Advanced Controls of Next Generation Offshore Wind Turbines

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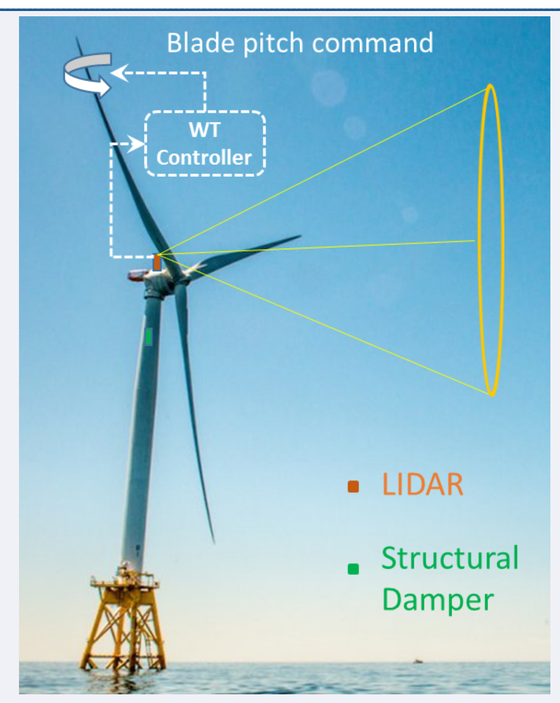
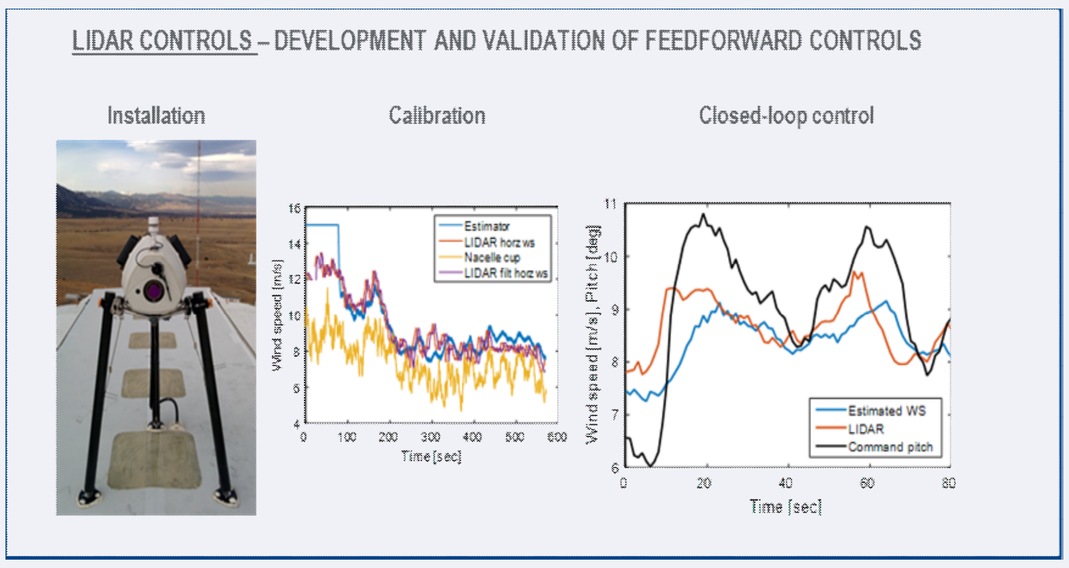
MOTIVATION AND OBJECTIVES

Advanced turbine controls and structural dampers have the potential to significantly reduce the cost of energy (CoE) for offshore wind turbines. Progress made in these two areas on a Department of Energy (DoE) funded program is reported. A lidar-assisted control strategy, with objective to reduce component loads and increase energy capture, is developed and implemented. The controller results indicate a significant reduction in the tower fatigue loads. In a parallel effort, potential of a passive and semi-active tuned-mass damper (TMD) is evaluated to mitigate fatigue and extreme loads. Simulation results with passive and semi-active TMD indicate significant load reduction for tower and substructure for both fixed-bottom and floating wind turbines.

