TWIND

Twinning for an Offshore Wind Energy Partnership

Call identifier: H2020-WIDESPREAD-2018-2020

D2.3 – Think-Tank Summary

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857631

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Disclaimer

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CONTENTS

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1 EXECUTIVE SUMMARY

The TWIND project has enabled collaboration between the Offshore Renewable Energy Catapult, Tecnalia, WavEC, and TU Delft. This project activity included four think tank events, which are documented in this deliverable report, D2.3.

The first think tank was around numerical modelling. This event consisted of three sessions. The first looked at the problems which are currently examined using numerical models, including wind and wave interactions with structures and floating platforms. The second session provided an overview of the OC6 project, looking at Offshore Code Comparison, Collaboration, Continued, with Correlation and unCertainty. It also looked at the benefits of higher fidelity models at the point of design, rather than just for control. Session 3 looked at modelling the electrical aspects of offshore wind, including dynamic and export cables, and wider grid integration.

The second think tank was based around data analytics and digital twins. This was a shorter online event (due to the COVID-19 pandemic) and was held during the height of travel restrictions and lockdowns across Europe. The online event gave all TWIND partners the opportunity to discuss their research interests and priorities relating to data analytics and digital twins. For example, in the case of ORE Catapult, presentations were made in the areas of blade design/validation and power electronics condition monitoring and fatigue modelling.

The third think tank focused on subsea and dynamic cables. This included several sessions covering areas such as dynamic cable design and modelling, cable validation, condition monitoring and inspection, reliability and data management, protection systems and EI cable topologies. In addition to exchanging information in these areas, the think tank session was also opened to additional industry representatives. This provided a different (and valuable) perspective to the challenges facing the sector.

The fourth think tank covered the emerging topic of hydrogen; an extension to the grid integration of renewables research them identified in deliverable, D2.2. The event was divided into four sessions. First was technology development, including the optimal ratio of electrolyser to wind farm capacity, methods of wind energy transmission, and integrating turbines with electrolysers. Second, we looked at modelling and simulation, and how these can help to identify the best use cases for hydrogen. Third, we considered testing and research infrastructure, including the role of large and small test facilities, and how different sizes provide flexibility. Finally, we looked at best practice and sector activities, including a review of an ORE Catapult hazard identification study on offshore wind powered electrolysis.

The four think tanks have allowed the consortium partners to undertake detailed discussions in areas that are key discussion points under the eight research themes identified in deliverable, D2.2. These think tank discussions have provided another means to share information and exchange knowledge (in addition to staff exchanges, summer schools and other methods used in the TWIND project). For the early career researchers attending the think tank sessions, they have also provided a training forum to learn more about the subject matter and the key challenges currently facing the ORE sector.

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2 INTRODUCTION

The TWIND project is funded via Horizon 2020 by the European Commission and has a budget of €796,000. The main objective of the project has been to create a network of information and knowledge exchange that will spark ideas from a pool of specialised research professionals and trainees in the domain of offshore wind energy. This will support an emerging industry in Portugal in a field with excellent prospects for growth that currently does not have a dedicated national training curriculum.

The TWIND consortium consists of three research organisations and one university. The research organisations include WavEC, from Portugal, which is devoted to the development and promotion of offshore renewable energy through technical and strategic support to companies and public bodies. Other organisations are Tecnalia, a Spanish applied research centre, and the UK's Offshore Renewable Energy Catapult, both of which are working in research and innovation in the field of offshore renewable energy. The university is TU Delft, which was been working on wind energy research for over 40 years.

A key part of the project activities has been the planning and execution of several think tanks, where the consortium gathered to discuss the frontiers of offshore renewables and to share learning and a selection of key topics related to the eight research themes from deliverable, D2.2. Four think tanks were delivered, covering numerical modelling, data analytics and digital twins, subsea and dynamic cables, and hydrogen. This report gives an overview of the sessions delivered through these events. Section 3 provides a summary of the four think tanks and Section 4 provides some key conclusions from the combined activity.

Due to the COVID-19 pandemic, the completion of this deliverable was deliberately delayed until the end of the project to maximise the time available to complete D2.3 related activity. This allowed more time to schedule the face-to-face activity that is crucial for this deliverable. As a result, we were able to have a fourth think-tank on hydrogen in October 2022 and accommodate senior staff exchanges as late as mid-December, only a matter of days before the official end date of the TWIND project.

