NEWSLETTER II – January 2021

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# INNOVATIVE FUTURE-PROOF TESTING METHODS FOR RELIABLE CRITICAL COMPONENTS IN WIND TURBINES

3 COUNTRIES

4.8 M€ BUDGET

8 PARTNERS

36 MONTHS

## INNTERESTING ID

### Acronym
Horizon 2020- INNTERESTING

### Program
The European Union´s Research and Innovation Program Horizon 2020 LC-SC3-RES-1-2019-2020
Developing the next generation of renewable energy technologies

### Duration
January 2020- December 2022

### Main objective
To accelerate wind energy technology development and to extend the lifetime of wind turbine components by developing innovative virtual and hybrid testing methods for prototype validation of pitch bearing and gearbox components.

### Partner countries
Belgium, Finland, Spain

## EDITORIAL

Dear readers,

We are delighted to inform you that INNTERESTING has completed its first year and that it has successfully achieved every stablished milestone! The second edition of the Newsletter is intended to give you an overview of the activities carried out during the second semester of the project, which covers the period from July 2020 to December 2020.

In this issue, besides an update of the technical progress of the project, we want to share with you the activities held with Stakeholder Groups that are supporting the project both in its technical aspects and on sustainability issues. Furthermore, we have a new section "getting to know project partners" where you will have the opportunity to read brief interviews made with some of our partners.

Lastly, we will keep you up to date about the project partners´ activities and initiatives related to INNTERESTING as we will provide you with short summaries of the latest project events.

It needs to be raised that the COVID-19 pandemic situation that hits the world puts now the project and all the overall working scheme in a different perspective, and many activities and meetings have been postponed or changed into online formats. The top priority now is to contain the disease and to be able to be back on normal business as soon as possible. In the meantime, the consortium will keep working and sticking to the work program as best as possible, but some modifications will be necessary.

In the following issues we will share with you more of our achievements and fruitful results, and we will inform you about project milestones and events.

For more information and news about INNTERESTING project, please visit our website:

www.innterestingproject.eu/project/

We hope you will enjoy reading this second issue of INNTERESTING Newsletter.

Your feedback and comments are always welcome!

The consortium

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 851245.

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STAKEHOLDER ENGAGEMENT

## INNTERESTING TECHNICAL ADVISORY GROUP MEETING

The Technical Advisory Group was created during the first semester of the project, with 7 technical stakeholders that due to their profile or relevance would benefit from the research of the project and whose participation would benefit the project: GE OFFSHORE, LORC (Lindo Offshore Renewables Center), ORE (Offshore Renewable Energy) CATAPULT, VESTAS, SIEMENS GAMESA, DNV-GL and IBERDROLA. As for their profiles, SIEMENS GAMESA, VESTAS and GE are three of the most relevant turbine manufacturers worldwide, IBERDROLA is a wind farm operator, DNV-GL a certification body and ORE CATAPULT and LORC test centres for large components. Additionally, during the last semester of the year, a new test centre has joined the Technical Advisory Group, namely SIRRIS- OWI LAB.

The 1st INNTERESTING Technical Advisory Group meeting took place on the 9th of September.


The objectives of the meeting were to give an overview of the progress of the project, to receive feedback from participating experts and to get feedback on the applicability of the solutions and possible improvements. Stakeholders contributed interactively within a co-creation session to the definition of the technical, social and environmental requirements of future wind turbines (2030-2050) and to the design tools and methodology to be developed.

## INNTERESTING SUSTAINABILITY STAKEHOLDER CONSULTATION MEETING

The Sustainability Advisory Group was also created during the first semester of the project. In this case, target groups were wind energy associations, policy makers and regulators, civil society organisations, environmental and social NGOs, or citizens in general. An open invitation was launched through social media for a sustainability stakeholder consultation meeting to improve the future social acceptance of newly developed wind energy technologies.

On the 10th of September, a sustainability stakeholder consultation meeting was organized for a broader public in an online webinar format. The webinar had more than 30 participants from 20 different European companies.

After the introduction of the INNTERESTING project made by IKERLAN, VITO presented the preliminary results for the Life Cycle Sustainability Assessment (LCSA). Among the topics discussed, were the environmental and social requirements of future wind turbines and requirements to improve the future social acceptance of wind energy.

