TIGER Webinar
Anti-fouling and anti-corrosion requirements of tidal turbines

Impact of surface roughness on tidal turbine blade performance

21/10/2020 | John Walker, Project Engineer

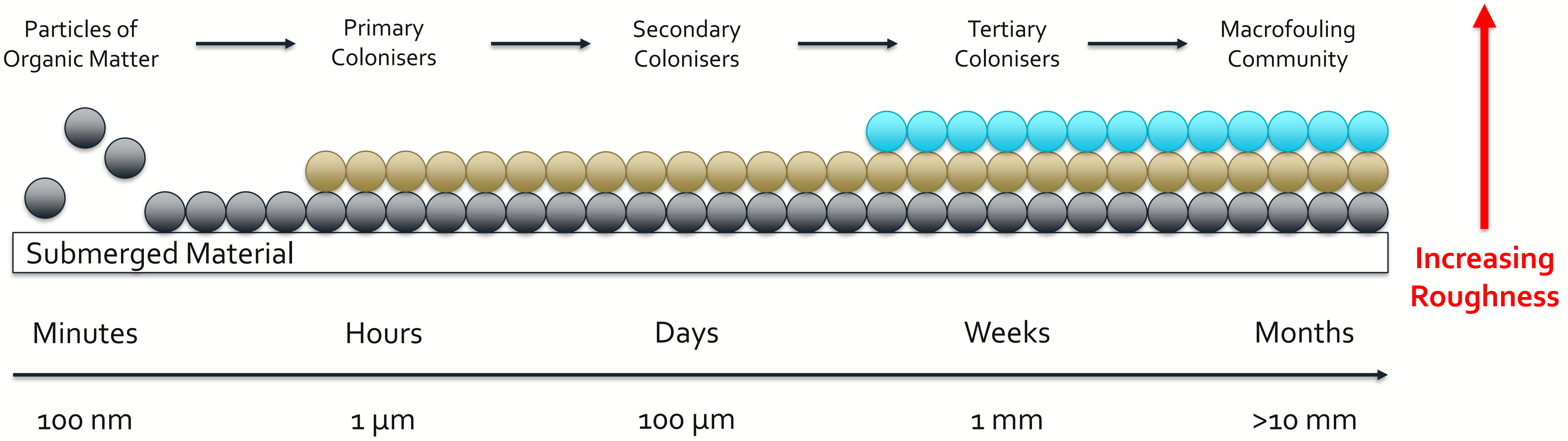
CATAPULT Offshore Renewable Energy

Surface Roughness on Tidal Turbine Blades

- Efficient tidal turbine designs rely on hydrodynamic blade performance
  - For lift-based devices, optimise lift-to-drag ratio
- Blade performance affected by:
  - Erosion due to scour or cavitation
  - Object impact
  - Fouling of the blade by marine growth
- Outcome is increased LCOE
  - Reduced Power (Lower Cp – increased drag, lower lift)
  - Increased OpEx to recover performance
  - Limited opportunities for maintenance
- Understanding and preventing this loss is critical
  - Limited studies on fouling and turbine performance
  - Key industry concern for advancing technology
  - Effects often device and site specific

Marine Biofouling Mechanism

The unwanted accumulation of biological material on submerged man-made structures, but will only begin to interfere with a technical process once a certain fouling threshold has been reached