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3 THINK-TANKS

The four think-tanks carried out are listed in the following table. The first think-tank was completed in the first year of the project. Due to the COVID-19 pandemic, the second think-tank was delayed by about six months and then moved to an online event in October 2020. The third and fourth think-tanks were both carried out in 2022 after COVID-related travel restrictions eased allowing them both to be conducted as in-person events (with some online participation); a more effective set-up for the think-tank structure.

29th October 2019	Numerical Modelling
21st October 2020	Data Analytics and Digital Twins
16th June 2022	Subsea & Dynamic Cables
21st October 2022	Hydrogen

3.1 Numerical Modelling

3.1.1 Agenda

The first think-tank on Numerical Modelling was held at Schiphol airport, Amsterdam in October 2019. The meeting was conducted with the following agenda with representation from the TWIND project partners:

9:00 – 9:30 – Arrival and refreshments

9:30- 10:00 – Introductions and setting ambitions for the day

10:00 – 12:15 - Brainstorming session on themes and deep dives

12:15 – 13:00 – Lunch and networking

13:00 – 14:45 - Further deep dives

14:45 15:00 – Conclusions and wrap up

3.1.2 Introduction

The think tank was opened with short presentations to frame discussions and provide focus. A recent Science paper 'Grand Challenges in the Science of Wind Energy' (P. Veers et al., Science 366, eaau2027 (2019). DOI: 10.1126/science.aau2027) was shared with the attendees – with three Grand Challenges highlighted:

1. Improved understanding of atmospheric and wind power plant flow physics
2. Aerodynamics, structural dynamics, and offshore wind hydrodynamics of enlarged wind turbines.
3. Systems science for the integration of wind power plants into the future electricity grid

It was noted that these are the scientific challenges, and other factors are relevant for industrial and research organisations – in particular, the economic challenges around reducing the LCOE of floating offshore wind to maintain competitiveness with alternative energy sources.

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3.1.3 Discussions

3.1.3.1 Session 1

The initial discussions focussed on the areas that each partner currently apply numerical models and CFD and the types of codes used.

Common areas of interest included:

- Modelling wind and wave interactions with structures
- Modelling for floating platforms
- Wake models for floating wind farms
- Wind farm control systems
- Damage and fatigue models for blades and powertrains.
- Developing machine learning systems to increase computational efficiency

Examples of open access codes used by the partners include FAST and SOWFA developed at NREL. It was noted that the numerical models provided a good basis as a design tool, however CFD and high-fidelity models were required for wind farm control calculations.

Recent H2020 projects mentioned during these initial conversations included LIFES50+, Total Control and CI-windcon.

Discussions moved into calculations for next generation turbine design and control systems, including modelling the frequency impact on the structure for high tip speed turbines, and the impact on the floating platform design and the benefits of vertical axis wind turbines in reducing wake effects, potentially leading to a reduction in LCOE.

The areas for further development and research that came out of this discussion were:

- Integration of CFD and numerical models to optimise speed of calculation and fidelity
- How do we bridge the gap between design and wind farm control given the different modelling needs?
- Can we develop a CFD or higher fidelity system that would work for industry?

3.1.3.2 Session 2

Session 2 opened with an overview of the OC6 project (Offshore Code Comparison Collaboration, Continued, with Correlation and unCertainity), an international project run by the International Energy Agency Wind Task 30. Tecnalia, WavEC and TUDelft are all members of OC6 which recently started and will run for 4 years and is focussed on validating tools by combining engineering models, high fidelity models and measurement data. The discussion included some examples of code coupling in hydrodynamic modelling performed by WavEC showing the impact of wave and surge on a floating platform. The next step would be to couple this with further models to build a full turbine model, however this is on the edge of current capabilities.

Discussions moved to the benefits of the higher fidelity models at the point of design, rather than just for wind farm control. A potential driver for industry would be an overall cost reduction in manufacture of turbines as high-fidelity models would result in more accurate safety margins, the value of this is currently difficult to quantify.

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It was highlighted that the current design models are the cheapest way for industry to design systems and they will be effective in the short term. Longer term development of a high-fidelity model could reduce the cost of wind turbine design, and potentially open the market up to more OEMs.

