Engineering and Physical Sciences Research Council

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Assessing the effect of intentional and unintentional blade add-ons on tidal turbine performance

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Introduction

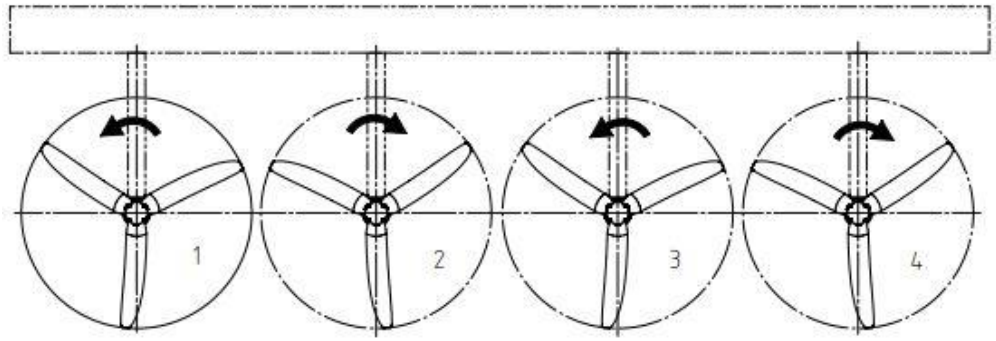
- Small changes to the blade surface of tidal turbines can have large impact on the system's performance because of the sensitivity to boundary layer effects
- Fouling poses a **performance risk** for tidal turbines
- Vortex generators offer an **opportunity to improve** the performance of tidal turbines

- **Compare the power and thrust performance of "clean" and "fouled" turbine rotors in field tests**
- **Estimate the increase in drag and reduction of lift on the respective hydrofoils**
- **Predict the impact vortex generators (VGs) have on the performance of a specific instream turbine**

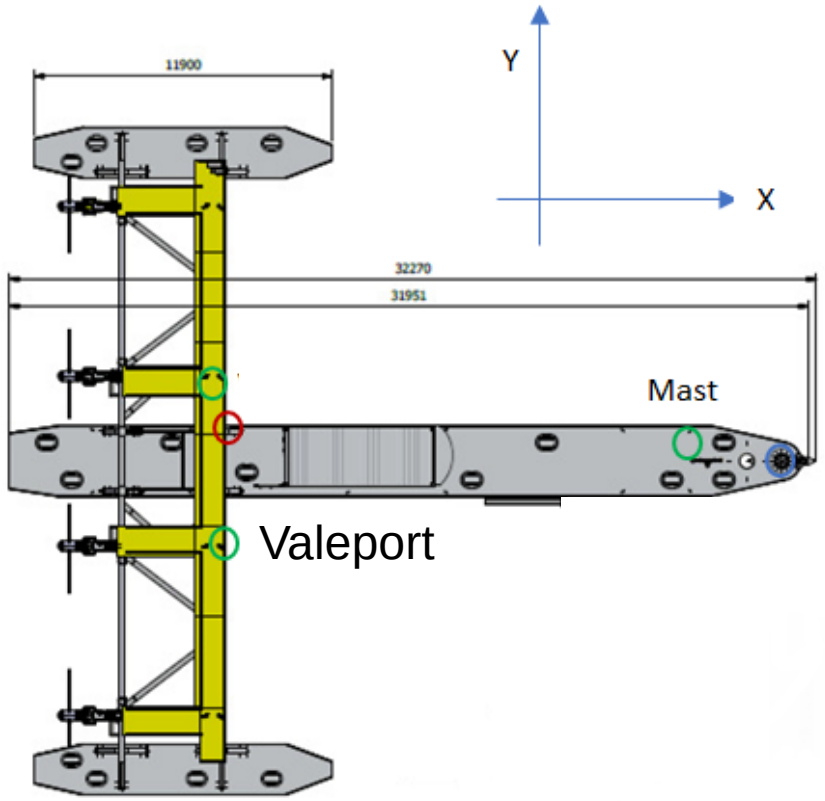
[1] https://doi.org/10.1002/we.2191

PLAT-I & SCHOTTEL Instream Turbine

- Floating three-hull tidal energy platform
- Hosting 4 x SCHOTTEL Instream Turbines (6.3m rotor diameter)
- Each drivetrain rated at 70 kW (platform: 280 kW)



Performance Instrumentation Setup



- Valeport Current velocity:

  Valeport Electromagnetic Current Meter

  (single measurement point)

  → no ADCP as per IEC

- For each turbine individually:
  - Thrust (via load pins)
  - Power, torque, rot. speed
- Raw data sampled with 1 Hz
- Data post-processing according to IEC 62600-200

Foil Conditions

Fouling achieved by keeping rotor deployed in parked condition for 4 weeks at Grand Passage.

