Control Co -design for Confinement -exploiting Arrays of Cross -flow Turbines

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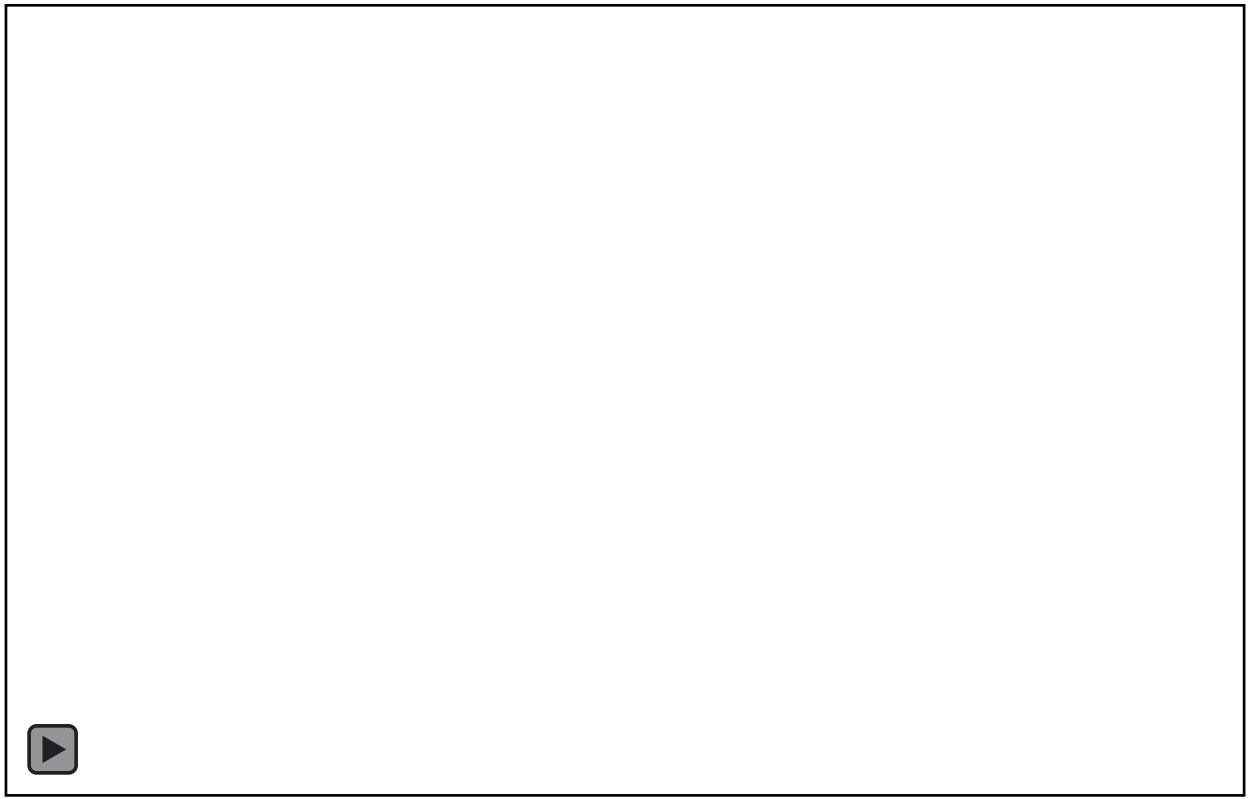
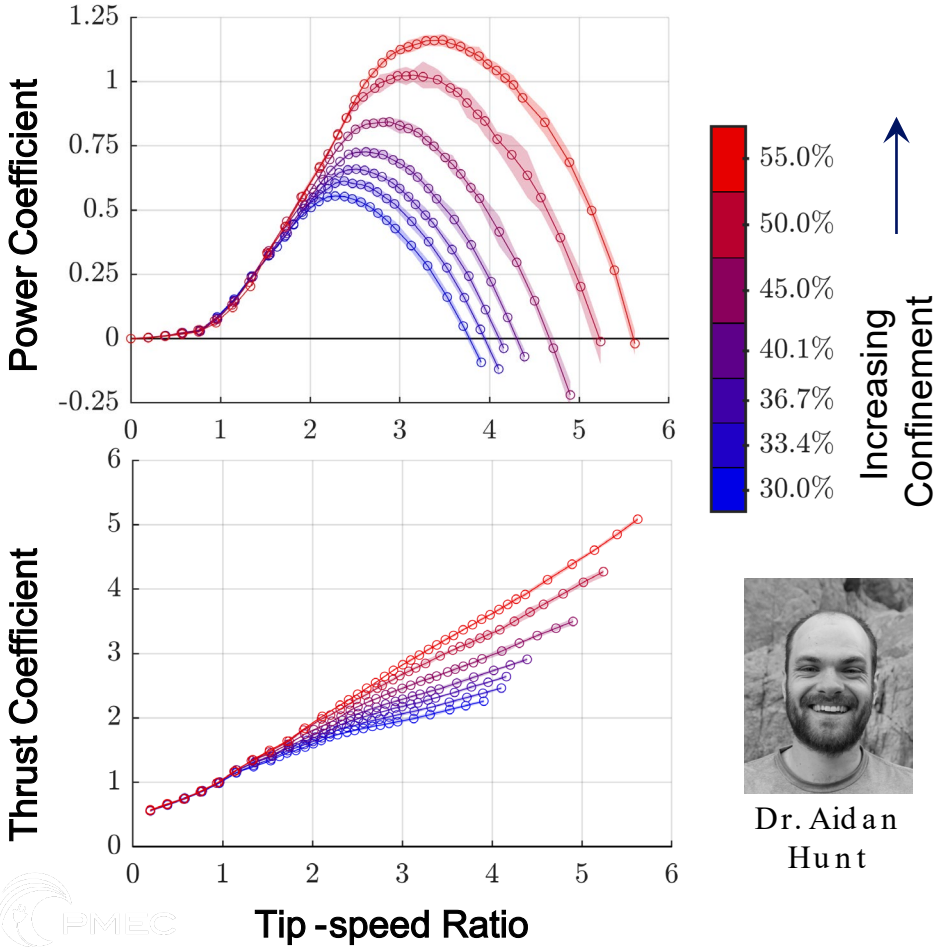
Confined Flow



