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Air-jet Design and Scaling Performance of AeroMINE Distributed Wind Energy Harvesters

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1. Introduction

Distributed wind currently makes up less than 2% of the U.S. wind energy market [1]. Existing distributed wind solutions suffer from three major weaknesses: i) they sweep a small area and produce proportionally small power, ii) they have many moving components at height, often exposed to harsh environments, leading to vibrations and mechanical failures, and iii) they have fast moving blades that require large standoff distances and can produce significant aero-acoustic noise. As shown in Figure 1, AeroMINE (Motionless, INtegrated Extraction) wind harvesters have large swept-areas with no external moving parts, making them transformative for distributed wind energy in power production, reliability and safety.

Very low-pressure regions are created by wind flowing between the foil-pairs that make up the external body of AeroMINEs. The low-pressure surfaces of the foils contain orifices (air-jets). The foils themselves are hollow. The low pressure between the foils pulls air out of the air-jets, which are supplied by the interior of the foils. The interior of the foils are in turn supplied by ducts. These ducts are connected to a manifold which contains an internal turbine-generator that produces electricity. The turbine-generator section is located inside the building for ease of maintenance and to avoid harsh environments. The inlet to the system can be either inside or outside the building, as desired. The turbine-generator are isolated from people and wildlife. A rendering of AeroMINEs on a remote building, integrated with solar photovoltaics (PV) is shown in Figure 2.

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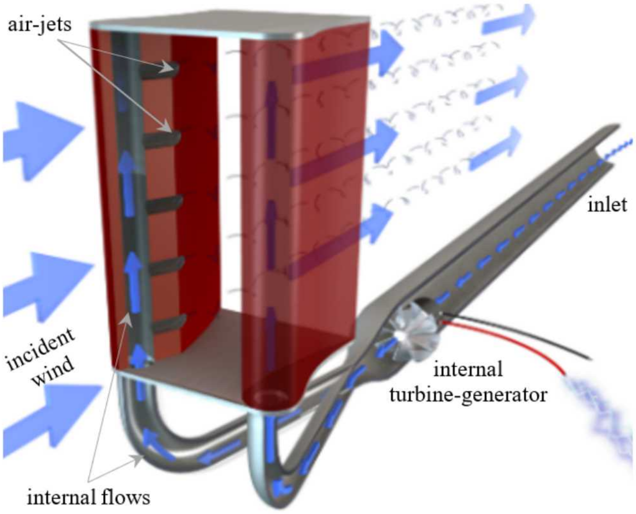

Figure 1: Operation of a foil-pair that makes up the base AeroMINE unit, with semi-transparent cutaway foils and ducting showing the internal airflow (rendering by Vincente Garcia).

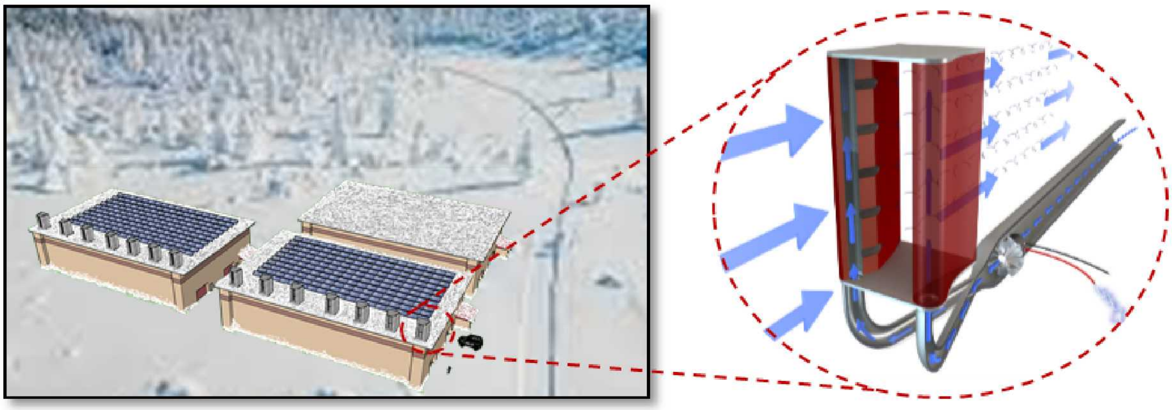
Figure 2: Rendering of an array of 14 AeroMINEs operating in parallel on a remote facility where they are expected to produce the same energy per year as the 180 solar PV panels when the site has both favorable wind and solar resources.

2. Objectives

The two primary objectives of this work are to demonstrate *i)* the influence of air-jet design on the aerodynamic performance and *ii)* the power scaling with the height of AeroMINEs. These are both critical to the optimization of the device. Commercialization requires the device be economically competitive with current distributed renewable systems such as solar PV.

3. Methodology

Wind tunnel tests were carried out at the National Wind Institute (NWI) at Texas Tech University as shown in Figure 3 on AeroMINEs designed based on an S1210 airfoil, selected for its excellent lift characteristics over a wide range of freestream velocities [2]. Performance was measured by a pressure and flow rate measurements and additionally characterized by particle image velocimetery (PIV) measurements. Detailed power measurements for an optimum configuration are given in Pol *et al*. [3]. Here the difference between several air-jet designs are considered. Freestream velocities were varied between 5 and 15 m/s, corresponding to chord-based Reynolds numbers of *Re* ~130,000 to 400,000, respectively.

Figure 3. (left) Inlet duct (outside the tunnel) with choke section for load measurements, and (right) 0.5 m chord AeroMINE pair mounted on the wall inside the NWI wind tunnel. This shows the full-height test with a static pressure measurement section (green) mounted between two half-length sections.

4. Results

Sensitivity to air-jet design and total air-jet area was observed by both varying the air-jet shape and by covering rows of air-jets (first row shown covered in the Figure 3). The inlet area outside the tunnel was held constant, though various chokes were applied. Results suggest a performance optimum where the boundary layer remained attached over most of the chord.

Scaling with height was excellent. The full-height test showed slightly better than double the power performance of the half-height version, suggesting better than linear scaling with height.

Detailed results will be presented in the full Torque paper.

5. Acknowledgements

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6. References

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