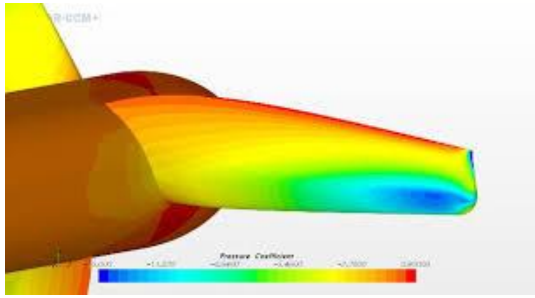


Marine Biofouling

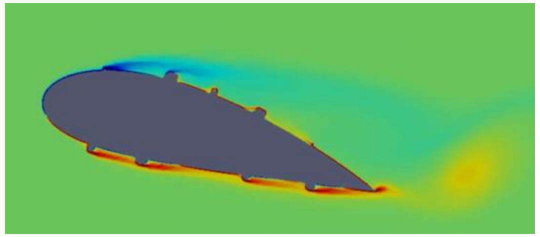
- A level of fouling is currently inevitable
    - Process is cumulative – surface becomes more susceptible
    - Level of fouling varies across blade surfaces
- Dependent on environmental and geographical factors
    - Local flow speed and turbulence level
    - Water quality, salinity, temperature and sunlight levels
    - Turbine blade material and anti-fouling
    - Geographical location
    - Meteorological seasons and species breeding cycle
    - Device operation
- Selection of coating key consideration for ensuring long term operation
    - Ultimate goal for fouling not to be present
- Barnacle (inc. *Chirona hameri*, *Balanus crenatus*) dominant macrofouling species in UK

Methods to Investigate Impact of Fouling on Blade Performance

Numerical

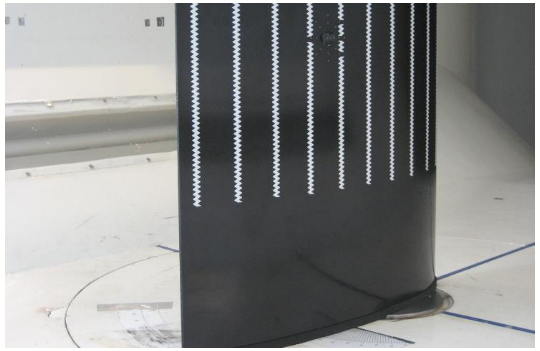


Song et al. (2019)

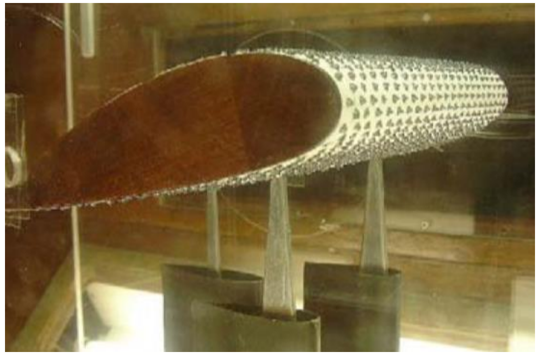


Rivier et al. (2018)

Blade Section



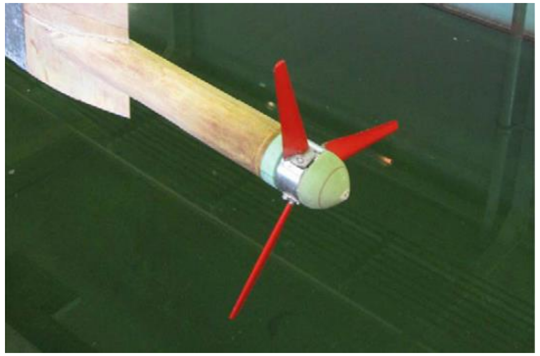
Picture Credit: J Walker



Orme et al. (2001)

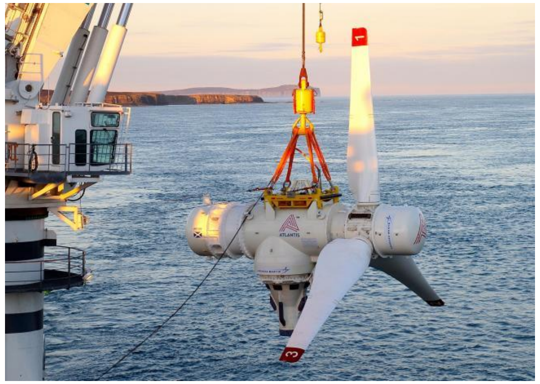
Scale Rotor Model

Walker et al. (2014)



Milne et al. (2013)