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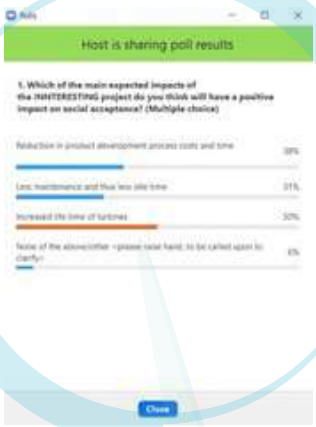
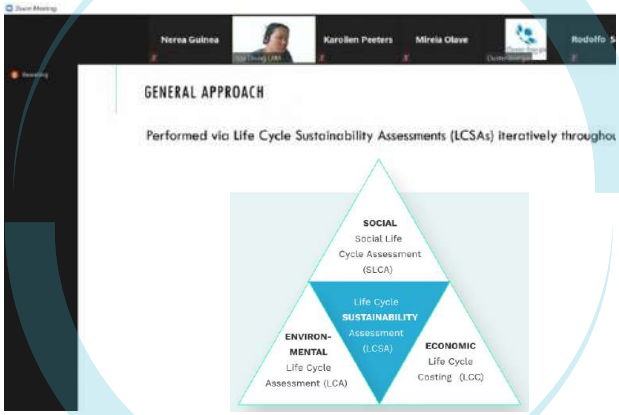
During the meeting, there were some Poll Questions that showed the knowledge of the participants and their concerns about the topic. In this way, the attendants shared their point of view and their previous experiences related to the social, environmental and sustainability assessments.




## NEW VIDEO OF INNTERESTING

The INNTERESTING consortium released a short video to show the main idea of the project. The video explains how hybrid testing (instead of using large physical test-benches) will contribute to reduce cost and time-to-market in new product development, as well as the three new concepts and technologies that will be developed in the project as case studies for this new methodology. These are the topics that the video contains:

- What is INNTERESTING
- Main objectives of the project
- Description of the three case studies
- Main expected impacts

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## PROJECT PROGRESS

INNTERESTING has had a lot of activity done in this last period, and this section shows the progress of some of the partners:

### IKERLAN:

In the framework of WP1 (Requirements and concept development) LAULAGUN, MOVENTAS and IKERLAN have defined the design / concept that will be used to respond to the three Case Studies described below:

1. CS1 Novel pitch bearing design concept. CS1 is based on an innovative pitch bearing concept that will be installed in a 20 MW offshore wind turbine from the year 2030 onwards (hub height of 160, rotor diameter of 276 m and the pitch bearing diameter of 7 m). The turbine will be installed in a wind farm with a size of 2 GW with 100 turbines.

2. CS2 Novel gear design concept. CS2 is based on a new gearbox concept that will be installed in a 10 MW onshore wind turbine from the year 2030 onwards (hub height of 119, rotor diameter of 202 m and a torque density up to level of 200Nm/kg). The wind turbine will be installed in a farm size of 100MW with 10 turbines.

3. CS3 Novel stiffening concept for lifetime extension of existing pitch bearings. CS3: In this CS, a 3,4 MW wind turbine will be installed in 2020, and the pitch bearing will fail at an early stage of the lifetime (<10 years): a reparation and stiffening solution will be required in the pitch bearing.

In the WP2, were IKERLAN is the WP leader, the task that is more advanced is the T2.1: "Probabilistic load calcula-tion methods" is to develop a numerical approach to quantify stochastically the wind condition variability between the WT of the same wind farm.

In task T2.1 a probabilistic load calculation workflow is defined in order to analyse the variability between the WTG of the same wind farm. The 20 MW reference wind turbine generator (WTG) model has been selected as reference aeroelastic wind turbine model. The selected wind farm location is Anholt Offshore Wind Farm and the defined layout is described in the deliverable. The wind condition results obtained with FLORIS would be processed to obtain the, probabilistically, most decisive conditions for wind speed, turbulence intensity and power law coeffi-cient. Finally, OpenFAST would be used to carry out simulations for a single wind turbine, which should be considered the equivalent or the same for all the turbines in the farm, for all the wind conditions. After that, from each set of resultant time series, rain flow and posterior fatigue equivalent resultant load have been post-processed. At the end of this task, the probabilistic distribution of the equivalent loading on the blade root coordinate system would have been expected instead of a deterministic value that is usually calculated.

