Harnessing High Altitude Wind Energy employing a Hybrid Lighter-than-air Platform with Aerodynamic Lift from the Magnus Effect

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The last decade has seen an increasing number of initiatives to harness energy from the greater power density present in high altitude winds. The different concepts can be classified into three broad groups: static approaches which hover in the air; crosswind approaches and vertical approaches where the motion of the device is perpendicular to the ground.
Omnidea is developing a system in the third category based on a pumping cycle of a hybrid lighter-than-air platform that benefits from buoyancy and aerodynamic lift from the Magnus effect of a rotating cylinder. The system being developed under the HAWE project, comprised of an airborne module (ABM) tethered to a winch at a ground station via a multi-functional cable is described, in which the motor acts both as a winch and a generator. Rotation of the ABM by small on-board electrical motors causes movement of the surrounding air producing a vortex around the ABM which results in aerodynamic lift due to the Magnus principle, and together with the buoyancy of the lighter-than-air construction, gives rise to an upwards force that is used to generate electrical power.
The power-generating sequence of a pumping cycle consisting of four phases operating essentially in a two-dimensional vertical plane is described.
A simplified model, assuming certain conditions, is developed to assess the maximum theoretical performance that can be achieved by the system. A more realistic model is elaborated taking into account parameters such as wind speed varying with altitude, the energy spent in the rotation of the ABM and transition phases from the production phase to the recovery phase. The two dimensional model derived is used to analyse loads and power produced and to investigate the effects of different control strategies related to issues such as load limitation and power optimization amongst others.
Typical operating characteristics are described. The results of a demonstrator 16 metres in length and 2.5 m in diameter are provided as a proof-of-concept and current tests using a larger scaled-up version of 25 metres are discussed as a basis of a system that will deliver power in the megawatt range and be capable of operation at altitudes of about five km.