MODELING THE UNDERWATER NOISE ASSOCIATED TO THE CONSTRUCTION AND OPERATION OF OFFSHORE WIND TURBINES

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Abstract – The operation and in particular the construction of offshore wind converters induce considerable underwater noise emissions. It is assumed that small whales and seals can be affected by noise from machines and vessels, piling and installation of the wind turbines. Piling, in particular using hydraulic hammers creates impulsive noise with considerable high energy levels. Currently, only little knowledge about the effects of different noises to marine life is available. Here, we present the objectives of the ongoing project of the Laboratory of Applied Bioacoustics (Technical University of Catalonia): to simulate the generation, radiation and propagation of underwater noise; to develop forecasting hydro sound models of offshore wind converters and future noise reduction methods during pile driving; to determine the impact area of offshore wind farms; to allow the formulation of recommendations for acoustic emission thresholds; and to develop standard procedures for the determination and assessment of noise emissions.

Keywords – Offshore wind farm, pile driving, underwater noise.

I. INTRODUCTION

Several control measurement campaigns have been conducted during construction of several wind farms in Europe, specially in Great Britain and Germany [1] [2], but the lack of accurate models on sound generation and propagation in shallow water scenarios and on the scientific evidence of the effects on marine life prevents to make a decided call for legislation on mitigation mechanisms, maximum levels, safety distances from specially sensitive areas, etc. We propose to develop propagation models to assess the structural and environmental radiating noise directly produced by the construction and operation of wind turbines.

II. PILE DRIVING

Wind turbines are usually anchored to the sea bed with cylindrical steel piles that are held in place by vibration or impact hammers. The impact of these hydraulic hammers during the piling process introduces a significant acoustic energy that propagates into the marine environment and, as do other high intensity sources, may affect marine organisms [3] [4]. The structural vibration induced can be modeled using finite element simulation (FEM). For the environmental noise induction and propagation, other methods like boundary element simulation (BEM) or multipole expansion (FME) can be better suited. Long-range propagation of sound must also be simulated accounting for the complex waveguide-like scenario of the shallow waters where wind farms are constructed (wavenumber integration methods).

In order to obtain reliable results from numerical simulations of the complex mechanism of generation of transient signals and radiated noise, it is necessary to know the impact force applied to the system over time and the response of the pile at this impacts. One of the characteristics of the hammer is the maximum impact energy (for instance a hammer IHC 250 piles of 1.5 m for the maximum energy is 280 kNm). Based on experimental measurements provided by accelerometers installed in existing wind farms, one can provide the maximum power to set the input function into the simulation program. Once the data of the sound source is characterized, the use of numerical models must serve for predicting the level of noise produced by the hammer impact at any point in space.

III. WIND FARM OPERATION

The noise generated by the routine operation of the mills will also be simulated using wave propagation algorithms in shallow waters, allowing the estimation of the noise radiated from an hypothetical number of different elements (Mills) and a variety of environments. In terms of sound levels, the last process is crucial to advise on the noise introduced in the environment and accordingly decide on the maximum number of elements that would compose a sustainable windfarm field. The very specific shallow water (less than 20m) scenario, where the effects of reflections from surface and bottom can be assessed and the structure of the problem is roughly constant over distance a propagation model based on wavenumber integration or normal mode analysis with multiple sources can be performed.

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