Offshore Deployment



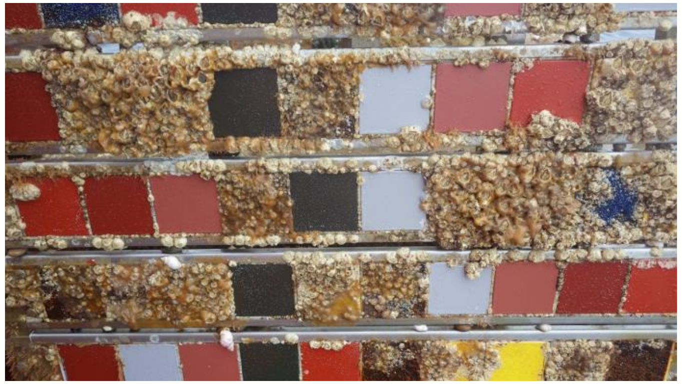
Picture Credit: MeyGen

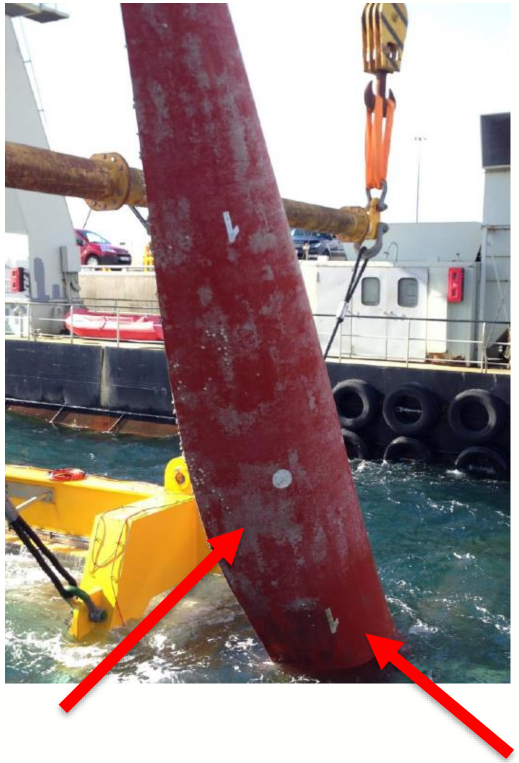
Potential Commercial Implications?

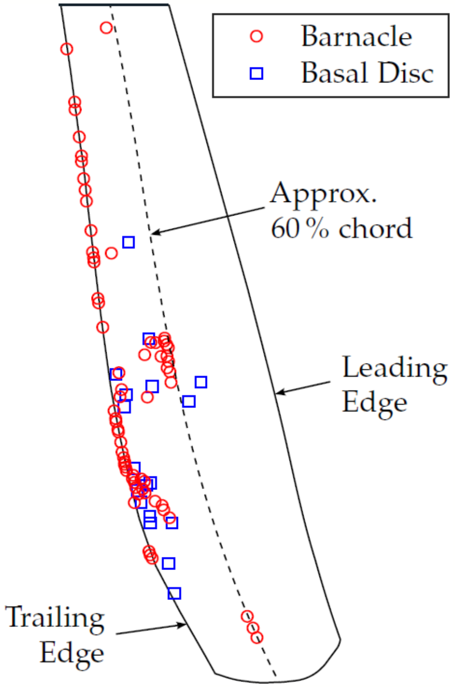
Requires understanding of fouling size, distribution and scaling effects

Turbine Blade Performance Assessment

- Blade performance ultimately determined from Cl and Cd curves
  - Geometry discretised to blade sections (BEMT)
- Surface roughness modifies flow transition and separation
  - Leading edge vs trailing edge
  - Suction vs pressure
  - Thicker blade sections
- Critical fouling parameters
  - Chordwise location and extent
  - Size (Height) – biofilm or barnacles?
  - Not evenly distributed
  - Different from wind turbines
- How to determine a 'limiting' case?
  - Site survey – plates vs blades
  - Mean tidal vs local flow speed
- Hypothesis: Flow shear stress at wall