Discussions then moved on to areas where the offshore wind industry could learn from more established industries. From a modelling perspective aerospace was highlighted, where panel methods are currently used in wing design -can these be applied to wind turbine blade designs to improve the fidelity of models compared to blade element momentum (BEM) models currently used.?

The second session concluded with a short discussion on potential opportunities to collaborate with the H2020 LC-SC3- RES19 *Demonstration of innovative technologies for floating wind farms* discussed. This is an area that all partners have active interests in and further discussions on opportunities to collaborate would be carried out post think tank. H2020 LC-SC3-RES 31 *Basic science-technology development for offshore wind* was also highlighted as a good opportunity to collaborate further to develop higher fidelity tools for design and control, WavEC are currently investigating this and plan to contact TWIND members for more discussions in the future.

There were also discussions about developing a WP for a H2020 programme focussed on the techno-economic analysis based on the limitation of turbine size based on the supply chain, market, and country. This would expand on some of the 10MW business cases provided in the LiFe50+ consortium.

3.1.3.3 Session 3

Session 3 was opened with a move to look at the electrical side of offshore wind and the modelling elements with this.

Initial discussions focussed on dynamic cables and export cables and the modelling elements that go into the design and deployment of these systems. Tecnalia briefly discussed some work they are carrying out to model the friction between the cable and seabed and how they can validate the current model developed in Orcaflex. There was a brief introduction to harshlab, an offshore testing site that is suited to validating these models. ORE Catapult have active research looking at failure modes of export cables using Orcaflex and Ansys models which are going to be validated using the dynamic cable test rig at ORE Catapult. TU Delft have researchers looking at export cables and preventing failures. WavEC have a team looking at the optimal geometry for dynamic cables and developing tools to help design these. This work benefits from their experience in tidal devices and demonstration floating projects in Portuguese waters.

Discussions moved on to the wider grid integration modelling challenges including the introduction of more intermittent renewables into Virtual Power Plants (VPPs). Key areas to model here are the economic aspects, developing a reliable database on costs and modelling risk elements. Discussions also included super grids and the potential transnational grid networks to integrate renewables such as a North Sea wind farm network coupling several countries.

The final discussion point was around the modelling of electrical components within a turbine and wind farm. This includes the application of the PSCAD tool to look at events like low-voltage ride throughs, and the electrical storage needs to facilitate brown start and black start of turbines and wind farms.

3.1.4 Conclusions

Throughout the think tank areas for collaboration were identified by all parties participating, funding calls that have been identified for further discussion are:

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1. H2020- LC-SC3-RES19 – submission due December 2019
2. H2020 – LC- SC3 – RES 31 – submission due April 2020

Areas for further collaboration have also been identified:

- Integration of CFD and numerical models to optimise speed of calculation and fidelity
- How do we bridge the gap between design and wind farm control given the different modelling needs?
- Can we develop a CFD or higher fidelity system that would work for industry?
- Development of panel methods as alternative to BEM – analogous to aerospace
- Reducing safety margins and therefore cost through development of higher fidelity models.
- Improving the models for next generation export and dynamic cable deployment, and preventing damage.

Areas for staff exchange:

- There was a strong interest in staff exchange opportunities around the fundamental model developments that were included in discussion 1 which could be facilitated by both senior or early stage researcher exchange opportunities.
- Floating offshore wind turbine development was a strong theme that would also benefit from senior staff exchange opportunities, taking advantage of each organisation's different capabilities and expertise.

3.2 Data Analytics and Digital Twins

3.2.1 Agenda

The second think-tank on Data Analytics and Digital Twins was held as an online event due to the COVID-19 pandemic in October 2020. The meeting was organised by Amorina Armayor from WavEC and conducted with the following agenda with representation from all TWIND project partners:

5 min: Introduction / scene setting – ORE Catapult

20 min +5 – Tecnalia plenary

10+5 – ORE Catapult research interests and projects

10+5 – TUD research interests and projects

10 +5 – WavEC research interests and projects

15 min: Coffee break (session left on for any additional conversations)

60-90 mins – Discussion and deep dives

Wrap up – with actions for further discussions / staff exchanges.