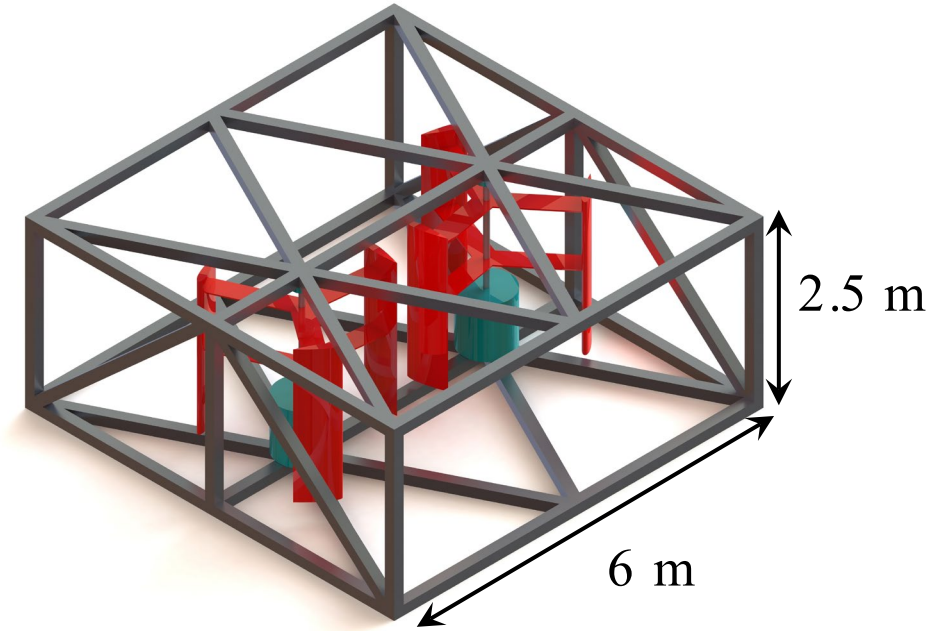
Motivation

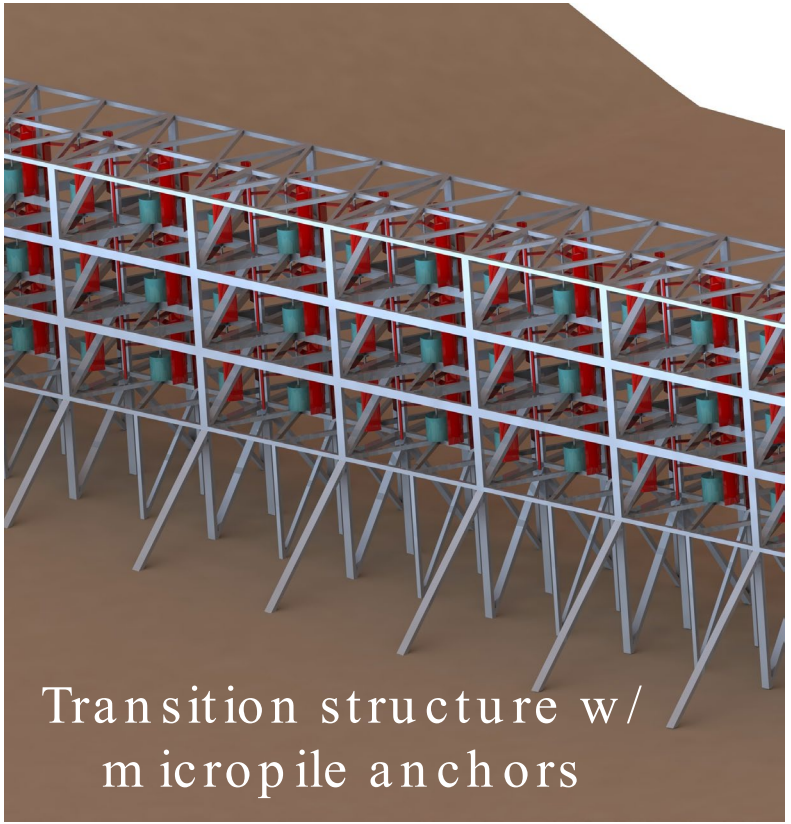


Dr. Aidan Hunt

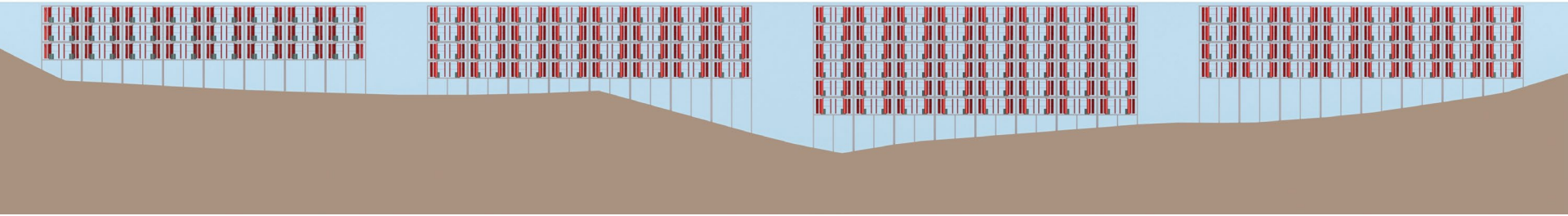
- Confinement increases turbine power output, but also increases forces
- **Can we use confinement to reduce levelized cost of energy?**
- **What is the most favorable control strategy?**