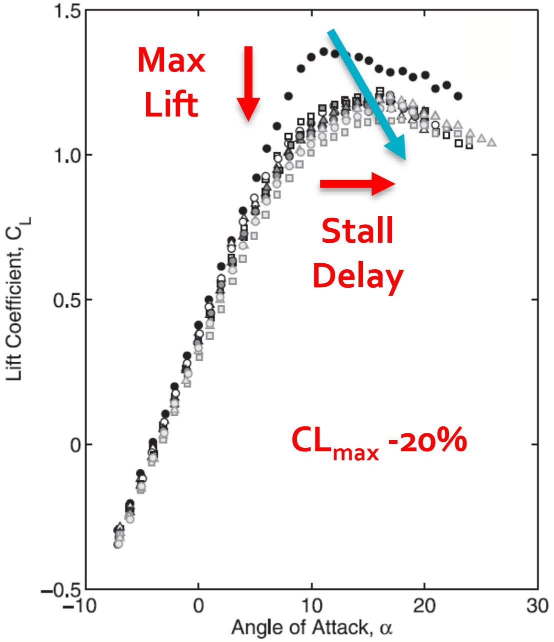


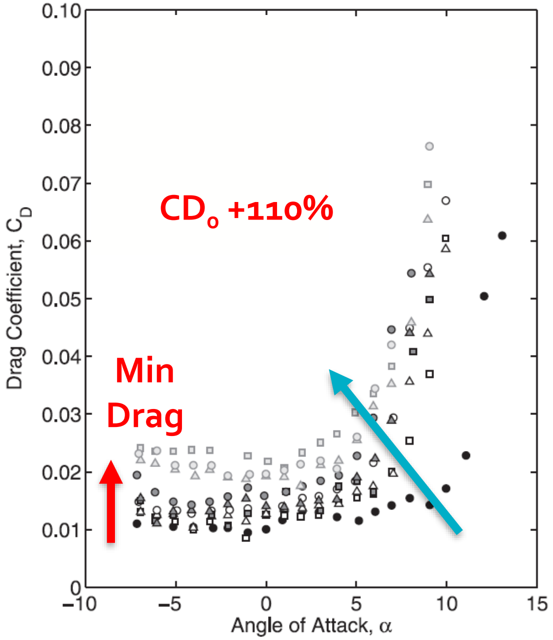


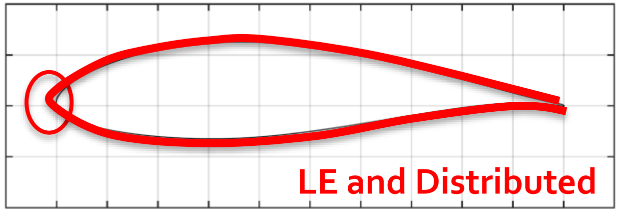
Walker et al. (2020)

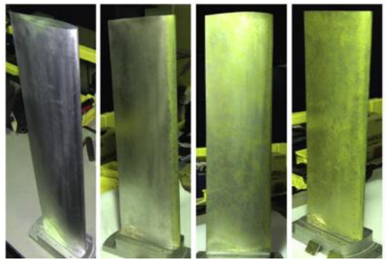
Surface Roughness: Impact on Lift and Drag

Data from Walker et al. (2014)



