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Poster n°36

The CAP project

Developing an innovative and comprehensive wind farm control solution

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The project at a glance

A project selected by France 2030:

- **Partners:** GreenWITS (coordinator), IFP Energies nouvelles, Epsiline.
- **Duration:** 48 months.
- **Start date:** October 2nd, 2023.
- **Budget:** 4.3 M€.

Lauréat
RÉPUBLIQUE FRANÇAISE

Objectives:

- To develop an effective solution for wind farm control, based on wake steering.
- To validate it by demonstrations in operational environments.

Demonstrators:

- Two experimental campaigns on:
  - an onshore wind farm;
  - a fixed offshore wind farm.
- Digital demonstrator on a representative floating farm.

Focus on wake steering

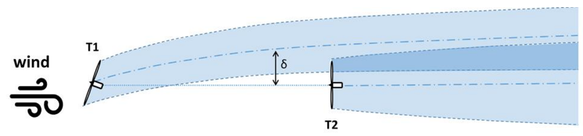
Wake effects are a major issue for large farms:

- Production losses:
  - from 5-10% (onshore) to 10-20% (offshore).
- Increased fatigue due to additional turbulence:
  - 5-15% component fatigue life reduction.

Horns rev 1 (DK) offshore wind farm (160 MW – 80 V80 – 2.0 MW)
© Christian Steiness, Vattenfall – 2008

Wake steering is a promising control strategy based on a simple concept:

- Upstream turbines are intentionally yawed to reduce their impact on the downstream turbines.

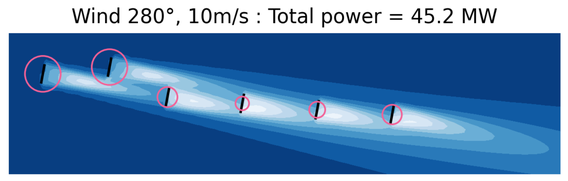


Expected gain: +1.5 to 3% in Annual Energy Production (AEP)

Additional gains (1-2%) can be achieved via the initial performance analysis and the associated corrective actions

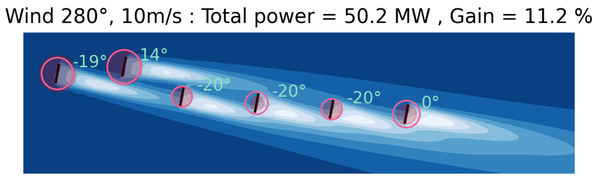
An example (fictional fam based on Ablaincourt onshore farm layout)

Wind 280°, 10m/s : Total power = 45.2 MW

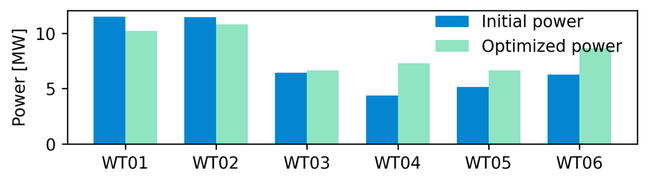


Due to wakes, downstream turbines can produce ~30% less power than the upstream turbines.

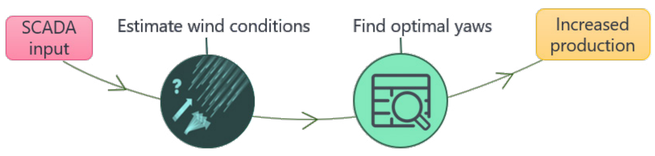
Wind 280°, 10m/s : Total power = 50.2 MW , Gain = 11.2 %



Wake steering increases wind fam power by 11.2% for this wind bin.



Boosting wind farm control



From open-loop control, the state of the art, …

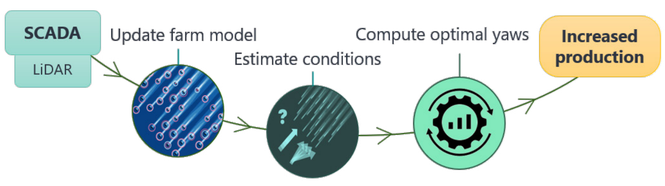
Model-based, pre-computed yaw setpoints stored in a look-up table and interpolated while in operation,

… through online optimization…

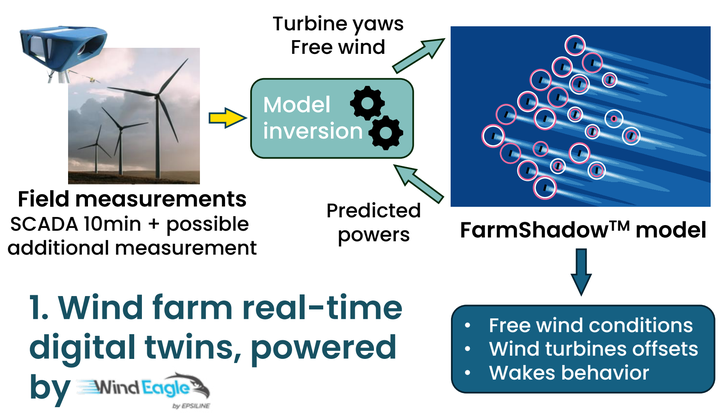
Real-time update of set-points using wind farm digital twin, taking into account operating conditions,

… towards closed-loop control

Real-time update of set-points using feedback-based online adaptation of wind farm digital twin.

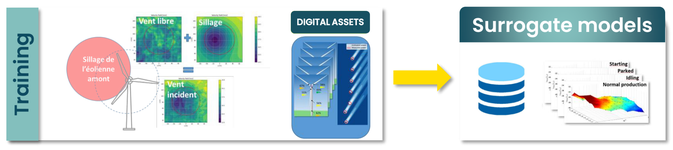


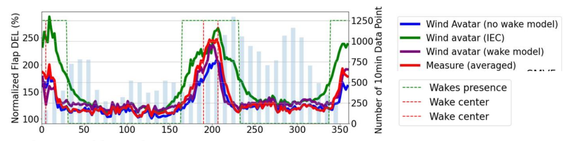
Key features and components



1. Wind farm real-time digital twins, powered by Wind Eagle by EPSILINE

- Live representation of wake effects
- Structural digital twin enabling **fatigue monitoring.**

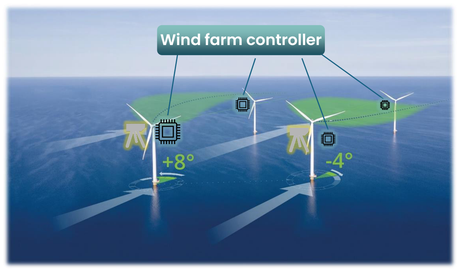




Fatigue life of structural components (blade root flap DEL)

2. Advanced wake steering, via online optimization and closed-loop control

- Accounting for environmental and operational inputs;
- Maximizing production **under fatigue constraints.**



3. Minimal hardware addition

- Selected short-range nacelle LiDARs.
- Wind farm supervisor, **yaw box.**