- An underlying biofilm was found on the “fouled” blades
- Two dominant macro-fouling species of algae had been identified with a length of up to 10 cm

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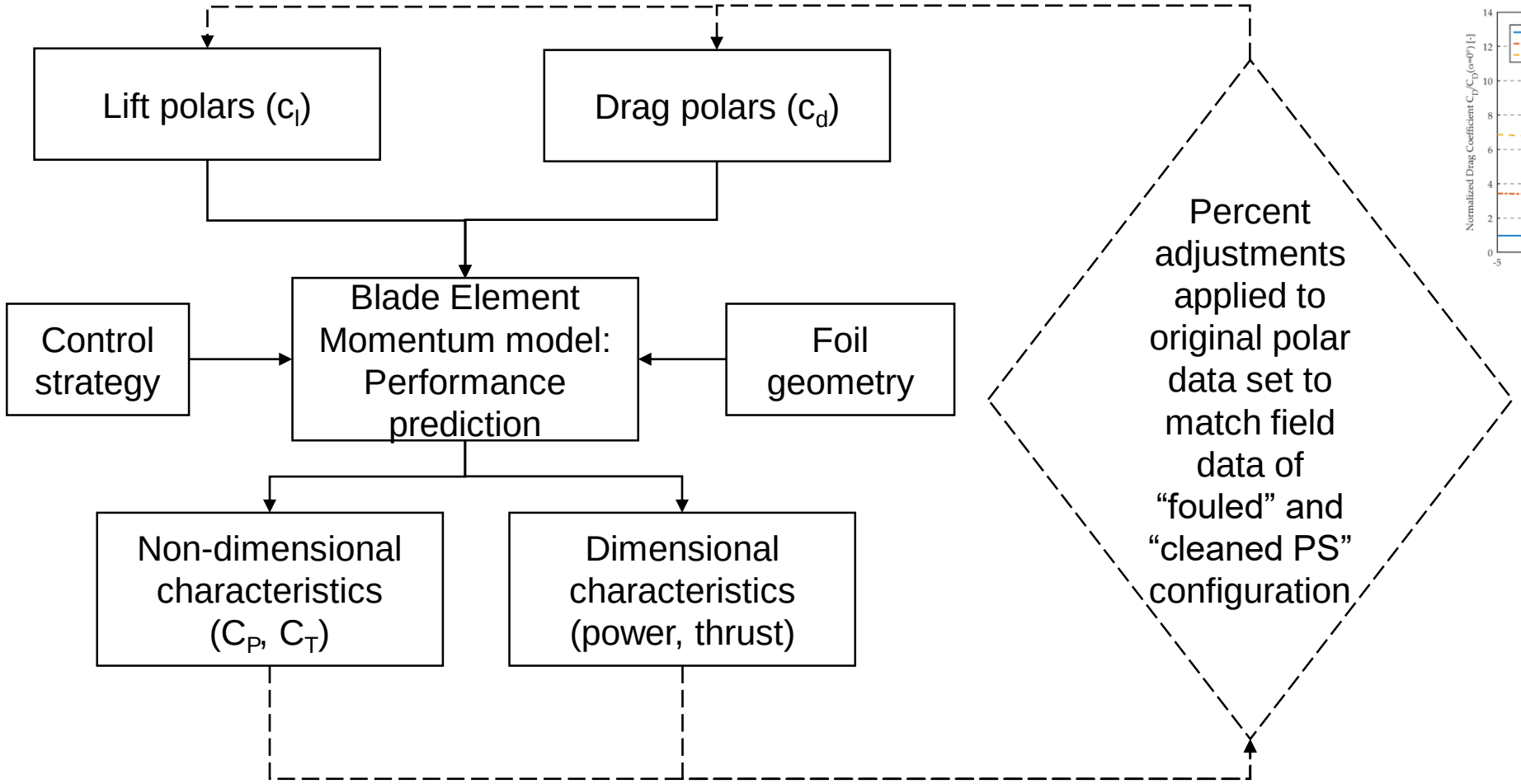
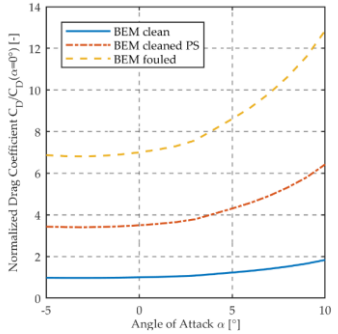
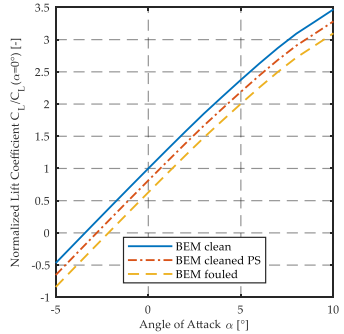
- An underlying biofilm was found on the “fouled” blades
- Two dominant macro-fouling species of algae had been identified with a length of up to 10 cm
- Investigated foil conditions:
  - **Clean**
  - **Fouled**
  - **Cleaned Pressure Side (PS)**
- Fouling was successfully removed