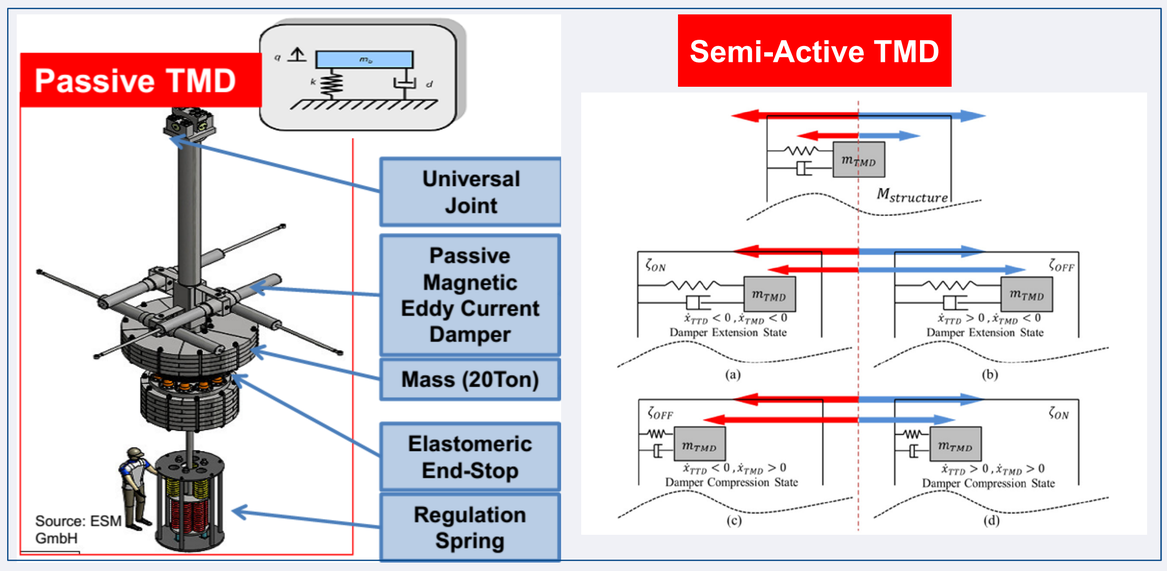


METHODOLOGY

LIDAR CONTROLS

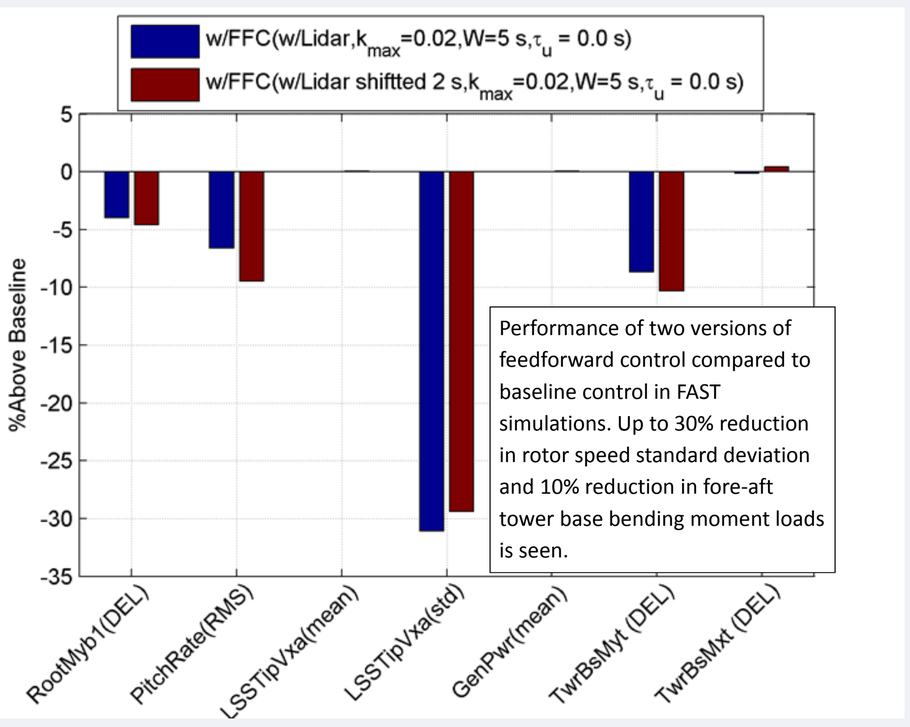


STRUCTURAL DAMPERS



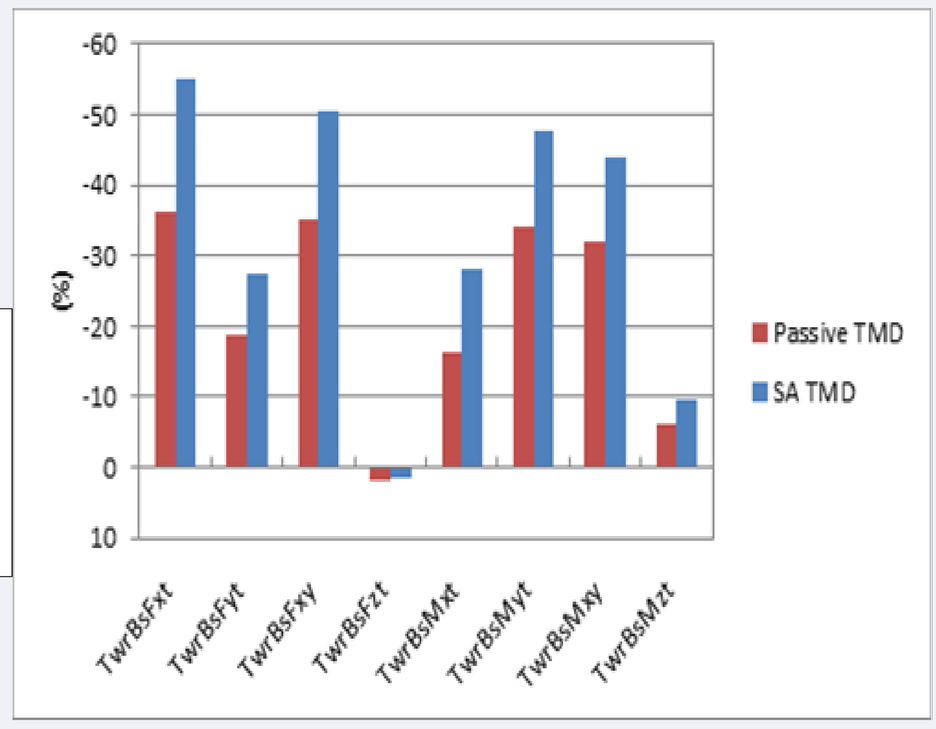
RESULTS

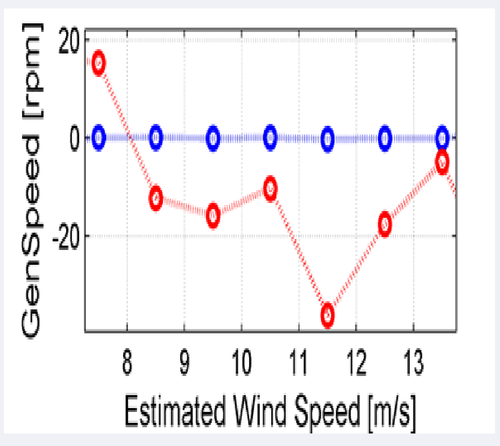
LIDAR RESULTS

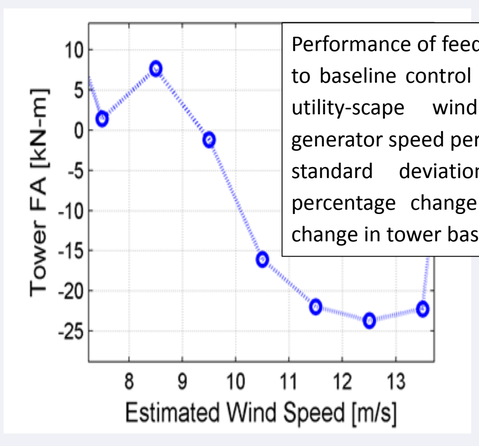


Performance of two versions of feedforward control compared to baseline control in FAST simulations. Up to 30% reduction in rotor speed standard deviation and 10% reduction in fore-aft tower base bending moment loads is seen.

FAST simulation results showing tower base extreme load (forces and moments) reductions with passive and semi-active TMD for 6MW turbine on a monopile compared to baseline case (no TMD).

