Next level wave intelligence for floating wind farms (FOWF)

It could meet Europe's electricity demand seven times over, and the United States' electricity demand four times over. In the last decade, offshore wind power has developed from an expensive rookie to a competitive source of energy. As the world's interest in offshore wind grows, there is a rapidly growing need for cost-effective solutions. But as always, there are some major challenges.

Traditionally, offshore wind has been focusing on bottom-fixed parks due to the proven design, the shallow waters and the easy accessibility. However, most other potential areas have much deeper nearshore waters which are not suitable for bottom-fixed turbines. The challenge lies in making these areas accessible for offshore wind. Floating wind technology enables wind turbine installation in deeper waters not suitable for bottom-fixed turbines. As the name implies, a floating wind turbine is not permanently fixed to the seabed but floats. It's kept in position by a mooring system.

As the offshore renewable energy sector grows, efforts to develop the technology needed for the floating wind market are also increasing in scale and scope. Most of the commercial floating wind farms are still in the development phase. The main aim is to analyze the behavior of the assets under real operational and extreme conditions and gain real-life knowledge from the construction, operation, and maintenance of the unit. The collection of data is key in this process.

Why is wave data important?

Like bottom-fixed turbines, the operations offshore to construct and maintain the floating turbines are hugely affected by the wave conditions. Weather and waves are a major risk factor for offshore operations. Especially waves contribute to the downtime during projects as the work is only allowed to limited wave conditions for safety reasons. This applies to all offshore operations; floating offshore wind farms are no exception.

Obviously floating wind brings extra challenges due to the deep water, the distance to shore and the broad spectrum of forces in the floating construction. Wave measurements provide crucial input for testing and validating the different designs of floating solutions like semisubmersibles, tension leg platforms or floating spar buoys. During these projects data will be collected to analyse how the construction behaves in (extreme) wave conditions. And the dynamic performance will be compared to the models.

Each turbine is equipped with measurement systems. The loads in the construction of the foundation and turbine are measured with strain gauges. The wave and wave direction have impact on absorbed loads and movements by the foundation and the turbine itself. Besides, measuring the water levels on the different floaters or beams (depending on the design), gives insight of the tension on the mooring lines. The measurements can validate the loads under different wave heights and wave directions. All this data is used to stay within the design limits of, for example, the pitch of the turbine.

How to measure the waves?

As floating turbines are typically installed in deep water, most wave measurement methods like buoys are not available or quite challenging and expensive in deployment. Measuring the waves by radar from the turbine itself is an interesting and cost-effective solution. In addition to the advantages of dry and maintenance free measurements, it's highly accurate.

Radac is known for its reliable wave radars used in the offshore wind as well as the offshore oil/gas industry. Their unique directional wave monitoring system which consists of three wave radars, becomes the first choice for many offshore wind farms. Several prominent contractors decided, after a comparison study of three to six months, to replace wave buoys with this wave radar system.

Recognizing the importance of accurate wave data in order to develop and validate the floating constructions, Radac saw it as its responsibility to design an accurate monitoring solution. Numerous hours of technical discussions and workshops with our clients were put into this project. Proudly they can now present a fully motion compensated system to measure waves (height, period, direction) from a floating wind turbine.

Measurement principle

The radar principle used is FMCW (Frequency Modulated Continuous Wave). The FMCW-radar transmits a high frequency signal whose frequency increases linearly during the measurement phase (called the frequency sweep). The signal is emitted, reflected from the measuring surface and received with a time delay. The difference calculated from the actual transmit frequency and the received frequency is directly proportional to the distance. This leads to a highly accurate and direct measurement of the wave height, in contrast to the navigation or pulse radar.

With an array of three radars, the elevation of the sea surface is measured at three positions. These positions form a virtual triangle at the water surface by pointing one radar perpendicularly downwards and tilt the other two by 15 degrees. The principle of operation is based on the synchronized measurements of sea elevation (heave) at these three spots. Using these measured elevations, the water surface slopes are calculated relative to two perpendicular horizontal axis. Hence the wave direction can be determined.

An integrated motion sensor in each of the radars compensates for the roll, pitch and heave motions.

PES wanted to delve deeper and were very happy that Rolf van der Vlugt, Managing Director and Tuna Sener, Business Development Manager agreed to answer some questions.

PES: Hi it's a pleasure to welcome you both to PES Wind. To begin with would you like to introduce us to Radac?

Tuna Sener: Absolutely, it's my pleasure too. Radac is a Dutch technology company focusing on the marine and offshore industries by developing the most advanced wave monitoring solutions that the industry can take advantage of.

This year, we are celebrating our 25th year of customer-centric operations and as it was in the past, going forward, our focus is to apply the cutting-edge radar technology into a simple to use wave radar that is suited to the harsh conditions of the offshore environment. We have a strong team with experts and a natural interest for sea. We even have the World champion kitesurfing in our team!

PES: Of course, we know you work in several sectors, but which do you feel is the most important and which ones you are currently developing?

TS: Currently, we have four key focus areas. Offshore wind, Oil & Gas, vessels and ports. Within these sectors, offshore wind plays an important role in our developments. Floating wind farms indicate a promising future, but to achieve the successful integration of our systems we had to go beyond the expectations and that's what we did with our motion compensated directional wave radar system. More interesting news still to come.

PES: It would be interesting to know where your main clients are based and if this has changed over the years, any geographical interest?

TS: Europe is still an important market for us. But over the years, we are expanding rapidly and globally. Today, our systems are installed in every corner of the World from largest projects down to the local installations. In today's market, Far East Asia and the USA are the hotspots where our systems are appreciated.

PES: Just how important is the weather to operations at sea?

TS: Both the weather and waves are very important for any offshore operations. They define and draw the line for safety, workability and accessibility while our systems are often used to finetune the weather forecasts. By knowing exactly what is happening around the construction in Real-Time, contributes to reducing downtime and supports the decision making process.

PES: Can you tell us about the development of the wave radar for the floating turbines?

Rolf van der Vlugt: It was quite a natural progression, where we combined two of our existing products into a more advanced level. Our WaveGuide 5 Direction is becoming the standard in the offshore wind industry. It's suitable for fixed turbines and transformer platforms to measure wave height, wave direction, wave period and tidal parameters.

On the other hand, we have the WaveGuide 5 Onboard 2 to measure wave height and free board from a vessel, for example an offshore construction vessel, multi support vessel, pipelaying vessel and so on. This single wave radar is compensated for the motions of the vessel.

Combining these products to create motion compensated directional wave information was a logical step. Our clients had shown interest in it for some time already and asked us to develop such a system. It turned out to be a very interesting and challenging project. At first it might look as a simple subtraction sum. But the challenge lies in the testing and validation.

Tuna Sener

Rolf van der Vlugt

As a lab environment has its limits to test a system with three radars moving with different frequencies of roll, pitch and heave, a simulation software needed to be built. We had to go quite far into the simulation of the sea and the specific movements and frequencies of the floating turbine to be able to test and validate our software. We're pretty proud of the simulation environment we build and the performance of our final product.

PES: Are you currently working on any projects, or future projects you can tell us about?

TS: At Radac, we are continuously working towards smarter, innovative products and improving, customer-focused systems. This being said, we might have some other surprises in the near future. So, I say, stay tuned!

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