Pumping Mode Rotary Airborne Wind Energy Systems: Exploration and Experimentation

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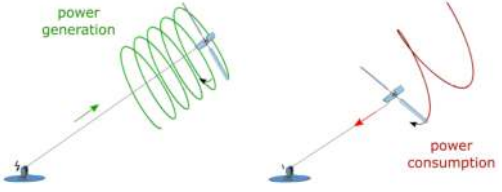
Pumping mode rotary airborne wind energy (AWE) systems have been described in literature [1,2] but despite their potential advantages over single-wing AWE systems, they have not been comprehensively researched or explored yet. Due to the high crosswind speed of the tether the efficiency of a single-wing AWE system breaks down as the tether length increases. Single-wing systems also have to fly acrobatic trajectories close to the ground at high speed during take-off and landing.

Rotary AWE systems on the other hand use a quasi-stationary tether and achieve crosswind motion by orbiting multiple connected wings around a center. As shown in the figure the tether of a pumping mode rotary AWE system only performs a reel-out and reel-in translational motion thus, significantly reducing tether losses and the complexity of the control system.



Working principle.

The feasibility of torque-based rotary AWE systems with lifter kites has been successfully demonstrated [3]. However, the use of a lifter kite and the tensile rotary power transmission (TRPT) provide significant challenges in automation and up-scaling [4]. The implementation of cyclic pitch control for rotary AWE systems [5] has removed the need for a dedicated lifter kite and has opened the path to pumping mode rotary AWE systems. Evaluating their viability, someAWE has been exploring, conceptualizing and experimenting with pumping mode rotary AWE systems. Searching for solutions for some of the functional requirements, different architectures and design options have been explored for:

- Rotor designs with cyclic and collective pitch mechanisms
- Methods for launching and landing
- Ground station designs with a generator and launch and landing capability
- On-board power systems

This talk presents different designs being evaluated and the current results with functional demonstrators

References:

[1] Vergnano, G., Don Bosco, C.: Ultralight Airfoils for Wind Energy Conversion. US Patent 8,113,777, Feb 2012

[2] Chernyshov, D.: Tethered glider system for power generation. US Patent US8421257B2, April 2013

[3] Read, R: Kite Networks for Harvesting Wind Energy, Ch21, in Schmehl, R: Airborne Wind Energy Advances in Technology Development and Research

[4] Tulloch, O: Modelling and Analysis of Rotary Airborne Wind Energy Systems ś a Tensile Rotary Power Transmission Design. PhD Thesis, University of Strathclyde (2021).

[5] Unterweger, D: Cyclic Pitch Control of a Rotary Kite. Master Thesis, University of Freiburg (2021).