Several topics were covered during the think-tank as potential applications for Data Analytics and Digital Twins. Two examples are given here:

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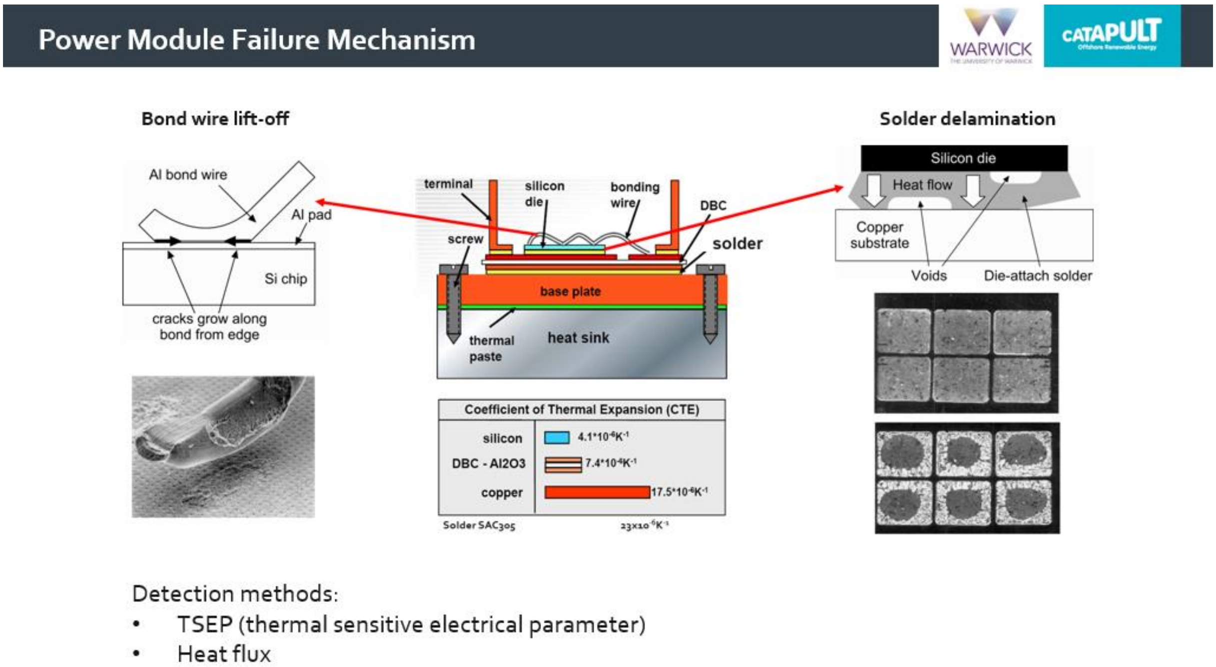
3.2.2 Power Module Degradation Monitoring – Data Analytics

This subject was presented during the think-tank and areas covered included power module failure mechanism, a heat flux detection method, artificial neural networks (ANN), ANN-based heat flux detection, and related test and verification. This is relevant to the think-tank because data analytics is being utilized (through ANN methods) to tackle the challenge of power module degradation and how to effectively monitor the degradation level under complex operating conditions such as those presented by offshore wind turbines. In time, degradation monitoring with prognostic capability can lead to Smart O&M methods and the elimination of unplanned maintenance due to power module failure.



3.2.3 Blades – Digital Twins

A digital twin is a digital replica of a physical asset and a wind turbine blade is one such physical asset within a wind turbine where it is beneficial to have a digital twin. The digital representation incorporates information about the blades' manufacture and it can be continuously updated throughout its operational lifetime using information gathered from sensors and inspections. This means the digital twin can be used as a tool to direct and schedule blade maintenance operations, thus minimizing or preventing sudden failure and unplanned maintenance/repair.