Turbine Design: Building Block to Array



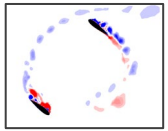


Array Layout

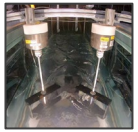


Array Blockage ~ 55%

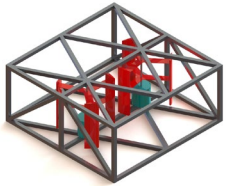
Co-Design Framework



Non -dimensional rotor performance (simulation or experiment)



Dimensional rotor performance



Powertrain design

Powertrain performance

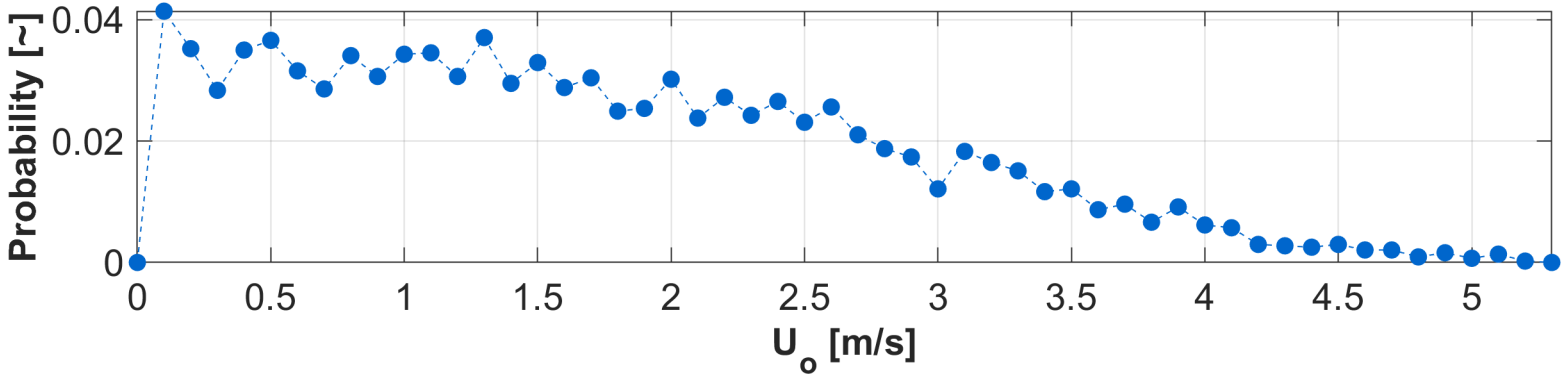
Superstructure evaluation

Blade design check (simulation only)

