

Economic value of dual-wing airborne wind energy systems

Jochem De Schutter,
Moritz Diehl
University of Freiburg

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



Courtesy by Makani Power

Dual-wing airborne wind energy systems significantly boost levelized revenue of electricity compared to single-wing systems for similar capital investment

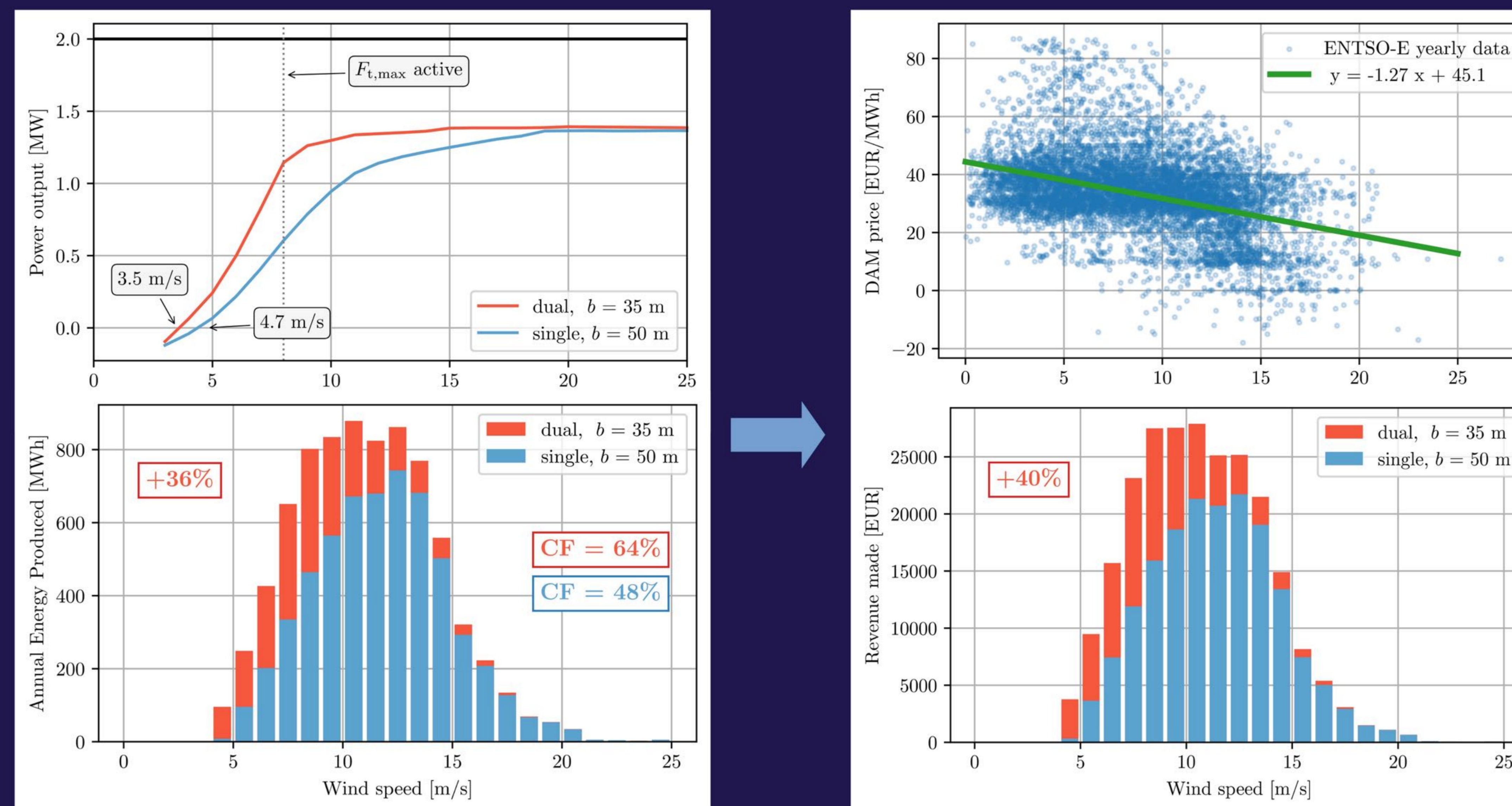


Fig.: Power curves (top-left), annual energy production (bottom-left), electricity price model (top-right) and annual revenue (bottom-right) of a single- and dual-wing AWE system with identical total wing areas, at an onshore location in Germany.



