Modeling of Noise Produced By Offshore Wind Turbines with Different Foundations and Effects on the Marine Environment

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Abstract

Vibration produced by offshore wind turbines during their normal operation transmits through the tower into the foundation where it interacts with the surrounding water and is released as noise. The noise produced by offshore wind turbines can be detected by fish and marine mammals and may lead to alteration of their behavior. Given that noise is emitted at the interface between the foundation and water, it is likely that the intensity and frequency of the noise will be strongly affected by the nature of the foundation. Factors that may affect the nature of the noise emitted are the surface area of the foundation, the material used to construct the foundation and its internal damping and the nature of the connection of the foundation to the sea floor. There are many designs of foundations including, jackets, monopiles and gravity bases; each of which will have different noise emission characteristics.

An acoustic-structural interaction model developed in COMSOL Multiphysics® was used to model the underwater sound-field around different foundation types that support a 6 MW wind turbine (Figure 1). The level of vibration and resulting sound levels were modeled for different wind speeds. The propagation of vibration related to components in the drive train of the turbine, such as the gearbox and generator, are modeled as they move through the tower into the foundation and surrounding water column. The resulting sound fields were then compared to hearing sensitivity of marine mammals such as whales, seals and bottlenose dolphins to determine whether there was risk of harm to these species.

The sound field surrounding all foundations were strongly tonal with peak levels associated with the gear meshing frequencies in the gearbox. The monopile produced the highest sound pressure level (SPL) of the foundations at lower frequencies (< 200 Hz), with levels of 147 dB within 5 m of the foundation at 125 Hz. The jacket produced the highest SPL at high frequencies (>500 Hz) with 177 dB at 700 Hz and 191 dB at 925 Hz within 5m of the jacket.

The modeled noise levels are likely to be audible to marine mammals. Jacket foundations generate the lowest overall marine mammal impact compared to monopile and gravity foundations. Species with hearing specialized to low frequency, such as minke whales, can sense the wind farm at least 18 km away and are the species most likely to be affected by noise from operational wind turbines. Harbor seals, grey seals and bottle nose dolphins are not considered

to be at risk of displacement by the operational wind farm modeled. It is unlikely that any marine mammals would experience auditory injury as the result of operational wind farm noise.

Figures used in the abstract

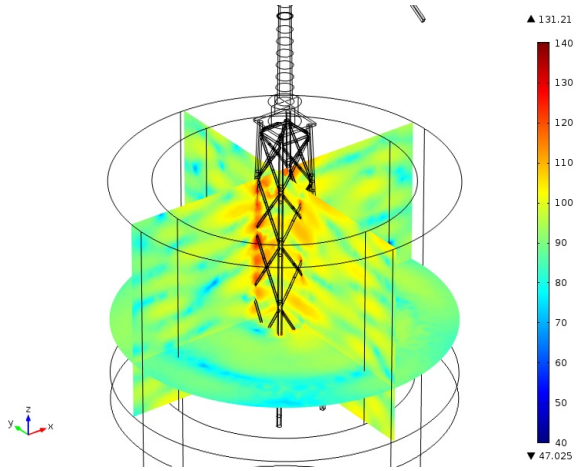

Figure 1: Sound field at 125 Hz surrounding a jacket foundation supporting a 6 WM wind turbine operating in 15 m/s winds