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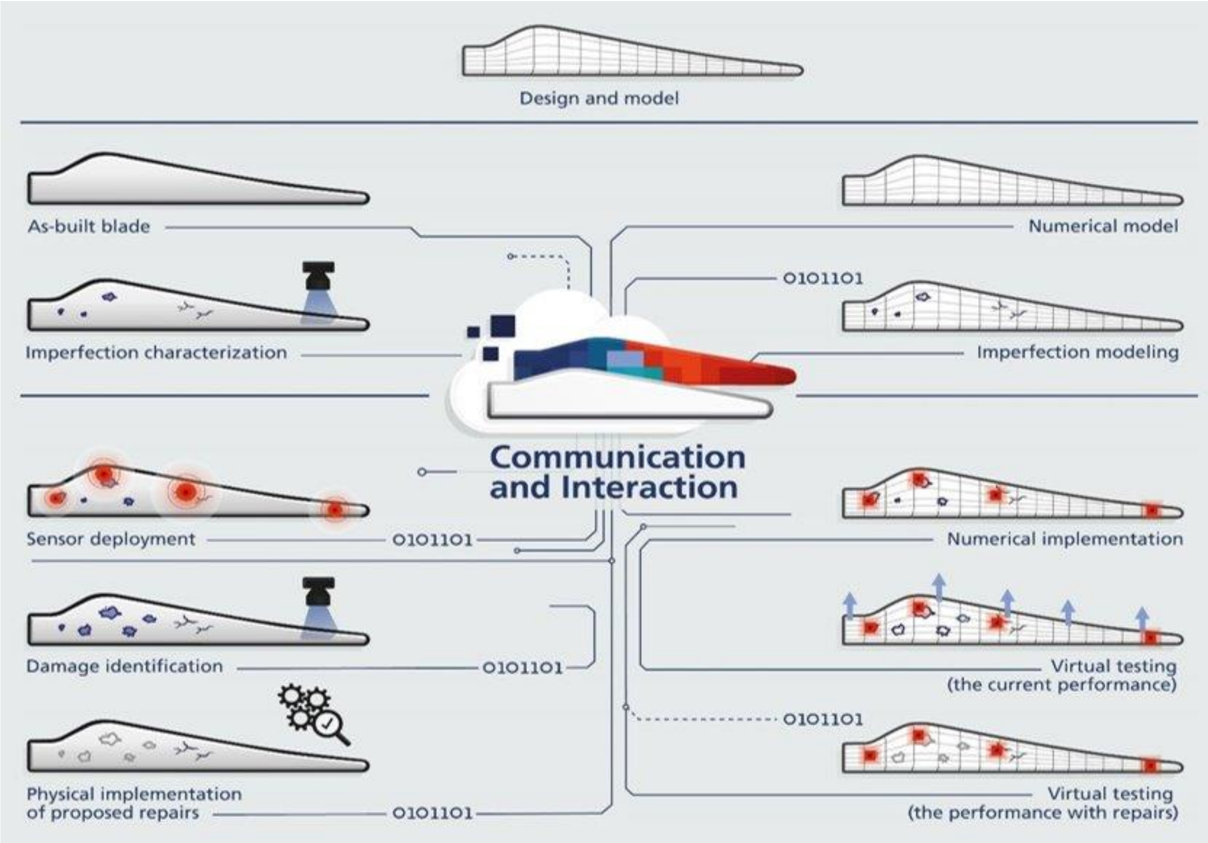

3.3 Subsea & Dynamic Cables

3.3.1 Agenda

The third think-tank on Subsea and Dynamic Cables was held at London Heathrow airport in June 2022. The meeting was organised by ORE Catapult and WavEC (both present in London). Representatives of Tecnalia, TUDelft and some industry stakeholders joined online. The meeting was conducted with the following agenda:

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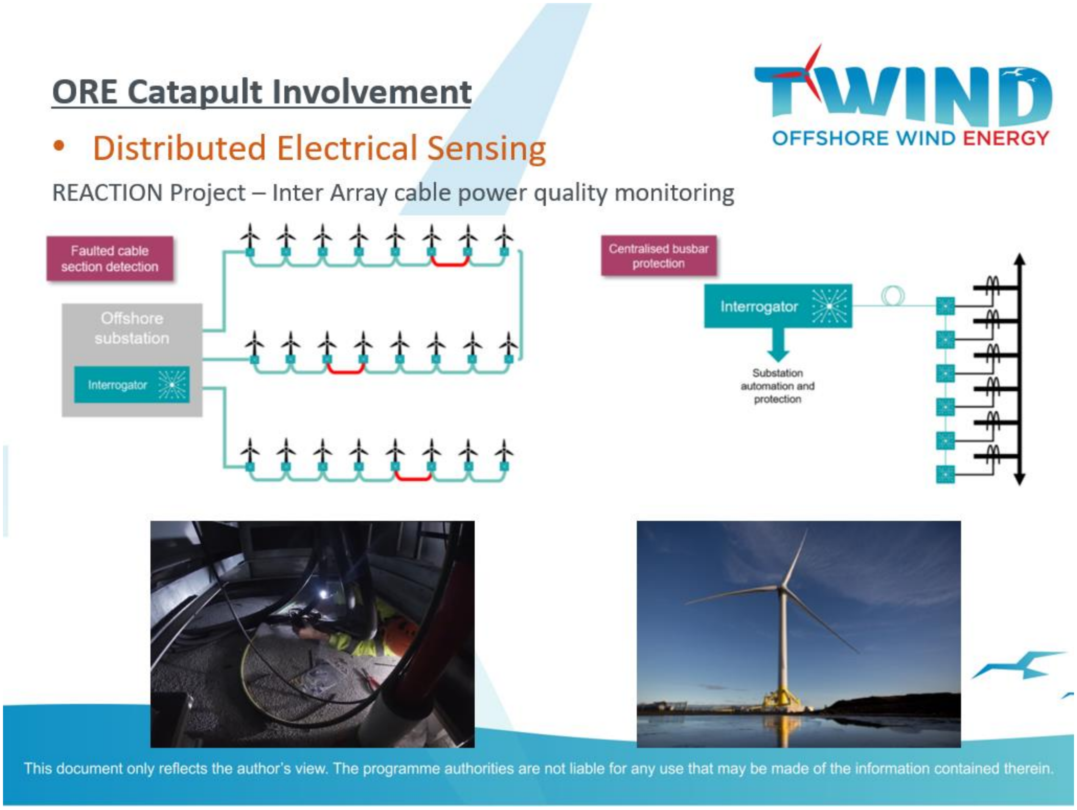
13.00 – Introduction and Round Table
13.15 - Dynamic Cable Design & Modelling
13.45 - Cable Validation
14.15 - Cable Condition Monitoring & Inspection
14.45 – Break
15.15 - Cable Reliability & Data Management
15.45 - Cable Protection Systems
16.15 - Cable El Topologies
16.45 – Wrap Up/Next Steps

Two of the topics from the agenda above are presented in more detail below:

