ABSTRACT

The ever-existing source of energy, based on wind, has undergone significant practical development in the past century. Two principal zones of application can be distinguished. The first concerns high-power output systems, which have converged towards a single solution: the three-bladed horizontal-axis rotor. This approach, however, is accessible only to highly developed industries and requires substantial financial resources. The second zone of interest involves small-scale turbines, which have been developed intensively in recent decades. While initially implemented for individual use, such systems are now increasingly being deployed in densely populated urban environments. Unlike large-scale wind energy, this sector has not converged to a single technological solution. Instead, there is a wide spectrum of approaches, reflecting various technical, environmental, and social considerations that must be carefully analyzed. The present work addresses this challenge by formulating the following hypothesis:

The integration of wind energy into urban environments necessitates specific wind turbine characteristics that must be addressed to ensure their acceptance from both environmental and social perspectives.

In order to test this hypothesis, the research explores urban wind energy as a promising yet underexplored area of sustainable power generation. With the increasing global demand for renewable energy and the urgent need to reduce reliance on fossil fuels, wind energy presents a compelling, environmentally friendly solution. Historically, deployment and research have been dominated by large-scale installations in rural or offshore locations, where steady and unobstructed wind flows are available. By contrast, urban wind energy has received comparatively little attention, despite its considerable potential for decentralized energy production in cities where demand is concentrated.

This work therefore investigates the feasibility and performance of Savonius-type vertical axis wind turbines (SVAWTs), which are particularly suited to turbulent and multidirectional wind conditions in urban areas. The central research question is: *How applicable and efficient are Savonius wind turbines in urban settings, considering both their power generation capabilities and acoustic impact? To address this question, the study combines experimental, computational, and analytical methods.

The main objectives include assessing the suitability of different wind turbine technologies for urban deployment, analyzing wind energy potential at multiple sites across two countries, and conducting detailed aerodynamic and acoustic investigations of Savonius turbines. Experimental studies in wind tunnels and on rooftop prototypes are complemented by CFD simulations to capture performance under both controlled and real-world conditions. Acoustic measurements, carried out using single microphones and microphone arrays, enable the identification of noise sources and mechanisms. This understanding is essential for evaluating the acoustic impact of Savonius turbines in urban environments, ensuring regulatory compliance and minimizing disturbance to residents.

An innovative contribution of this work is the study of a twin-rotor Savonius configuration, designed to improve power output while maintaining scalability and cost-effectiveness for urban applications. Furthermore, by systematically examining the relationship between power generation and acoustic emissions, the research establishes optimal operating parameters that balance efficiency with noise reduction—an important step toward socially acceptable wind energy in cities.

The thesis is organized into five parts: the introduction and problem statement; theoretical foundations; performance analyses of SVAWTs through experiments and simulations; detailed acoustic

studies; and finally, the integration of turbines within urban environments, including wind pattern analysis and site-specific assessments.

In summary, this research makes a significant contribution by advancing practical and scalable solutions for harvesting wind energy in cities. By addressing both technical performance and acoustic challenges, it supports the development of turbine designs that can operate harmoniously within densely populated areas. In doing so, it demonstrates how tailored turbine characteristics can enable the wider acceptance of urban wind energy, thereby validating the central hypothesis.