In this WP, IKERLAN is working on developing:

- a stochastic numerical approach for estimating global WT structure fatigue probability of failure
- a simulation method to analyse the induction hardening process and apply it to the Case studies
- a procedure to design life extension solutions for cracked pitch bearings

In the framework of WP3 (Simplified tailored physical testing), IKERLAN is working on developing:

- experimental characterization of the microstructural effect on the fatigue properties
- contact fatigue-based failure modes
- characterization of repairs for existing pitch bearing lifetime extension, lifetime extension technology demonstration for design tool validation
- structural fatigue failure testing for wind turbine components
- new pitch bearing concept validation test in LAULAGUN test centre

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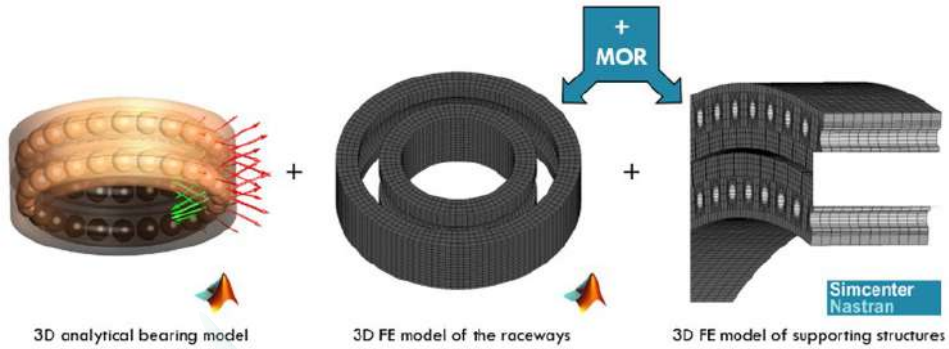
## KULEUVEN:

In order to obtain accurate yet computationally feasible pitch bearing models that fit the objectives of the INNTERESTING project, the LMSD research group (KULeuven) developed a modelling approach that combines 3D lumped-parameter modelling with Finite Element (FE) modelling and Model-Order Reduction (MOR), see Figure below. 3D analytical lumped-parameter models are used to compute the contact forces excerted by the bearing rolling elements on the raceways; FE models are used to model the elasto-dynamic behavior of the bearing raceways and their supporting structures; and finally analytical and reduced-order modelling techniques are used to greatly reduce the computational cost of the combined model.




Combination of three submodels in the KULeuven flexible bearing simulation approach

In the second half of 2020, the LMSD research group focused its efforts on collecting and/or developing the ingredients of this multiscale modelling approach. To compute the rolling element forces in current and future generation wind turbine pitch bearings, 3D models of four-point-of-contact ball bearings (see Figure above, left) and three-row-roller bearings (see figure below) were developed. In addition, a parametric FE model generator for discretizing the geometries of these advanced bearing technologies was developed, based on the group's prior experience in FE-based bearing modelling (see Figure above, middle). Finally, algorithms for applying MOR to these FE models were implemented.

Three-dimensional lumped-parameter model of a three-row roller pitch bearing

In the first quarter of 2021, KULeuven will develop a technique to efficiently combine FE data from commercial FE software packages – used to construct FE models of the bearings' supporting structures, possibly including defects (see Figure above, right) – with the FE data generated by the raceway FE model generator. Then the several components of the multiscale modelling approach will be combined to conduct elasto-dynamic pitch bearing analysis.

The obtained multiscale dynamic pitch bearing modelling approach will be used in the first half of 2021 to develop novel Virtual Sensing (VS) techniques that will aid in improving and accelerating prototyping for novel pitch bearing solutions. In a first step, the model will be used to optimize sensor selection (which kind of sensors to use, which number of sensors to use) and sensor placement (where to install the sensor to obtain optimal measurement accuracy) for measuring relevant quantities in pitch bearing design and analysis.

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PROJECT PROGRESS

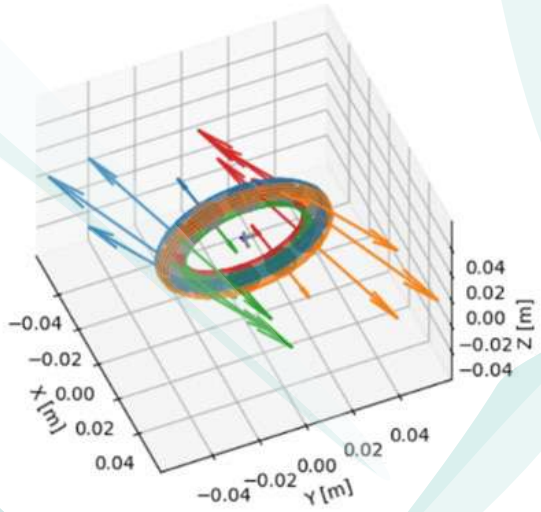
## SIEMENS:

In the framework of WP2 (Advanced virtual testing and design tools for ensuring reliability) SIEMENS is developing analytic multibody models for 4 and 8-point-of-contact ball bearings. These models rely on a parametric description of the bearing geometry in order to be applicable to, potentially, any bearing size and to correctly represent the scaling effects needed for the INNTERESTING methodology.