Estimate Impact of Fouling using BEM







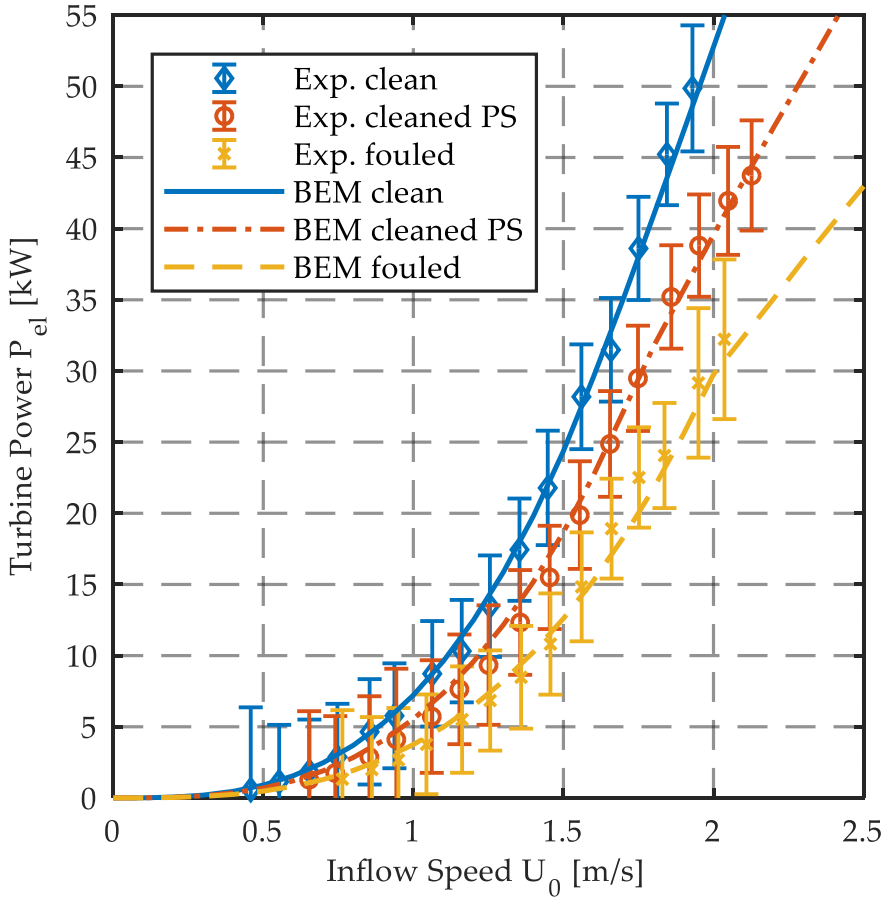
„Fouled" Condition:

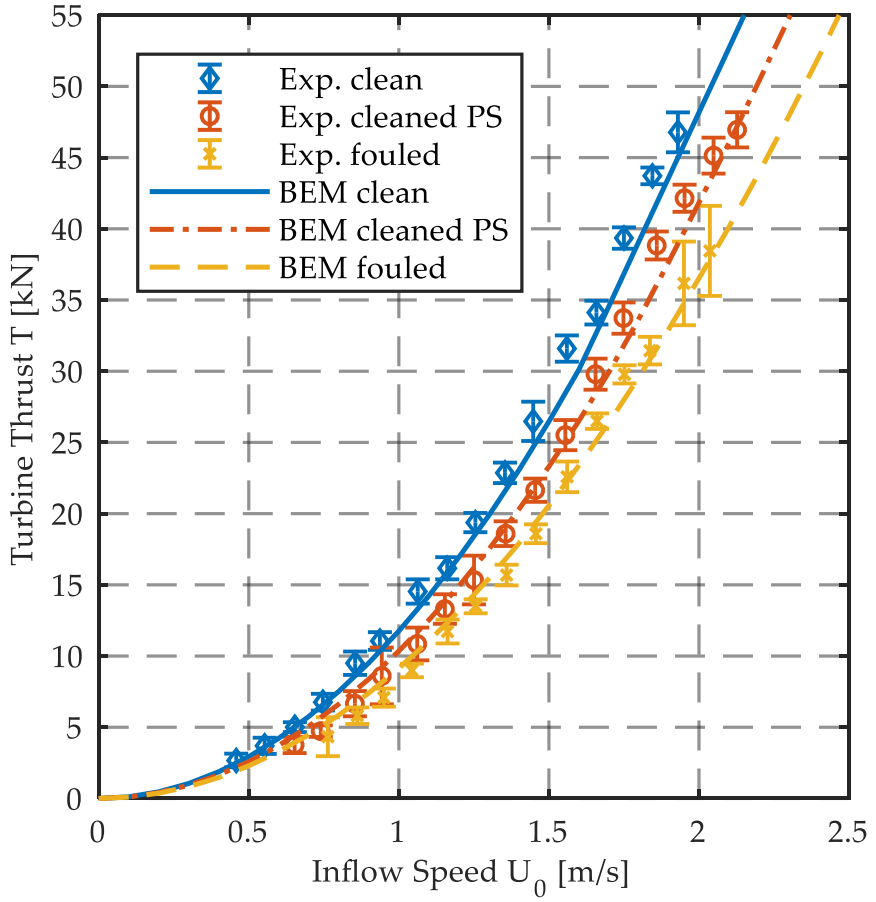
- C_d increase by 700%
- C_l reduction of 40 %

Effect of Fouling on Turbine Performance

- BEM shows good agreement with „clean“ foils
- Fouling results in power reduction of **43%**
- Fouling results in thrust reduction of **25%**

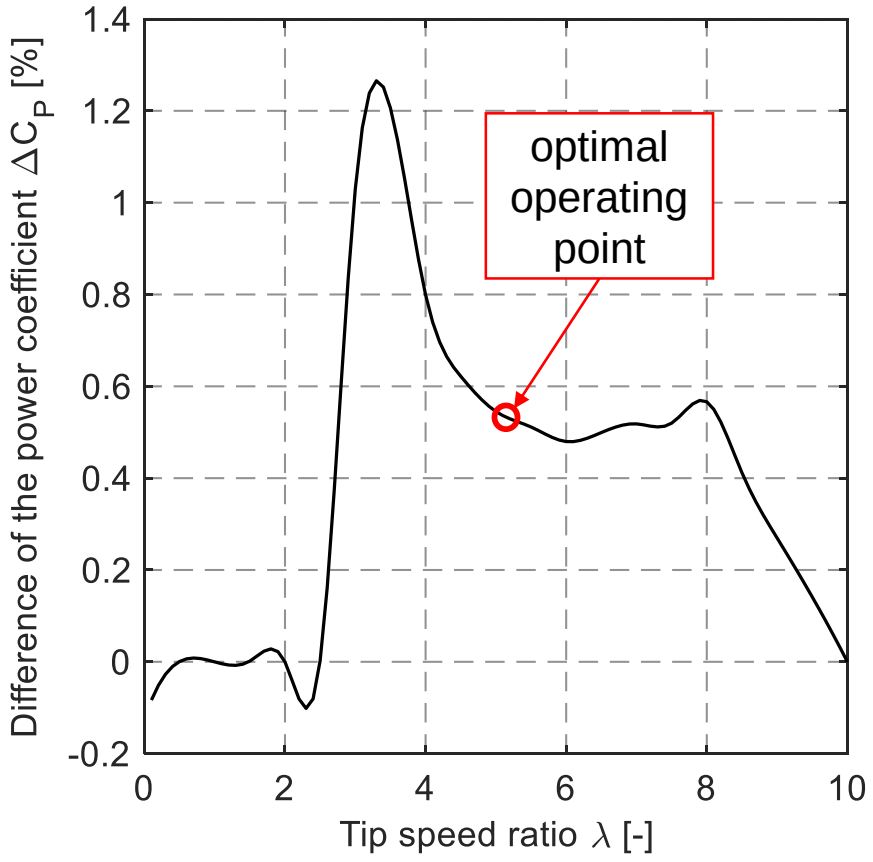
→ Resulting “fouled” polar data was used as the reference for the wind tunnel tests