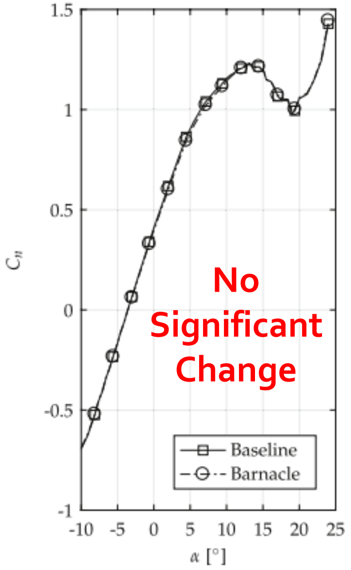


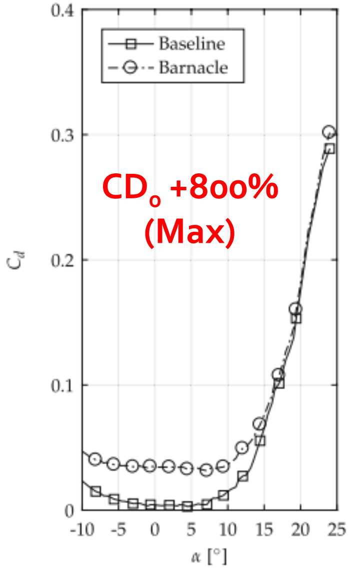


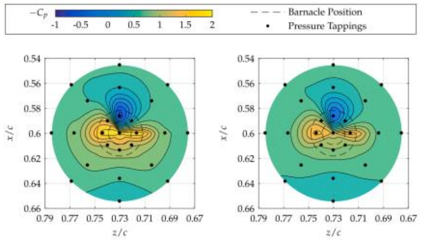


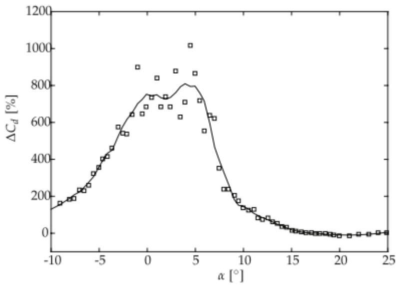
Roughness

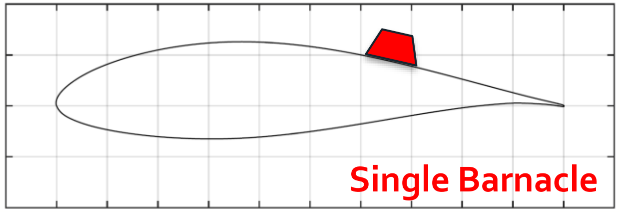
Data from Walker et al. (2020)