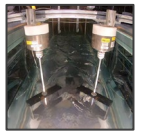
Array performance

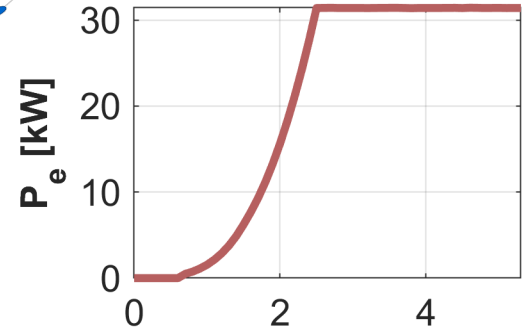
Economic evaluation

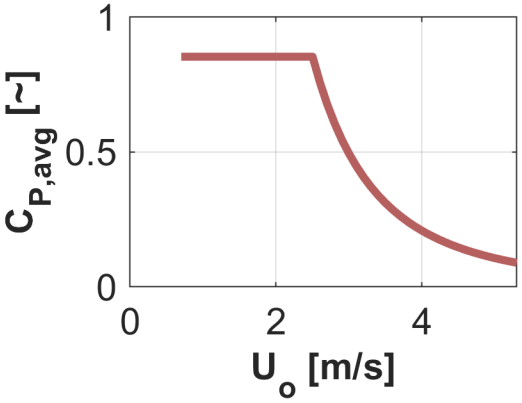
Dimensional Performance



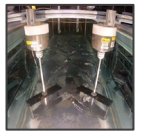
Operating Strategy Options

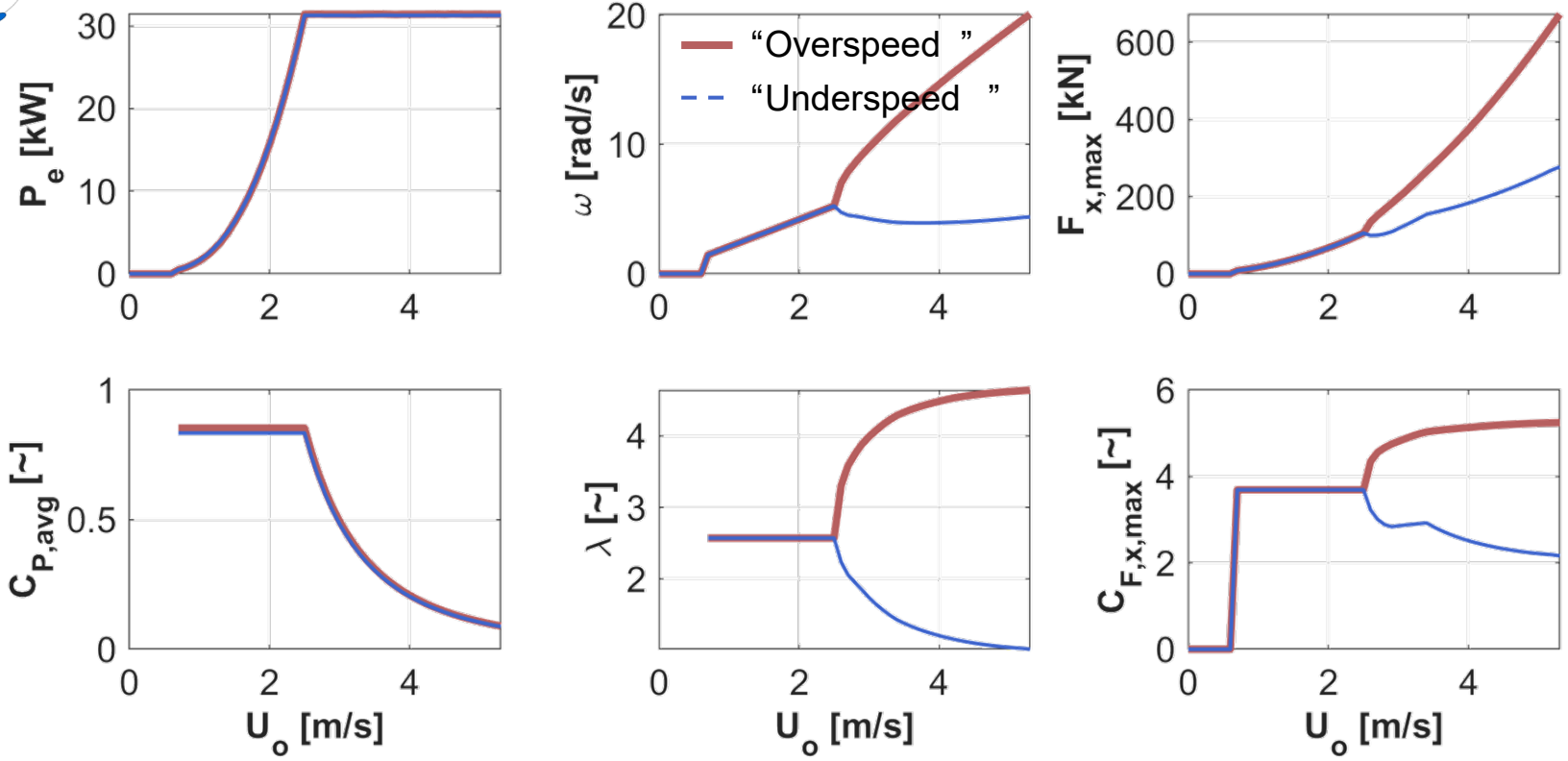