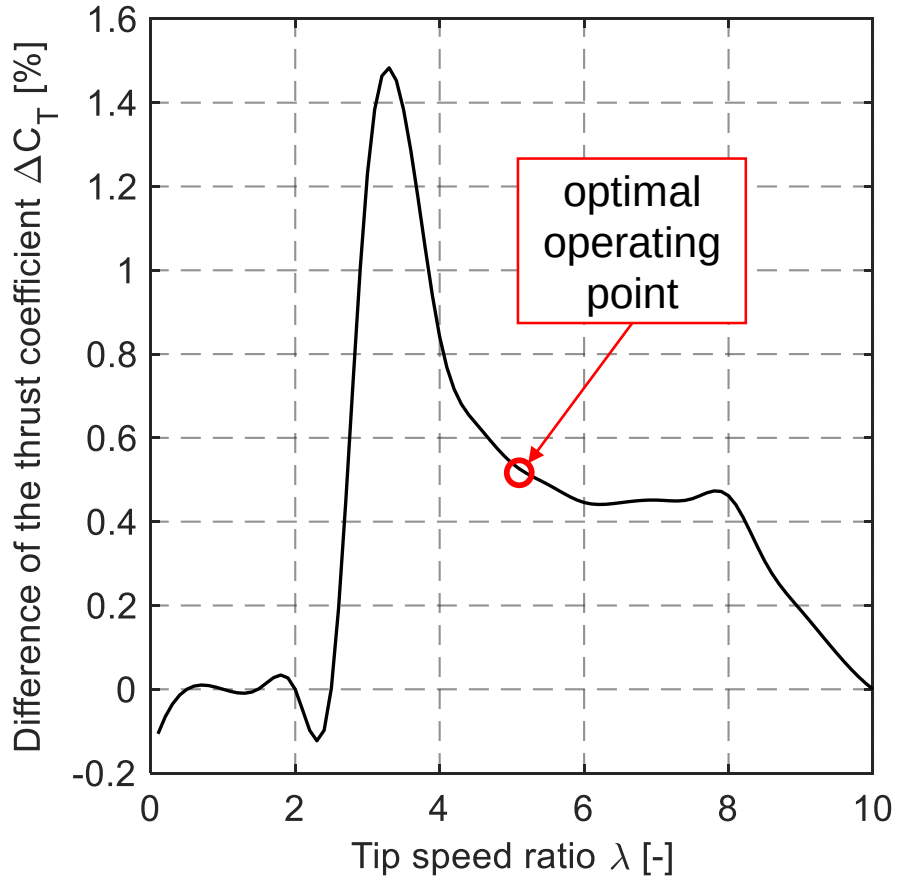




Predicting the Impact of Vortex Generators

- Polar data resulting from 2D CFD study were used to predict the turbine
- Resulting power and thrust characteristics were compared to the as-built reference
- Maximum performance increase at high angles of attack
- ~0.5 % increased power output at the optimal operating point
- VGs have a similar effect on power and thrust characteristics





Conclusion

- Fouling has significant impact on the turbine performance
  → accessibility of the turbines is very important, ideally avoided
- Fouling is a very complex phenomena with high number of variable parameters
  → further research is required to increase understanding

- VGs had positive but minor impact on performance on the specific blade investigated
- To maximize their potential, VGs should be considered during the blade design process

Thank you

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