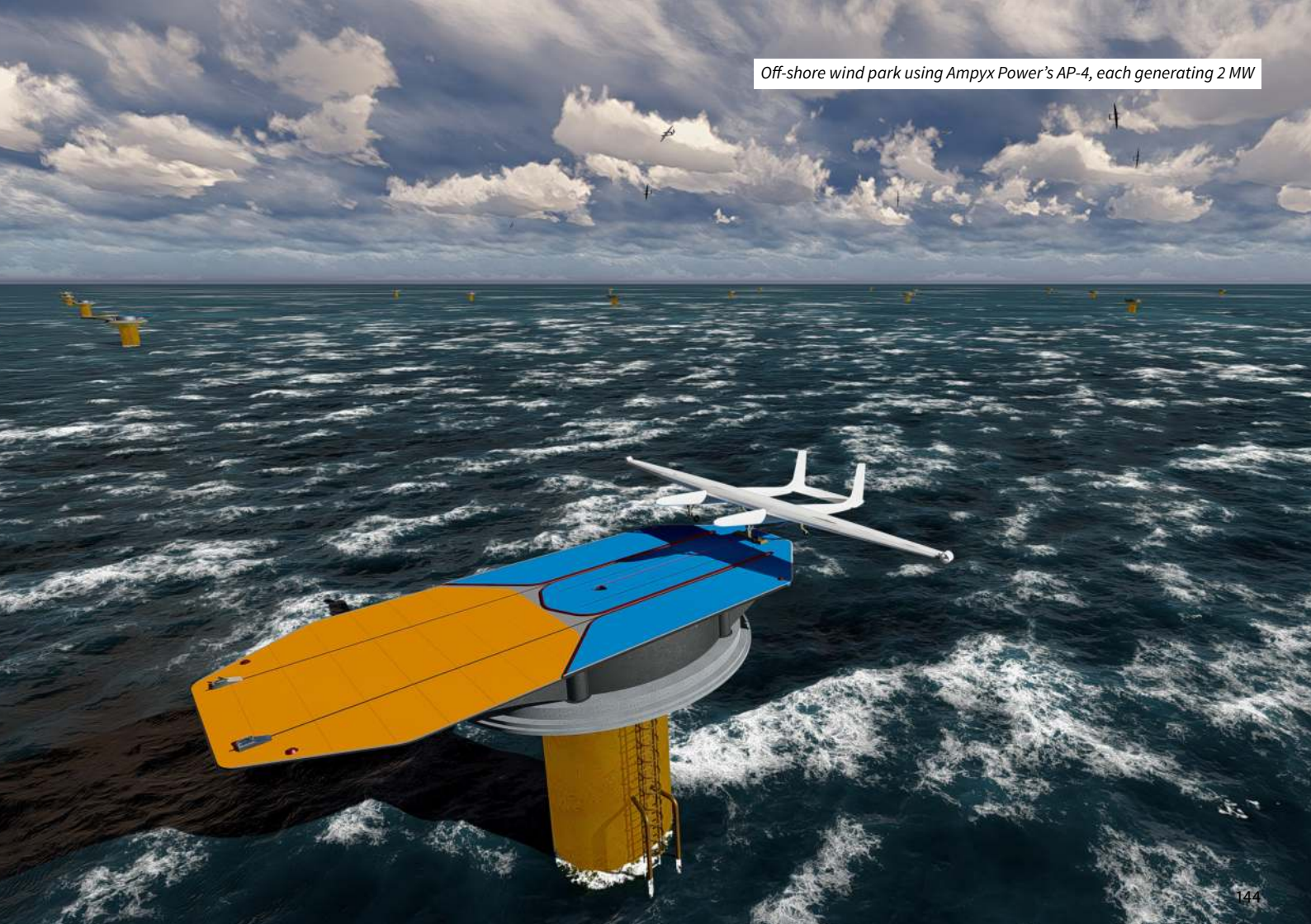

Off-shore wind park using Ampyx Power's AP-4, each generating 2 MW

Autonomous Takeoff and Landing of Rigid Wing Airborne Wind Energy Systems

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An overview of the design of an autonomous horizontal takeoff and landing approach for AWES utilising a rigid wing aircraft is presented. Ampyx Power's approach uses a combination of ground-based and aircraft-based system components to provide and remove energy from the system, specifically a catapult mechanism for injecting kinetic energy into the system during launch, and an arresting system that utilises the tether for removing energy during the landing. The design approach is rooted fundamentally in minimising the system footprint.

The methodology for sizing of the catapult is presented, as well as the means for ensuring the tether does not collide with the aircraft body during the initial climbout. A mathematical model for simulating the catapult interaction with the aircraft is presented, together with simulation results of the launch phase over all operational wind speeds.

During landing, the aircraft is guided to the landing point without active propulsion, with control of airspeed provided by tether tension. Unlike conventional piloted aircraft that fly an inertial glideslope, our system flies a flight path that is determined as a function of wind speed, and optimised to minimise the effective landing dispersion. This results in approach paths that are not a constant angle in the inertial frame. In the final stages of the landing, the winch is decelerated and locked to allow the tether to be used for braking the aircraft. However, using the tether directly without any additional damping leads to forces on the aircraft along the longitudinal axis that would significantly increase the design requirements for the tether attachment point. To prevent this, an arresting mass is used to cushion the impact. The arresting mass is attached to a passive damper that allows for the deceleration forces transmitted to the aircraft to be tailored. The optimisation process for choosing the damper profile, together with Monte Carlo simulation results are presented to illustrate the robustness of the landing approach.

Tether-arrested landing, showing aircraft landing on a platform with tailored arresting system.