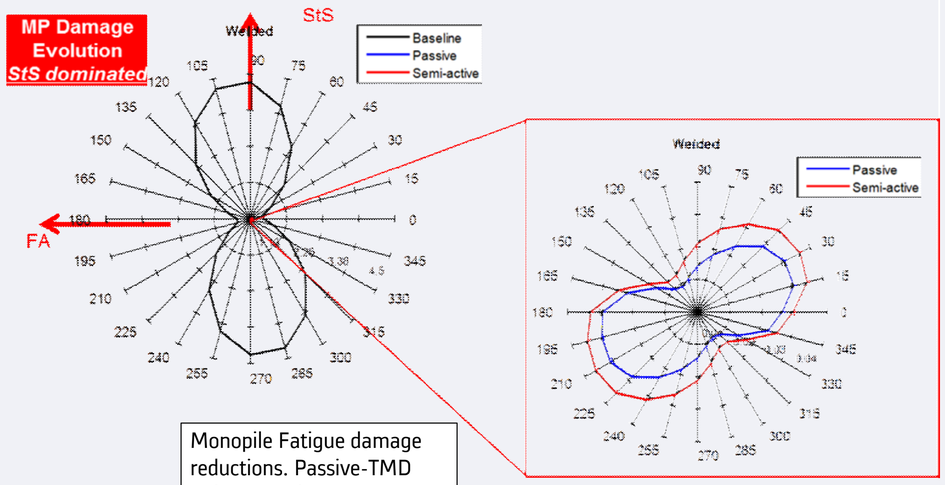






Performance of feedforward control compared to baseline control in field testing with 3MW utility-scape wind turbine. Left: mean generator speed percentage change (blue) and standard deviation of generator speed percentage change (red). Right: Percentage change in tower base fore-aft moment.

DAMPER RESULTS



Monopile Fatigue damage reductions. Passive-TMD reduces Mx by 69% & SA-TMD reduces 66% compared to the baseline scenario

CONCLUSIONS

A few of the main goals and activities of the DoE-funded project on advanced control of floating offshore wind turbines for reduction of LCoE are presented. The initial results with lidar-assisted feedforward control are discussed. Significant fatigue load reduction in region 3, are obtained based on these results. The performance of both a deep water fixed-bottom Monopile and shallow water TLP have been analyzed successfully while employing a passive TMD and semi-active TMD dampers. A key near-term future goal of this project is to test a subset of these advanced control methodologies on an offshore wind turbine. Lastly, the loads and energy capture benefits will be translated to the cost reduction via the developed LCoE model.

ACKNOWLEDGEMENTS

- DoE contract *DE-EE-0005494: Advanced Controls for TLP Wind Turbines*.
- National Wind Technology Center
- University of Massachusetts, Amherst
- ZephIR Lidar
- ESM GmbH

WindPower 2017 – May 22-25, Anaheim , CA