The models developed throughout this Task, considers the 5-dof relative displacement of the rings as input to compute the corresponding 5-dof reaction forces and moment at the bearing axis.

Starting from the relative displacement of the rings, the models compute the corresponding relative local displacement at each rolling element location. The local displacement results in the rolling element being compressed between the raceways which inevitably cause the rolling element and the raceways to locally deform. The contact force associated with the local deformation is estimated introducing a contact model that takes into account the local geometry and material properties of the contacting bodies. The contact being nonliner, an iterative scheme is employed to compute the equilibrium of each rolling element and consequently determine the contact forces at each contact location.

Once all the contact forces are evaluated, their contribution is combined to achieve the statically equivalent 5-dof reaction forces and moments at the bearing axis. Figure below shows an example for a loaded 4-point-of-contact bearing where each arrow represents a contact force.




Estimated contact forces for a 4-point-of-contact ball bearing under a tilting moment.

In the upcoming months, the model will be extended to include the rotation of the bearing about its rotation axis. This will allow for correctly estimate the stiffness fluctuation of the bearing due to the change in location of the rolling elements.
Once the development of this high-fidelity analytic models will be completed, a cross validation using the flexible multibody models developed by KUL will be performed. This activity will allow for a deeper understanding of the strengths and weaknesses of this lightweight, yet advanced, model.

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GETTING TO KNOW
PROJECT PARTNERS

In this section, project partners will let us know more about them and about their ambitions. In this edition, Mireia Olave from IKERLAN and Wai Chung Lam and Karolien Peeters from VITO have answered short questions regarding different topics, and here is the result!


PhD. Mireia Olave is a senior researcher in Mechanical Reliability team at IKERLAN, where she has been working for 16 years. MSc in Mechanical Engineering at the University of MONDRAGON, she completed her PhD at KULeuven in fracture behaviour of composite materials. During her professional career she has been actively leading R&D projects for companies related to the wind sector, her primary interest being structural evaluation, characterization and testing of pitch bearings. She currently leads and coordinates the H2020 project INNTERESTING, oriented to Innovative Testing Methods for wind turbine components.

## Mireia Olave from IKERLAN

### 1. Why does it make sense to change the way of testing different components of a wind turbine?

In the coming years, a significant increase in the average size of the wind turbines is expected: currently the average size of the installed onshore turbine is 3,1 MW and 7,2 MW for the offshore wind turbine (data from 2019), in 2050 these average sizes may increase up to 10 MW and 20 MW, and they may be even larger. It must be considered that the decarbonisation objecti-ves defined by the governments will speed up the need of these new solutions in the next years. In addition, the wind industry increasingly requests more demanding reliability and lifetime requirements for wind turbine components. One of the ways to ensure compliance with these requirements is to physically test the components on specific test benches: these real-size physical tests are very expensive and time-consuming. Apart from the strong economic investment, the flexibility of large test benches is, in most cases, very limited due to the surrounding structures, dimensions of the specimens and the defined actuators. They are usually designed for a limited range of component size and for a specific loading condition and thus may become obsolete in few years. For these limitations, full-size physical testing is currently a bottleneck in the wind energy sector, and it is hampering and delaying the proper advance of innovative solutions. Against large test-benches, more sustainable solutions are necessary in the medium term.

### 2. Which are the most significant challenges and opportunities related to INNTERESTING methodology in your opinion?

One of the most important challenges of this project is to be able to include in the prediction of the behaviour of the real scale component the variabilities coming from loads, characterization of the material and even from the manufacturing processes. The reliability and lifetime results of the component will consider all the effects analysed in simplified test benches, where testing time and costs are vastly lower. The test data will be combined with advanced predictive models, to generate a hybrid methodology that is able to predict the reliability. It is an important competitive advantage to be able to anticipate the possible problems that we may have due to the effect of scale and the uncertainties of new designs.