3.3.2 Cable Condition Monitoring and Inspection

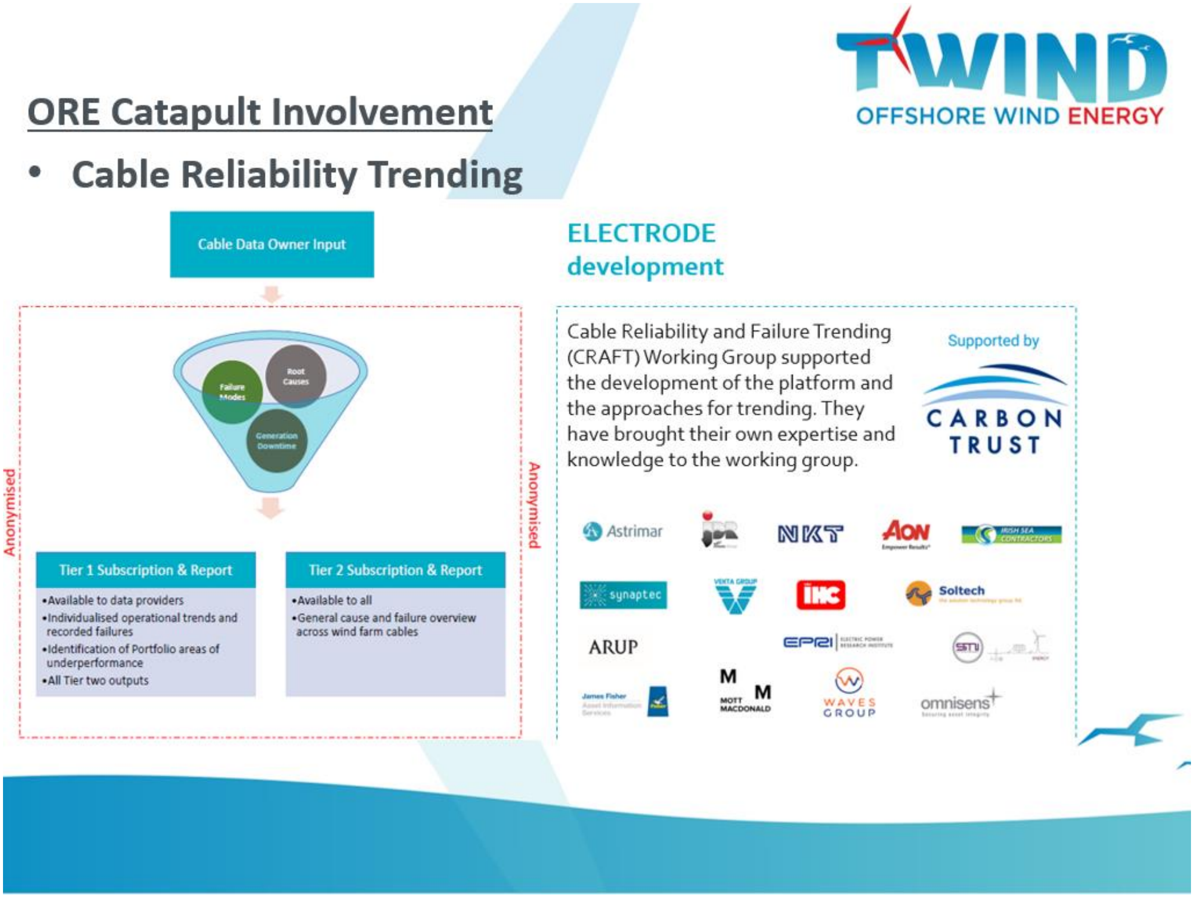
Real time monitoring of key offshore wind assets such as subsea cables is desirable, and several sensing technologies are under development that could provide viable future solutions. These include distributed temperature sensing (DTS), distributed acoustic sensing (DAS), distributed electrical sensing, and online partial discharge (PD) monitoring. The onset of floating wind and the need for dynamic cables makes such monitoring even more interesting as we are dealing with less mature and more complicated cable technology, i.e., a cable that is subject to dynamic mechanical fatigue as well as electrical fatigue.



Before these technologies become commercially viable, several challenges need to be overcome including data collection/analysis, condition monitoring optimization, and operational expenditure reduction through preventative maintenance (which is linked to the previous challenges). This presents future collaboration opportunities for the TWIND partners.

3.3.3 Cable Reliability and Data Management

Cable insurance claims are a large issue for the offshore wind sector (75-85% of OSW insurance claims are related to cables). Some cable reliability data is available in the sector, but it is limited and doesn't fully represent actual cable failure rates. There is a need for industry to work together (with project such as ELECTRODE to gather a reliable and central repository of cable data so cable reliability trending can be accurately performed.



As with cable condition monitoring, several challenges need to be overcome including cable data sharing (including data anonymity), failure mode recognition and reliable data from new technologies such as dynamic cables, joints, HVAC and HVDC cables. Nevertheless, this presents future collaboration opportunities for the TWIND partners.

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3.4 Hydrogen

The Hydrogen think tank took place at TU Delft on Friday the 21st of October. We had four sessions: Technology Development; Modelling and Simulation; Testing and Research Infrastructure; and best practice and sector activities. The following subsections give more detail on the material covered in each session.

3.4.1 Agenda

1) Introduction and round table 10-10.15am
2) Session 1 - Technology development 10.15-11am
3) Coffee break 11-11.15am
4) Session 2 - Modelling and simulation 11.15-12pm
5) Lunch and networking 12-1pm
6) Session 3 - Testing and research infrastructure 1-1.45pm
7) Coffee break 1.45-2pm
8) Session 4 - Best practice and sector activity 2-2.45pm
9) Wrap-up/AOB 2.45-3pm

3.4.2 Technology Development

This session covered the following points:

- Ratio of electrolyser capacity to wind farm capacity, and how a range of technoeconomic modelling studies have found that the cost of hydrogen is minimised when the capacity of the electrolyser is about 75 – 80% of the capacity of the wind farm.

