Eskeland Schütz	Designing a Refined Legal Framework for Legitimate Offshore Wind in the North Sea Basin, an Akademia agreement project.	1315	1768		
Akademia, field c ourse	Finn Gunnar Nielsen	Field course in wind measurements.	300			

Akademia, Prof II	Joachim Reuder	Charlotte Hasager, Academia project on erosion.	205	220	220	100
Akademia Prof II	Finn Gunnar Nielsen	Marte Godvik, Offshore wind turbines.	160	220	220	100
Prof II MET	Finn Gunnar Nielsen	Birgitte R. Furevik, Wind energy meteorology. Cooperation with MET.no	205	220	220	100
Large eddy simul ations	Mostafa Bakhoday-Paskyabi	Flow characteristics inside windfarms using LES and accounting for waves and coupling to mesoscale flow, an Akademia agreement project.	1427	1667	1403	0
GOV-WIND	Ignacio Herrera Anchustegui	GOW-Wind will provide a critical and rigorous interdisciplinary analysis of the current regulation of offshore wind in the EU/EEA and other selected jurisdictions from a market-oriented perspective	Project connected to a tenure track position at UiB			
PRE-DÉKOR	Ignacio Herrera Anchustegui	Study of the rules for decommissioning oil and gas as well as offshore wind and see if there are any relevant differences between the regimes	325			
LOWT	Joachim Reuder	Large Offshore Wind Turbines (LOWT): structural design accounting for non-neutral wind conditions; NFR FRIPRO	200	1500	1800	1200
ImpactWind Sørvest	Finn Gunnar Nielsen Joachim Reuder Ignacio Herrera Anchustegui	Competence building		700	3454	3478
To kurs om havvind ved Universitetet i Bergen	Finn Gunnar Nielsen	Continuing Education		627		
SUM			**8828**	**14638**	**10402**	**5078**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