DHI CASE STORY

PREDICTING SCOUR IN OFFSHORE WIND TURBINES – NOW A BREEZE

Making offshore wind energy more viable with long-term scour prediction tools

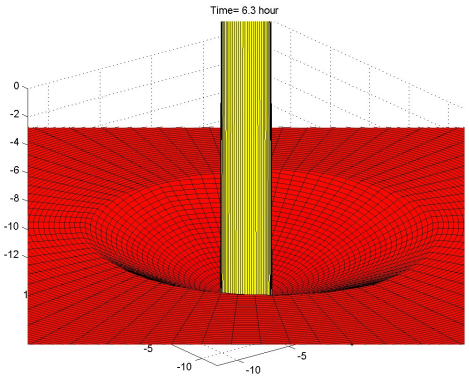
The total offshore wind power capacity is expected to touch 75GW by 2020 and the possibilities are immense. However, the offshore wind energy industry is still stricken with the burden of heavy capital investments. Our newly developed tool – 'WiTuS' can lighten that load. With WiTuS, we can predict long-term mono pile scouring – this can help in simplifying turbine designs, effectively reducing the investment required.

OFFSHORE WIND FARMS DEMAND A HEAVY PRICE

Offshore wind power refers to electricity generated from wind in wind farms constructed in water bodies. Offshore wind farms are expensive – investment prices can touch €3million/MW. The installation of the offshore wind turbine is a complex procedure. It generally comprises one third to half of the total investment in the wind farm, while the rest is comprised of infrastructure, maintenance and oversight. Also larger turbines with more energy capture capability, make more economic sense, when starting an offshore wind project. Thus, the larger the turbines, the greater the investment costs.

THE MONO PILE – ROOTED IN MOVEMENT

Although deep water floating wind turbines are being developed, most offshore wind farms today still utilise traditional fixed-bottom foundation technologies. Different types of foundations are used depending on the depth of water at which the turbine is being installed. These include monopile, gravity based, tripod, suction bucket and conventional steel jacket structures. Of these, monopile foundations have been the preferred foundation type so far. This is owing to the fact that they have an edge over other foundation types in shallow water, mainly with regards to construction, production, assembly and cost efficiency.



Example of a predicted scour hole, using WiTuS

A monopile foundation utilises a single pile structure driven 10-40m into the seabed

SUMMARY

CLIENT

This is a research project funded by the Danish Council for Strategic Research (DFS)/ Energy and Environment

CHALLENGE

- Protect wind turbine foundations against scour
- Heavy investment (up to €150,000/turbine) in scour protection due to lack of long-term predictability

SOLUTION

Our tool 'WiTuS' enables prediction of scour around mono piles over long time spans

VALUE

- Long-term scour predictions can slash scour protection investments by as much as €150,000/turbine –this is approximately 6-10% of the total average project cost
- This tool is customized to forecast scour around monopiles. However, it can be applied to any offshore and coastal pile-structure where long-term scour development is an issue
- If the environmental conditions are predicted, scour development around the structure can be better forecasted

depending on the expected loads on the wind turbine. When the monopile is installed, it rises 10-15m above the mean sea level. The wind turbine is later placed above it. As such, the monopile has to support all the loads on and from the wind turbine as well as loads from waves on the foundation.

Many of the planned offshore wind farms are going to be installed on monopile foundations at water depths ranging between 10-30m and generally at distances within 12km from the shore. The coastal sediments in these areas are often defined by sand and silt, making the seabed very mobile. At such locations, the wave and current interaction with the foundation has a significant effect on the total load on the turbine (nearly 50%). One of the most prominent risks to the offshore foundations is scouring, which occurs due to the constant wave and current action.

SCOUR RISKS AND STEEP PRICES – WHY SCOUR PREDICTION IS THE NEED OF THE HOUR

The presence of a monopile in a marine environment changes the flow pattern in its immediate neighbourhood, resulting in an increased local sediment transport. This causes scouring of the seabed around the monopile – in layman's terms, it is 'eaten away'. This is a serious risk. If there is excessive excavation of the immediate seabed, the stability of the wind turbine foundation can be gravely compromised. Also, the structure can suffer increased hydraulic loading. The cables on the seabed which transport electricity generated by the turbine, can be exposed to bending stresses beyond the design conditions, due to the eroded seabed around the monopile. Owing to the abovementioned threats, monopiles have to be protected against the effects of scouring. Although such protective measures are available, the dearth of long-term scour forecasting makes it imperative to heavily invest in fortification of the monopile. Today, scour protection for one wind turbine is estimated at €80,000 to €150,000. This is a steep price to pay and it adds on to the already high investment costs of setting up an offshore wind farm.

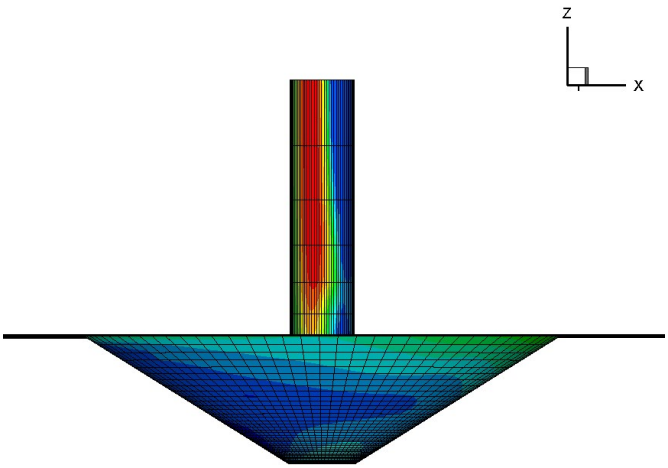
If long-term predictions of scour development can be made, heavy investments in scour protection measures can be offset to a large extent.

GAZE INTO THE FUTURE WITH OUR TOOLS, SAVE ON INVESTMENTS

Scour has been studied extensively in the past few decades, but very few investigations have been dedicated to the long-term forecasting of scour around offshore structures. Tide motions give rise to coastal currents, which in turn emerge as the primary driving forces of scour. Different coastal and offshore sites which have been identified for wind farm development, can differ significantly in terms of coastal bathymetry, shoreline geomorphology & orientation and exposure to the effects of waves and currents. Also the sediment composition at each site is unique to itself. All these factors and variables have to be taken into account when studying the scour around monopiles.

With WiTuS, we can predict long-term scour developments around monopile foundations. By becoming capable of predicting the exact scour/erosion depth, the estimations of loads and the fatigue life of the wind turbine can be improved. Armed with such predictive information, you can opt for simpler and cheaper designs for your wind turbine, without compromising on safety.

For example, for some wind farms, where only a very light scour is predicted, it might be more economical to discard the idea of scour protection altogether. However, in some areas, it is not wise to leave monopiles unprotected. It is a well-known fact that horseshoe vortices are majorly responsible for scour around unprotected monopiles, especially where the current action is more prominent. The vortices from the horseshoe and the lee-wake are also known to undercut scour protection. With WiTuS, we can take these variables into consideration, when foresting long-term scour developments in such areas. Accordingly, you can plan the accurate measure of scour protection for your wind turbine foundation and save on investment costs in the process.



Typical shape of a scour hole around a monopile

MORE TO IT THAN MEETS THE EYE

- WiTuS empowers you to forecast the scour development at a monopile more accurately, if environmental conditions in that area are predicted with similar accuracy.
- The special advantage of this tool is that, it can be used for any kind of offshore and coastal pile structure, where scour development over long time spans is a hindrance or an issue.

Contact: Martin Dixen - mdi@dhigroup.com
For more information visit: www.dhigroup.com