- Methods of exporting wind energy. This can be electrical energy export through cables, or chemical energy export, through pipelines or ships carrying hydrogen, ammonia, or other chemical energy carriers derived from hydrogen.

- The potential for wind farms to link to electrical infrastructure, or for their power supplies to be dedicated to hydrogen production through electrolysis

- The role that hydrogen may play in achieving 2030 and 2050 offshore wind targets.

3.4.3 Modelling and simulation

In the second session, we covered the following points.

- We went into more detail regarding optimal sizing of electrolysers compared to wind farm capacity, how this affects wind farm and electrolyser capacity factors, and how this impacts the cost of hydrogen.

- We gave an overview of the main options of connection wind farms to electrolysers: centralised onshore, centralised offshore, and decentralised (offshore).

- We considered how a major ramp up of offshore renewable energy, in areas with limited electrical networks, will have significant implications for the energy system, and the role of hydrogen to integrate this new generation into the wider energy system.

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- We looked at how models can help us to understand the best use cases for hydrogen, and how this can inform long term energy planning decisions.
- We also covered some technical issues around producing hydrogen, such as desalination, use of excess heat, off-grid deployment, maintenance, and reliability.

3.4.4 Testing and Research Infrastructure

In the third session, we covered the following areas:

- How the use of grid emulation equipment can be used to conduct sophisticated electrical testing of electrolysers and other electrical equipment
- The benefits and disadvantages of large and small test facilities, and how a mix of sizes or good flexibility can cover the needs of both well established and start-up companies.
- The role of demonstration projects in advancing sectors. We outlined some potential demonstration projects that are in planning at the Offshore Renewable Energy Catapult.

3.4.5 Best practice and sector activities

In the final section, we examined:

- Health and safety considerations of powering electrolysis from offshore wind, looking at some of the aspects captured in a hazard identification study commissioned by ORE Catapult.
- Logistics and regulatory challenges. As hydrogen use (outside of a handful of industries) is relatively new, there can be challenges in accessing equipment and even hydrogen itself. When equipment/hydrogen can be accessed, there are then challenges in deployment from a regulation perspective, where regulators can effectively block government funded projects.
- We also covered other activities in the sector, such as the work of Fraunhofer IWES and the IEA's Task 25.

3.4.6 Summary

The Hydrogen think tank was an excellent opportunity to share findings of a range of studies in a hydrogen space, and to get up to speed on the activities of a range of organisations.

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4 CONCLUSIONS

The TWIND project has delivered four think tank events, which is one more than the target of three set at the beginning of the project.

The TWIND project has enabled substantial knowledge sharing opportunities, especially delivered through the four think tank events. These events have presented the TWIND partners with an opportunity to engage in deep dive technical presentations and discussions around the challenges and technology-based solutions in four research topics well aligned with several of the eight research themes identified in deliverable, D2.2.

This has helped to boost understanding across the research organisations of the Offshore Renewable Energy Catapult, Tecnalia and WavEC, as well as the university TU Delft. These organisations are well placed to capitalise on these learnings and thus help Europe to meet its climate targets and supporting offshore renewable energy targets.

The four think tank events covered:

- Numerical modelling, with sessions looking at problems currently being investigated with numerical models, an overview of relevant projects, and modelling electrical aspects of offshore wind
- Data analytics and digital twins with specific examples showcased for how data analytics can help power module degradation monitoring/management and how digital twins can help operate and maintain physical assets such as wind turbine blades
- Subsea and dynamic cables, with sessions giving an overview of cable design, modelling and validation, condition monitoring and inspection, reliability and data management, protection systems, and EI cable topologies.
- Hydrogen, with sessions looking at technology development, modelling and simulation, testing and research infrastructure, as well as best practice and key sector activities.

Based on the TWIND priority research topics outlined in deliverable, D2.2, all topics covered by the four think tanks present key issues for the Portuguese offshore wind sector. Each topic has been addressed in detail and each partner organization has contributed input into the sessions from both senior and junior staff members. The think tank sessions have identified avenues and topics for further R&D collaboration to address the sector challenges and develop the technology-based solutions, many of which are still emerging. The think tanks have also presented an excellent training opportunity for junior research staff (and this was evident in the attendance of many junior researchers at some of the think tank sessions).

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