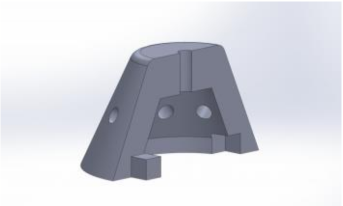








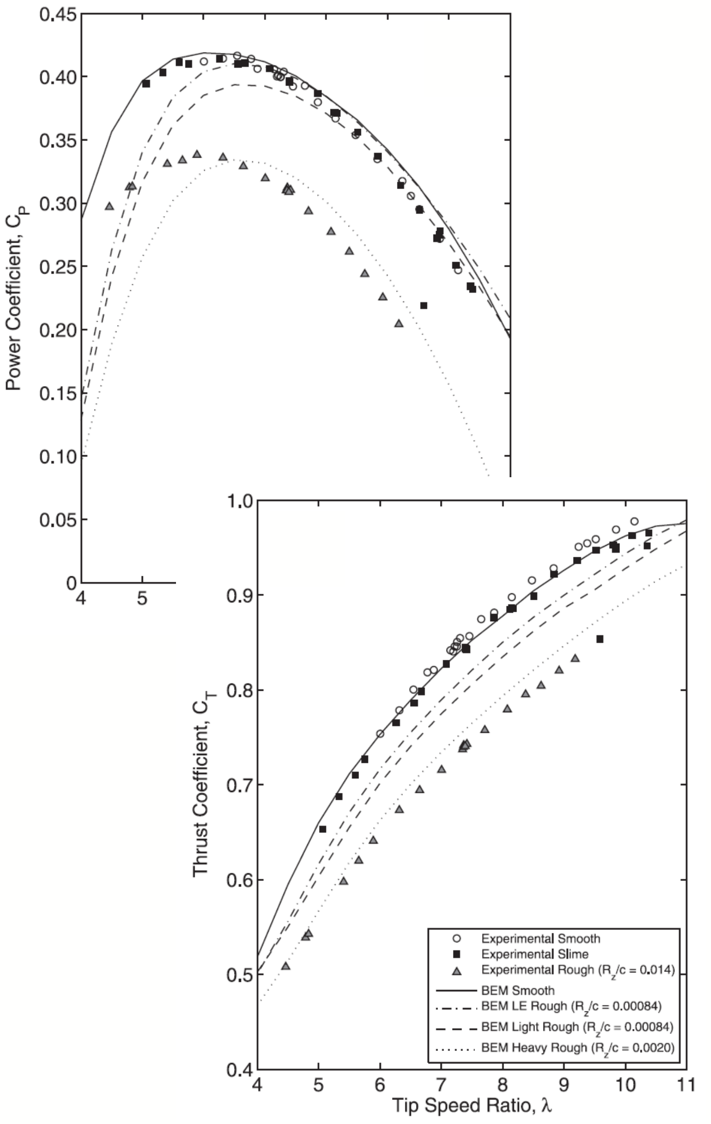




Surface Roughness: Impact on Turbine Performance

- Walker et al. (2014)
  - Experimental and BEMT
  - Cp Max: -19%
  - Decrease in thrust (Ct)
- Song et al. (2019)
  - Full-scale CFD rotor model
  - Cp: -11% at optimal TSR
  - Cp: -213% at TSR = 8
  - TSR decrease for optimal Cp
  - Operable TSR range narrows
- Representative roughness levels
- Direct impact on turbine AEP

Data from Walker et al. (2014)



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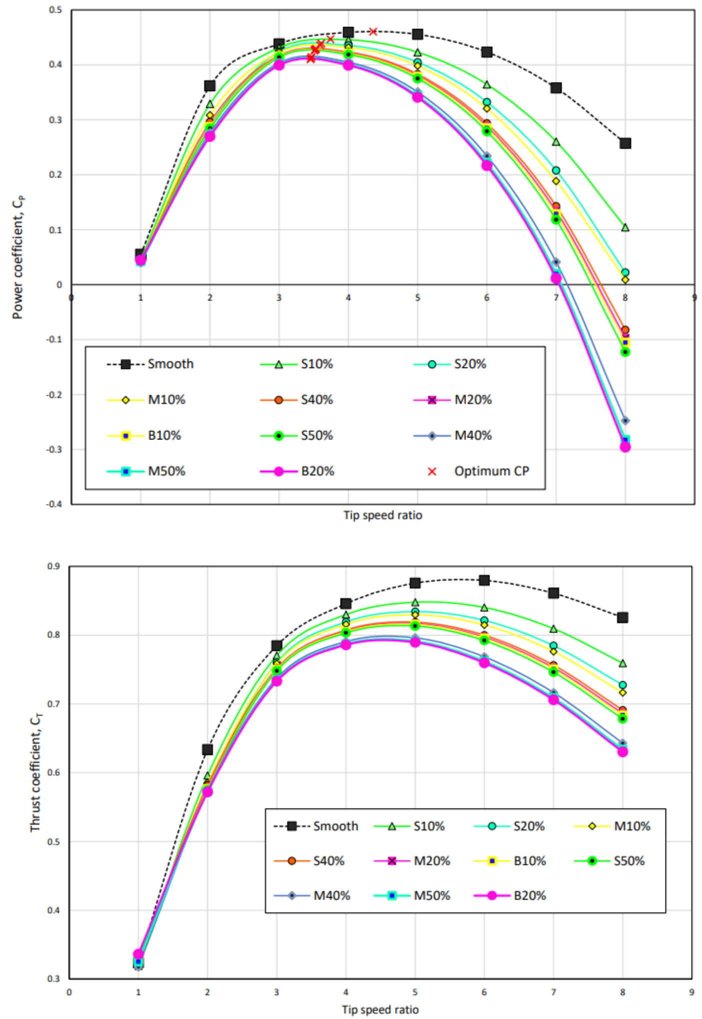

Conclusions

- Multiple interacting parameters influence blade surface roughness
- Turbine performance expected to degrade from initial fouling
- Understanding of fouling size and distribution is critical for performance evaluation

- Cp (Power) will decrease by as much as 20%
- Direct impact on AEP and LCOE
- Optimal performance window will narrow

- Highlights need for anti-fouling and anti-corrosion strategies and fouling prevention

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