We must also consider that in the future, when the size of the turbine is considerably increased, the simple scaling of current components will not always be a valid solution, and new renewable energy technologies and designs will be required to deal with these new challenges. In these cases, the most significant advantage of this methodology is the possibility of evaluating and validating new, more disruptive concepts, much faster and with less investment.

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### 3. Which are the companies that should be paying more attention to this new testing methodology? Manufacturers? Service providers?

The clearest indicator of the type of companies interested in this development is the technical advisory group that we have in the INNTERESTING project: currently, the technical advisory group is formed by representatives from DNV-GL, IBERDROLA, GE, LORC, ORE CATAPULT, SIEMENS GAMESA and VESTAS. So far, we have 3 of the most relevant turbine manufacturers worldwide, 1 wind farm operator, 1 certification body and 2 test centres for large components. Wind turbine component manufacturers, which are also partners of the project, have a big interest also. The expectation aroused is mainly due to the fact that this methodology directly affects the product development process: accelerating and reducing its final cost until the final valida-tion of the new product. So, both manufacturers and service providers will benefit from the project outcomes. In addition, these methods can be used not only in the components defined as the case studies in the project, but also in other wind turbi-ne components. The methods could also be applied in components from other sectors such as aeronautic or civil enginee-ring applications, where large investments are required for testing large structures.

### 4. When do you think that this new methodology will be available in the market?

The project is oriented towards the wind turbines of the future, with the years 2030-2050 as horizon. During the 3 years of development of the INNTERESTING project, the methodology will be developed and validated up to the level known as "laboratory validation", in this level we are doing a proof-of-concept of the tools and methods developed. In this sense, we hope that once the developments have been validated through the selected case studies, the next step towards standardization of the method can be taken. However, before a complete methodology can be brought to market, advances in simplified tests and virtual tool developments will be able to be used by the industry. These tailored physical tests based on smaller samples or specific failure modes will help to better understand the behaviour of the components. The improved virtual design tools and reliability predictions obtained from the project will help to ensure the lifetime of the components. Therefore, the advantageous results of all developments will be tangible from the completion of the project in December 2022.

## Wai Chung Lam and Karolien Peeters from VITO

**Wai Chung Lam** obtained her master's degree in 2008 at the department of Built Environment of the Eindhoven University of Technology. After her studies, she gained professional experience as a consultant sustainable development at a commercial engineering consultancy company. Wai Chung joined VITO as a researcher in the unit Smart Energy and Built Environment in March 2014. Within INNTERESTING, she is the technical leader of the work package 6 and responsible for the environmental life cycle assessment (LCA).

**Karolien Peeters** is an experienced life cycle assessment (LCA) practitioner, having conducted several ISO-compliant LCA studies for industry and governmental agencies, as well as working on ecodesign studies for the European Commission. Currently the focus of her research is on social life cycle assessment (S-LCA). Karolien is carrying out the S-LCA of the INNTERESTING project.

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## 1. Within the INNTERESTING project VITO is performing a life cycle sustainability assessment (LCSA), what is an LCSA?

An LCSA assesses the life cycle of a product system from an environmental, economic, and social point of view, which corresponds with the three pillars of sustainability. All life cycle stages are considered: starting from the extraction, transport and pre-processing of raw materials, to the manufacturing, transport, installation, use, and end-of-life of the product system. The potential environmental impacts caused by a product system are quantified and evaluated via an (environmental) life cycle assessment (LCA), and the potential economic and social/socio-economic impacts are assessed via life cycle costing (LCC) and social life cycle assessment (S-LCA) respectively.


## 2. What is the importance of performing an LCSA?

By performing an LCSA we will be able to gather insights in the potential environmental, economic, and socio-economic impacts of a product system. In this project we look at three different systems i.e. the three case studies. For each case study (see page 4 of this newsletter) the complete wind turbine is assessed over its entire life cycle. Those insights can be used to optimise the design, construction, use or end-of-life of the wind turbines. With the results of an LCSA, you can see which processes are generating the biggest impacts and should therefore be given priority for optimisation to lower the impacts.

Specifically, within INNTERESTING, we will perform LCSAs iteratively in the course of the project (see this link). In the first iteration, performed earlier this year and delivered in august, we have assessed three business-as-usual (BAU) reference scenarios. The intention of this first assessment is to gain insights in the environmental, economic and social/socio-economic performance of the different wind turbine components during the life cycle of a wind turbine. In addition, the results of the BAU reference scenarios will serve as a reference in the next iteration of the LCSA against which the INNTERESTING solutions will be compared to see the effect of the solutions on the life cycle impacts.

