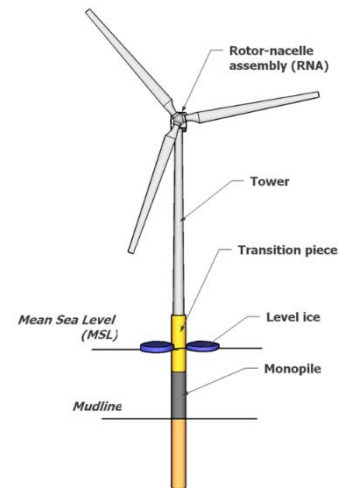


Mitigation of ice-induced vibrations of offshore wind turbines by Control Idling

Offshore wind farms are being developed at locations with moderate ice conditions such as the Baltic Sea, where drifting sea ice upon interacting with offshore structures could lead to the development of a phenomenon known as Ice-induced vibrations (IIV). These vibrations are especially severe when the turbine is idling. Current mitigation measures consist of an expensive solution of ice cones, which are only favourable when ice occurs seasonally.

The main objective of this study is to investigate numerically a novel approach to mitigate the ice-induced vibrations of offshore wind turbines by means of control idling.

Three regimes of IIV are generally distinguished, viz. intermittent crushing (ICR), frequency lock-in (FLI), and continuous brittle crushing (CBR). Among these regimes, the ICR and FLI can cause significant vibrations in the offshore structure. Preceding the ice action, the rotor aerodynamics during the parked condition shows that for the wind speeds below the cut-in wind speed of the rotor, the turbine operates in the unsteady aerodynamics termed as dynamic inflow.



The comparative analysis is made between the two cases: one with the ice action only, and, the other with the combined effect of ice and wind, where the rotational rotor speeds chosen are 3.0rpm, 6.9rpm and 12.1rpm. In the ice-action case, it is found that the structural response frequency during the ICR and FLI is around the first and the second natural frequency of the structure, respectively. In the case of ice and wind, it is found that the unsteady BEM method has certain limitations, especially in the ICR regime. Furthermore, the aerodynamic damping has no notable effect on the range of IIV regimes for the rotor speed of 6.9rpm and 12.1rpm. However, it does have a significant effect for the rotor speed of 3.0rpm. The quantitative comparison of fatigue damage between the two cases showcases that for the majority of ice-sheet velocities during ICR and FLI, the damage is found to be greater in the ice and wind case. Based on the results, it is concluded that the rotor aerodynamics does help in damping the vibrations in the ICR regime, but in the FLI regime, it has no significant impact when specific ice-drift speeds are considered.

It can also be confirmed that by the careful selection of the rotational rotor speed, the range of IIV regime can be influenced. However, to draw the general conclusion, the analysis needs to be conducted for varied ranges of rotor speeds. Also, the present framework of the aerodynamic model needs to be improved to capture the vortex-ring flow state to predict the rotor aerodynamics accurately for all the ice-sheet velocities.