Configuration Optimization of a Generic Crosswind Airborne Wind Energy System

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The aim of this work is to address fundamental questions related to crosswind airborne wind energy systems with hard wings: are the ground generation or the fly generation airborne wind energy system most cost efficient? In which cases are one better than the other? Which subsystems are crucial in terms of overall performance and costs?

To investigate these topics, the two crosswind generation types are studied with a unique model. A generalization of the Loyd power equations[1] into one expression is thus derived to leave a gradient-based optimization algorithm to range continuously within the two types. This expression is derived with the assumption of steady-state flight, the power losses due to mass are included with an analytical model. The optimizer can then design the geometry and the aerodynamics of the system while choosing some performance parameters, describing the generation types. To refine the model, the main subsystems and physics are considered. The model computes the power curve taking into account reel-in phase, drag penalty of the tether, wind shear, structural design of the tether and of the kite, take-off strategies and presence of tower. A cost and an operational life are finally assigned to these subsystems to make the optimizer to maximize the economic profit.

Unfortunately, or interestingly, many aleatory uncertainties and many epistemic uncertainties, related to different design strategies, are present in such a problem. Thus, a global sensitivity analysis involving physics and cost parameters is a suitable tool to analyze how these uncertainties influence the design. After the uncertainty quantification, the sensitivity analysis is carried out to determine the conditions for which one configuration is better than the other in terms of annual energy production and levelized cost of energy.

The main outcome of the present work is to give a quantitative overview of which subsystems are driving the design and under which conditions a fly generation could be preferable to a ground generation and *vice versa*.
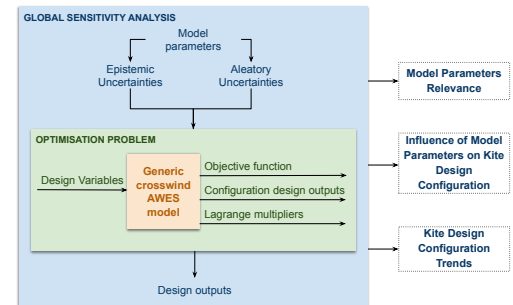

Diagram of the methods used to evaluate the generic crosswind AWES model.

References:

[1] Loyd, M. L.: Crosswind Kite Power. Journal of Energy **4**(3), 106-111 (1980)