## 3. Are S-LCA and social acceptance linked to each other?

Social life cycle assessment (S-LCA) and social acceptance are two different research areas. S-LCA is a methodology to assess the potential social impacts of products and services across their life cycle. The methodology provides information on social and socio-economic aspects for decision-making in the prospect to improve the performance of organisations and ultimately the well-being of stakeholders [1], such as the workers across the whole value chain of a product. A harmonised methodology does not exist yet, which leads to different approaches being used in various S-LCA studies. In this study we followed the UNEP/SETAC guidelines for social life cycle assessment [1] and applied a generic database to assess and quantify social hotspots along the value chain of the wind turbines. The S-LCA methodology we used does not include a quantifcation nor a qualification of the social acceptance of the product system assessed. There are other parties investigating whether it is possible to (semi-)quantify social acceptance of wind farms by stakeholders.. However, there is still a lot of discussion on quantifying a subjective topic as social acceptance. Within this project though, we did a literature review on social acceptance of wind energy which is included in deliverable 1.1 (report on requirements for future wind turbines).

## 4. What are the next steps within the LCSA?

In 2021, we will start with the data collection for a revision of the BAU scenarios. A revision is needed as we were not able to collect data on all current testing methods for pitch bearings and gearboxes. Without that data a fair comparison would not be possible between the BAU reference scenarios and the INNTERESTING case studies in which the impacts due to the INNTERSTING hybrid testing methods will be included. That comparison will show the potential environmental, economic and social benefits of all concepts that are being developed within INNTERESTING. The revision of the BAU scenarios will be included in deliverable 6.2 (June 2022) together with the results of the screening LCSA of the INNTERESTING scenarios for which we will also start collecting the necessary data. In the last half year of the project we will validate the screening LCSA to come to the final LCSA.

[1] Benoît-Norris C., Traverso M., Finkbeiner M. et al. (2020). Guidelines for social life cycle assessment – v3 draft February 2020. Available online: https://slcaguidelines.konveio.com/, last accessed: July 2020.

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PROJECT NEWS

## 30 July 2020 | Wind Energy Network Magazine

July edition of Wind Energy Network included in the "Industry News" section an article about INNTERESTING including background, development and expectations of the project.


## 9 September 2020 | The 1st INNTERESTING Technical Advisory Group meeting

The 1st INNTERESTING Technical Advisory Group meeting took place on the 9th of September. 6 European companies participate on it Vestas, Offshore Renewable Energy Catapult, Siemens Gamesa, General Electric (GE), Iberdrola and Lindo Offshore Renewable Center (LORC).

The objective of this first meeting was to introduce the project to the experts and to kick off this Advisory Group for a continuous collaboration and advice. This Group will overview technical progress of the project and will support the INNTERESTING consortium on its development.


## 10 September 2020 | The INNTERESTING Stakeholder Consultation meeting

On Thursday 10th of September, the INNTERESTING stakeholder consultation meeting took place via Zoom to enable the participance of all the stakeholders. The webinar had more than 30 participants from 20 different companies. After the introduction of the INNTERESTING project made by IKERLAN, VITO presented the social, environmental and sustainability assessments that had been done.

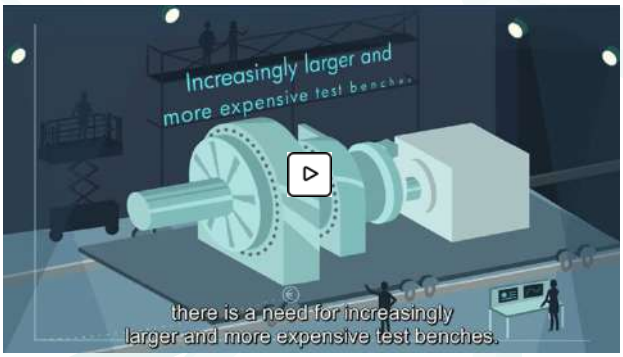

## 16 September 2020 | INNTERESTING was presented in the EERA JPWind & SETWind online annual event 2020

The last 16th of September Mireia Olave from IKERLAN and part of the INNTERESTING consortium, presented the INNTERESTING project at EERA JP Wind & SETWind Online Annual Event 2020 on the "Infrastructure for material and structural testing" session.

