Effect of inflow conditions on the source noise of large onshore wind turbines
zEPHYR Marie Skłodowska-Curie project: towards a more efficient exploitation of on-shore and urban wind energy resources

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CONTEXT

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The strong increasing demand on renewable energy forcing also a further extension and development of on- shore wind energy. New built or re- powered wind turbines with large rotor diameters lead to an improved performance but goes in hand with an increased noise emission. Therefore, a noise optimized design and noise mitigation concepts are essential in order to fulfil requirements on admission and increase public awareness.

Next to airfoil self noise, where noise is scattered at the blade trailing edge, the interaction of atmospheric turbulence with the leading edge is a potential noise source. Atmospheric turbulence hardly depends on weather and terrain conditions and the impact on noise emission through the interaction with the blade leading edge is largely unknown.

PROBLEM DEFINITION

The design of wind turbine blades requires an iterative process in order to generate an optimal shape for high aerodynamic performance and low noise emission. Numerical noise prediction tools might provide accurate solutions but they are associated with high costs and large computation times.

Analytical and semi- empirical noise prediction models offer the possibility for fast and accurate results, but underlaying partly geometrical restrictions [1]. To improve the state of the art inflow turbulence noise prediction models, a deeper understanding of the flow noise behaviour around the leading edge is necessary. Especially for the design of future noise mitigation technologies, reliable turbulence noise prediction models are essential.

OBJECTIVES

The accuracy of available analytical inflow turbulence model decreases for non- flat airfoil geometries [2]. This effect seems to be related to the turbulence distortion around leading edge [3]. Therefore, a detailed description of the distortion behaviour and the effect on the far- field noise emission is investigated. The gained perception are used to improve existing 2D inflow turbulence noise prediction models and later extended on 3D application. In a further step, noise mitigation technologies are explored and tested for 2D and 3D test cases.

METHODOLOGY

The focus lies on experimental testing of 2D airfoils in aerodynamic/ acoustic wind tunnel facilities combined with numerical methods. Inflow condition of wind fields will be reproduce for the planed tests to mimic realistic conditions.

[1] Amiet, R.K., "Acoustic Radiation from an Airfoil in a Turbulent Stream," Journal of Sound and Vibration, Vol. 41,No. 4, 1975, pp. 407–420. doi:10.1016/S0022-460X(75)80105-2
[2] Moriarty, P., Guidati, G., and Migliore P., "Prediction of Turbulent Inflow and Trailing-Edge Noise for Wind Turbines" 11th AIAA/CEAS Aeroacoustics Conference, 2005
[2] Moreau, S., and Roger, M., "Competing Broadband Noise Mechanisms in Low-Speed Axial Fans," AIAA Journal, Vol. 45, No. 1, 2007, pp. 48–57. doi:10.2514/1.14583

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