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18. abstract

1. Current State of Science and Technology

The expansion of wind energy is central to the energy transition but leads to conflicts with species protection, as wind turbines (WTs) pose a significant mortality risk for bats. Established monitoring methods—transect walks, mist netting, stationary ground detectors, and optional nacelle monitoring—only partially capture activity in collision-relevant rotor heights (60–250 m) and do not provide timely data for adaptive shutdowns. Initial research shows that drones can theoretically enable acoustic bat detection, but technical limitations remain (high noise levels, short flight times, unclear ecological effects).

2. Objective

The Drones4Bats project aimed to systematically develop drone-based detection methods, evaluate them ecologically, and assess their potential use during the construction and operation of WTs. The overarching goal was to mitigate the "green-green dilemma"—climate protection through wind energy vs. species protection—by providing more precise data and potentially adaptive operational strategies. Expected benefits for the wind industry include reduced shutdown times, scientifically grounded approval processes, lower ecological risks, and secured energy yields.

3. Method

The project combined technical development, laboratory investigations, and ecological field tests. Multicopter and lighter-than-air systems were equipped, reconfigured, and partly newly developed (propeller/ESC optimization, microphone placement, software, autonomous charging and landing platforms). Acoustic emission measurements up to 100 kHz, aerodynamic analyses, and microphone positioning tests were conducted to minimize noise. In parallel, standardized field experiments were carried out in two application scenarios: (1) transect monitoring before WT construction, (2) detection at existing WTs including deterrence studies, statistical analysis, and comparison with conventional methods.

4. Results

Technically, drone-based detection was successfully demonstrated. Ultrasound noise sources were identified and reduced, stable flight platforms with real-time data transmission and automatic charging infrastructure were established; signal detection was improved despite residual noise. Ecologically, deterrence tests showed species-specific behavioral effects ranging from none to slight deterrence. Drones provided additional activity data at heights of 60–180 m, which in several cases differed from patterns recorded by ground-based detectors, representing a genuine gain in information. Compared to nacelle monitoring, additional detection zones could be covered.

5. Conclusion and application potential

The project found that drones are a suitable complementary monitoring tool for the wind energy sector—especially at rotor blade heights. Potential applications include:

(1) Permitting – improved data basis before WT construction;

(2) Operation – supplementary use for adaptive shutdowns and reduction of energy losses;

(3) Species protection – more precise risk assessment in the aerial habitat.

Currently, deployment is not fully standardized but is technically feasible, ecologically acceptable, and promising from an industry perspective. Future steps include standardization, further development of low-noise drones, legal frameworks for autonomous drone use, and integration into guidelines.

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