

DOSITS Webinar > Underwater noise from wind turbines

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Noise from rotating wind turbines is a major issue for land-based wind farms, as levels are sufficiently high to be a nuisance to humans and long-time exposure could even pose health risks in some cases. This led early on to a concern for possible effects of underwater noise in the marine environment from offshore wind turbines. However, the nature of the underwater noise from wind turbines is very different from the air-borne noise and experience therefore cannot be immediately transferred from air to water.

Source of the noise

Air-borne noise from wind turbines is primarily generated by the air moving over the wings at high speed, generating a 'whoosh' sound, which can be heard hundreds of meters away. This noise from the wings is of course also generated by offshore turbines, but most of this noise is reflected at the sea surface and therefore it does not contribute in any noticeable degree to the noise in the water. The noise radiated into the water originates instead in the mechanical gears, bearings and generator of the turbine and is transferred down the tower, through the foundation and radiated into the water and has a distinctive 'grinding' sound.

Spectrum of the noise

The noise radiated into the water and measureable above the ambient noise is at low frequencies, in most cases below 1000 Hz, and with peak energy somewhere between 50 Hz and a few hundred Hz, and is dominated by energy at single pure tones between 50 Hz and a few hundred Hz together with harmonic overtones. These pure tones correspond to the so-called tooth mesh frequency of the gears, i.e. reflecting the rate at which the individual teeth of the gears engage each other. Depending on the type of turbine and gears, the peak frequency can change with wind speed or remain constant. The latter is especially the case in earlier turbines that rotate at a constant speed independent of wind speed, due to the single gear and asynchronous generator.

Level of the noise

Sound pressure levels measured in the water are comparatively low, in the range up to 130 dB re. 1 μ Pa and measured at distances of 10-100 m from the foundation. There does not seem to be a clear relationship between turbine size (measured as nominal capacity) and noise level. This is likely due to factors such as height of tower and diameter of foundation that scale negatively with emitted noise levels and thus counterbalancing the larger output of acoustic energy at the sources in the nacelle. The noise level increases with the load on the turbine, and thus with the wind speed. Although limited data is available, this increase appears to be more or less offset by a similar increase in ambient noise at higher wind speed, which means that the audible range of the noise is largely unaffected by changes in wind speed.

Potential impact

Potential effects are more likely to be found in species with good low frequency hearing, such as fish, baleen whales, and seals, rather than odontocetes, which have poor hearing below 1 kHz. As the level of the noise is low compared to noise from ships, the largest potential impact ranges are likely to be found in wind farms located in areas further away from busy shipping lanes. There is an almost complete lack of understanding of the effect of the hydrodynamic sound field on animals with particle motion sensitive hearing (fish and invertebrates).

DOSITS Links:

Animals > Potential Effects > Anthropogenic Sound Sources > Wind Turbines
<https://dosits.org/animals/effects-of-sound/anthropogenic-sources/wind-turbine/>

Decision Makers > Structured Tutorials > Anthropogenic Sound Sources
<https://dosits.org/decision-makers/tutorials/sound-source/>

Science of Sound > Introduction to Signal Levels
<https://dosits.org/science/advanced-topics/introduction-to-signal-levels/>

Science of Sound > Sound Pressure Levels and Sound Exposure Levels
<https://dosits.org/science/advanced-topics/sound-pressure-levels-and-sound-exposure-levels/>

People and Sound > How is sound used to research wind energy?
<https://dosits.org/people-and-sound/examine-the-earth/how-is-sound-used-to-research-wind-energy/>

Audio Gallery > Wind Turbines
<https://dosits.org/galleries/audio-gallery/anthropogenic-sounds/wind-turbines/>

DOSITS Hot Topic > Monitoring the Construction of the First U.S. Offshore Wind Farm for Potential Noise Impacts on Marine Life
<https://dosits.org/hot-topic-monitoring-wind-farm-construction/>

DOSITS Hot Topic > Ocean-Based Renewable Energy
<https://dosits.org/hot-topic-ocean-based-renewable-energy/>

Additional Resources:

Betke, K. 2014. Underwater construction and operational noise at alpha ventus. *In Ecological Research at the Offshore Windfarm alpha ventus.* 171-180. Springer, Berlin.

Madsen, P. T., M. Wahlberg, J. Tougaard, K. Lucke, and P. L. Tyack. 2006. Wind turbine underwater noise and marine mammals: Implications of current knowledge and data needs. *Marine Ecology Progress Series* **309**:279-295.