Design & Optimisation of a 3MW Airborne Wind Energy Reference System

More and more energy is demanded by a growing world population and the technologically improving societies, which comes with the growth in and possibility to do technical research. This is complementary to the human satisfaction, for nourishment and the ability to perform their jobs. Jobs are becoming progressively dependent on computers and other technological devices, which both require power.

The main focus of this report is on a relatively new research area, namely airborne wind energy systems (AWES). The current stage of this research is still in the prototype testing phase. No commercial utility-scale product has been released to the market yet. Universities and companies are presently both involved. This area is promising as larger and more persistent wind speeds are found at these high altitudes (e.g. 200m - 10km).

In the present world of wind energy, the NREL 5 MW reference wind turbine for offshore system development has become an important piece of the puzzle towards a renewable future with wind energy. Several companies and universities utilise the data and results provided for this turbine as a reference to compare their own design and analysis.

A publicly available reference system like this 5MW reference turbine does not exist in airborne wind energy. This research aims to achieve such a representative multimegawatt utility-scale system combined with minimising the Levelized Cost of Energy and initiate a benchmark network for AWE researchers. The motivation to focus on the LCoE is driven by the industries desire to commercialise their system designs.

To create the AWE system, a parametric model is set-up for the aircraft mainly focussing on the wing parameters. Some of the required information has to be reverse-engineered from published documents of airborne wind energy system design companies, such as Ampyx Power, Makani Power and Kite Power, or be designed from other publicly available aircraft/system design sources. As the system design will be mostly based on the Ampyx Power AP4 aircraft, as much parameters will be collected from Ampyx Power as they are willing to provide. The Ampyx Power AP4 system will be designed in the future in order to re-power decommissioning offshore wind farm installations. The initial parameters will then be used to initiate an optimisation framework which in turn generates the first publicly available LCoE optimised AWE reference system.

The research is then set-up in three parts. First, the Fluid Structure Interaction model is prepared, mostly focusing on the structure of the wing and adapting the model created at the Composite Materials and Adaptive Structures lab at ETH Zurich. Conventional actuators are implemented and parameterised for the Finite Element Model. Second, a cost model is developed in parallel for the airborne wind energy system to determine the LCoE. Last, a framework is created which can be used to optimise the defined system parameters for a minimal LCoE. Aerodynamic performance is still of key importance in this thesis as in order for a benchmark model to become a success it has to perform well.