Wind energy is a clean, renewable source of energy for meeting the enormous energy demands of our modern world. Sound emission from wind turbines cause annoyance and hindrance to daily life for people living in and around wind farms. It is the main reason for the reluctance of the general public to use wind energy extensively. This has forced a global initiative to reduce noise levels that cause environmental and psychological concerns to human beings. Thus, necessitating innovative noise mitigation strategies. Given the stringent regulations imposed by governments on permissible sound levels for wind turbines, noise mitigation is of utmost significance and a design parameter rather than a post-production fix.

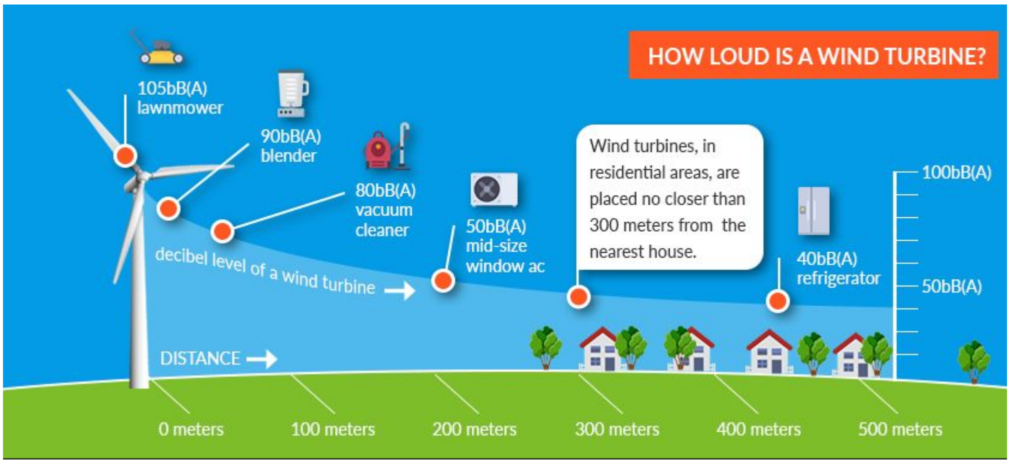

Figure 1: Noise levels of various daily life appliances. Source: www.letsgosolar.com.

The challenges facing the noise mitigation goals are that firstly, the physics and mechanism of sound generation and propagation is not fully understood. Secondly, noise control without compromising the performance is difficult. With additional industrial constraints such as feasibility, extra weight, maintenance etc, the trade off between performance and noise level reduction poses a challenge.

Flow and acoustic analysis of wind turbines operating in design conditions are extensively available. However, the rotor blades are subjected to non-uniform inflow conditions, large variations of angles of attack, leading to adverse pressure gradients. This causes boundary layer flow separation leading to aerodynamic losses, stall, fatigue loads, thus reducing performance and increasing energy costs. To tackle this, a particular flow control device - Rod Vortex Generators (RVGs), have been implemented to suppress/delay flow separation by creating streamwise vortices along the blade surface. Do these rods increase the problematic low frequency noise that propagates long distances (heard by residents living near wind farms)? The main objective of this project is to investigate the acoustic impact of streamwise RVGs.

To assess this acoustic impact, two approaches are undertaken - acoustic and flow measurements are conducted for a wind turbine airfoil with/without RVGs and the popular numerical Computational Aeroacoustic (CAA) approach to develop an in-house aeroacoustic code. Beamforming techniques will be investigated for analysis of the acoustic measurement data to estimate the noise sources emitted by the vortex generators and the boundary layer separation zone. Velocity profiles obtained from the Particle Image Velocimetry (PIV) analysis will further provide details on the impact of streamwise vortices on the boundary layer separation.

The aeroacoustic code is a general tool based on the integral solution to the Ffowcs-Williams and Hawkings acoustic analogy (FW–H). This code is capable of analyzing the total noise and its components (near-field and far-field contributions), both in time and frequency domains. Utilizing these capabilities of the code allows for a deep understanding of the physics of noise generation thus allowing to optimize the position/orientation of the vortex generators to decrease noise levels. It can be utilized for investigating wind turbine rotors, helicopter rotors, propellers, Unmanned Aerial Vehicles (UAVs) etc.