The morning session on day 3 at the online conference 2020, Mireia Olave gave a 15 minutes presentation about the INNTERESTING project: "INNTERESTING Innovative Future-Proof Testing Methods for Reliable Critical Components in Wind Turbines".


## 6 October 2020 | New video of INNTERESTING

The INNTERESTING consortium has just released a short video to show the main idea of INNTERESTING project. The video explains how hybrid testing (instead of using large physical test-benches) will contribute to reduce cost and time-to-market in new product development, as well as the three new concepts and technologies that will be developed in the project as case studies for this new methodology.

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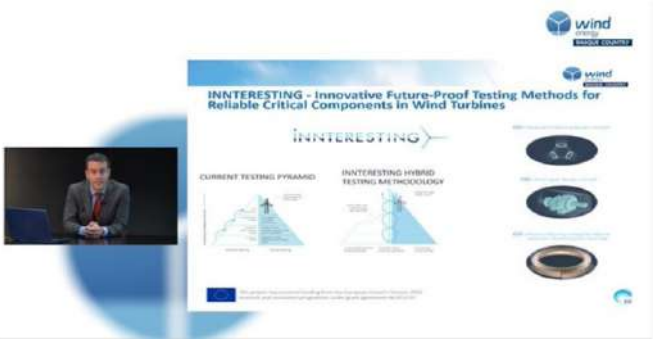
## 28 October 2020 | INNTERESTING was presented in the Fukushima REIF 2020

In collaboration with the Basque Trade & Investment, the Basque Energy Cluster (BEC), partner of the INNTERESTING Consortium, participated in the Fukushima REIF 2020 in a remote way last 28th and 29th of October.

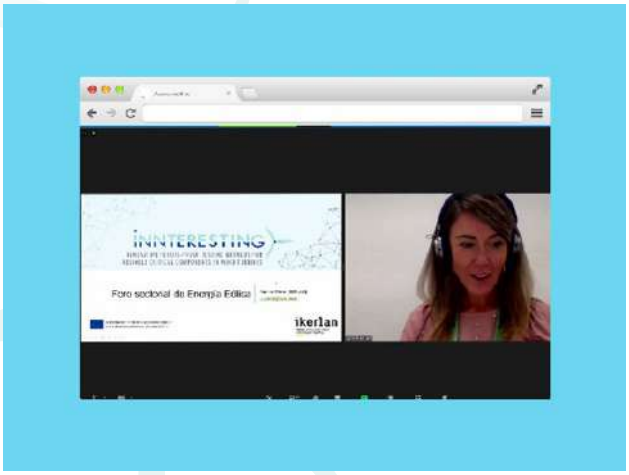
Under the Wind Energy Basque Country brand, BEC was present both in a physical and in a remote way. The video of the INNTERESTING project was shown in the physical stand and Marcos Suarez, from BEC, also introduced it during his online presentation.




## 12 November 2020 | INNTERESTING was presented during the Wind Energy Sector Forum

Last 12th of November, Mireia Olave from IKERLAN, partner of the INNTERESTING Consortium, presented INNTERESTING project during the Wind Energy Sector Forum organised by the Basque Energy Cluster (BEC), also partner of the project.

With 66 participants of 42 different entities, the Forum was used to put in common the different projects that are in progress, like INNTERESTING. Marcos Suarez from BEC presented the video of the project and Mireia Olave gave a presentation about the progress and methodology of the collaborative R&D of the INNTERESTING project.




## 3 December 2020 | INNTERESTING was presented in the WindEnergy Hamburg 2020

The last 3rd of December, Mireia Olave from IKERLAN and part of the INNTERESTING consortium, presented the INNTERESTING project at WindEnergy Hamburg 2020 during the afternoon session in the Exhibitor Talks.
WindEnergy celebrated its annual event the last 1st – 4th of December. The afternoon session on day 3 at the WindTV OpenStream, Mireia Olave gave a 10 minutes presentation about the project.


## 9-10 December 2020 | The INNTERESTING consortium meeting

During the 9th and 10th of December, INNTERESTING partners held an online Steering Committee meeting. All partners gave a description of the general evolution of the different Work Packages and future steps were discussed.

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# INNTERESTING

## INNOVATIVE FUTURE-PROOF TESTING METHODS FOR RELIABLE CRITICAL COMPONENTS IN WIND TURBINES

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