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Adaptation of Control Concepts for the Support Structure Load Mitigation of Offshore Wind Turbines

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Objective

- To develop an adaptive control that selects the most effective individual control concept for the given load event in consideration of its respective collateral effect.
- To take advantage of controller concepts without having considerable collateral effect.

Methodology

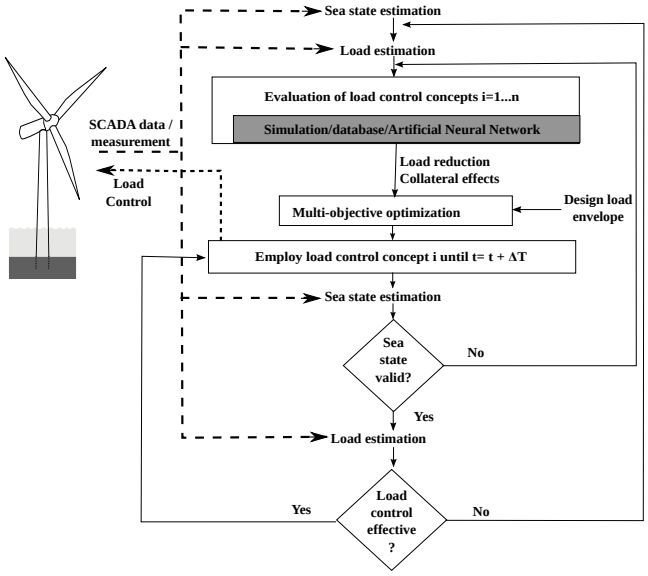


Fig 1: Flowchart of the steps followed for the selection of the most effective controllers

Analysis

Controllers used for NREL 5MW offshore turbine at 25 m water depth (MSL) at North Sea site founded on a monopile (f = 0.28 Hz):

1. Baseline controller (BLC)
2. Tower foreaft (TFA) controller - to reduce fore-aft bending moment
3. Active Generator Torque (AGT) controller- to reduce tower side to side bending moment

Collateral effects:

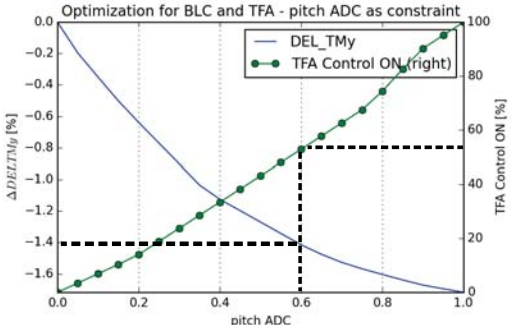
TFA : increased pitch activity given by pitch Actuator Duty cycle (ADC)

AGT : varying generator torque and hence increased power fluctuation

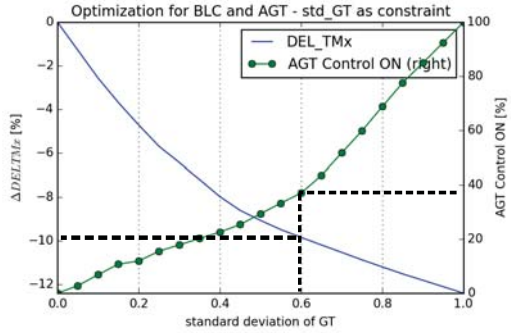
Load cases selected: mean wind speed of 14 m/s; IT = 14.2 %; wind-wave misalignment of 0°, 45°, 90° and 135°; 3 to 4 different wave heights per case; 6 seeds.

The optimization result of trade-off between tower fore-aft damage equivalent load (DEL_TMy) reduction and the increase in ADC is shown in Fig 2a.

a.



b.



c.

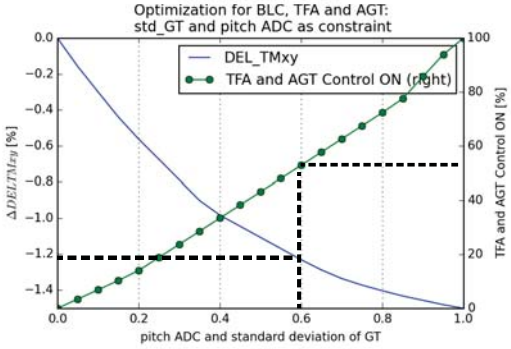


Fig 2: Optimization results for different controller settings and constraining factors for mitigation of a) pile fore/aft, b) pile side to side, c) pile Mxy bending moment at mudline

If 60 % of the total possible increase in pitch ADC is the constraint, the DEL_TMy is reduced by 1.5 % which is 78 % of the total achievable load reduction by operating the TFA for 53 % of time. The similar results in Fig 2b and Fig 2c shows that it is possible to considerably reduce the load when limiting the collateral effect for the given sea state.

Acknowledgement

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