Economic value of dual-wing airborne wind energy systems

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Problem statement
In non-subsidized cases, renewable energy systems are exposed to Day-Ahead-Market (DAM) prices. Hence, different designs should not only be compared in terms of levelized cost (LcoE) but also in terms of levelized revenue of electricity (LRoE).

Airborne wind energy (AWE)
- idea: replace wind turbine rotor tips with tethered wind drones
- reach higher altitudes with stronger, more persistent winds at a fraction of the material cost
- electricity can be generated by a generator on the ground, driven by periodic reeling of the tether
- largest real-world prototype has wing span of 26 m

Fig.: Power curves (top-left), annual energy production (bottom-left), electricity price model (top-right) and annual revenue (bottom-right) of a single- and dual-wing AWE system with identical total wing areas, at an onshore location in Germany.

Dual-wing vs. single-wing AWE
Eliminate tether drag, rendering small wings efficient:
- higher efficiency per wing area (more energy per material cost)
- low airborne mass (lower cut-in wind speed)
- but... high system complexity

Business case study
- single rigid-wing pumping AWES
- onshore location in Germany (54°N, 10°E)
- 2 MW generator prescribed
- no local storage
- non-subsidized

Aim
Compare revenue of single- vs. dual-wing systems for identical...
- aerodynamics
- total wing area
- operational constraints

Methods
- 6DOF aircraft trajectory optimization for power curve computation
- wind distribution from ERA-5 historical data
- ENTSO-E DAM price data