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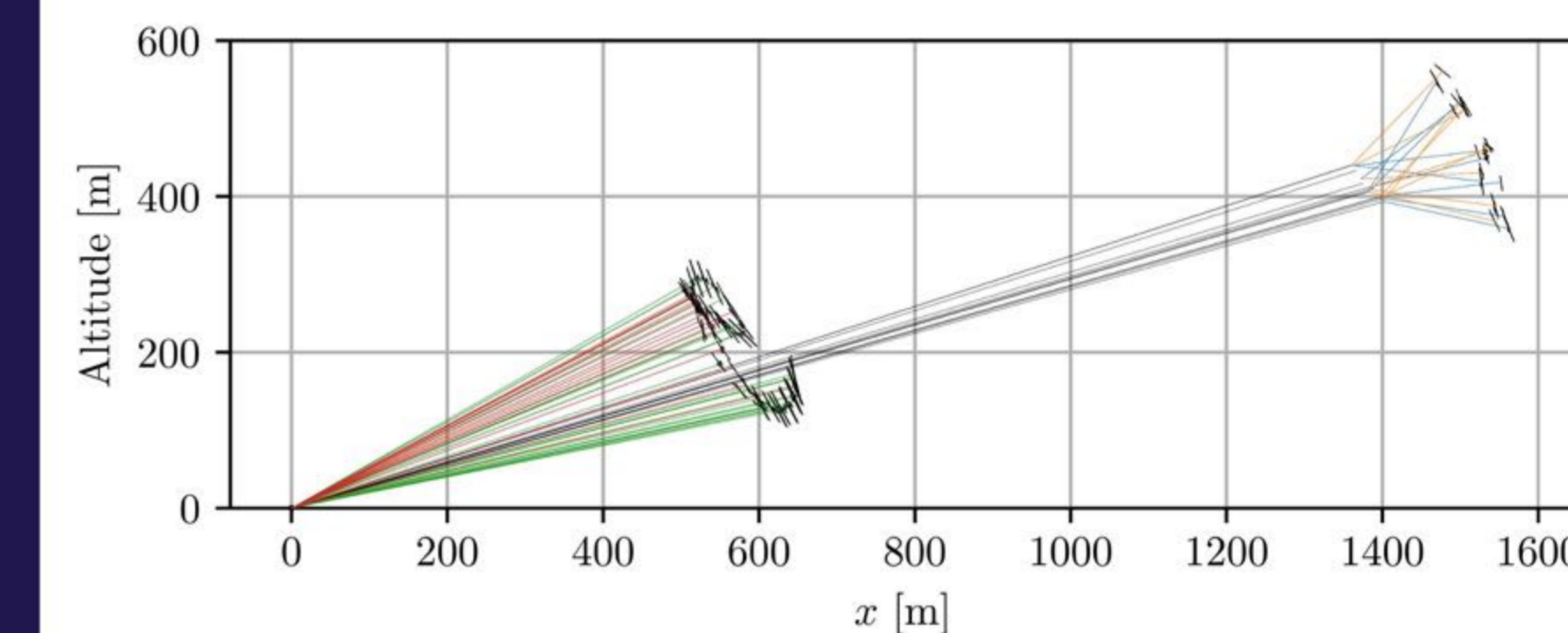


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Dual-wing vs. single-wing AWE

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