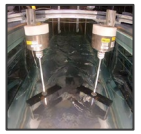


Operating Strategy Implications

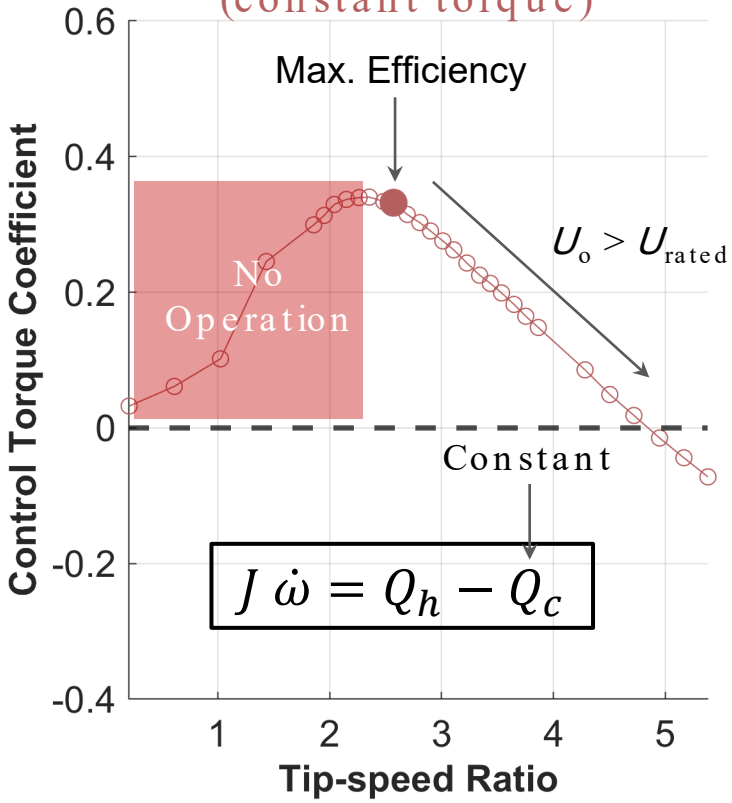




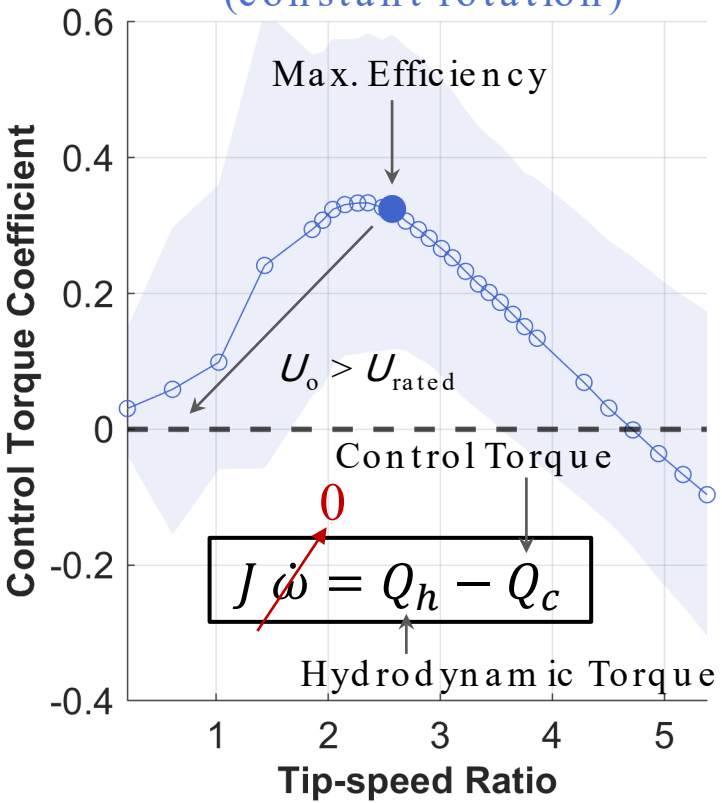
Operating Strategy Implications



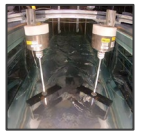
Overspeed Control
(constant torque)

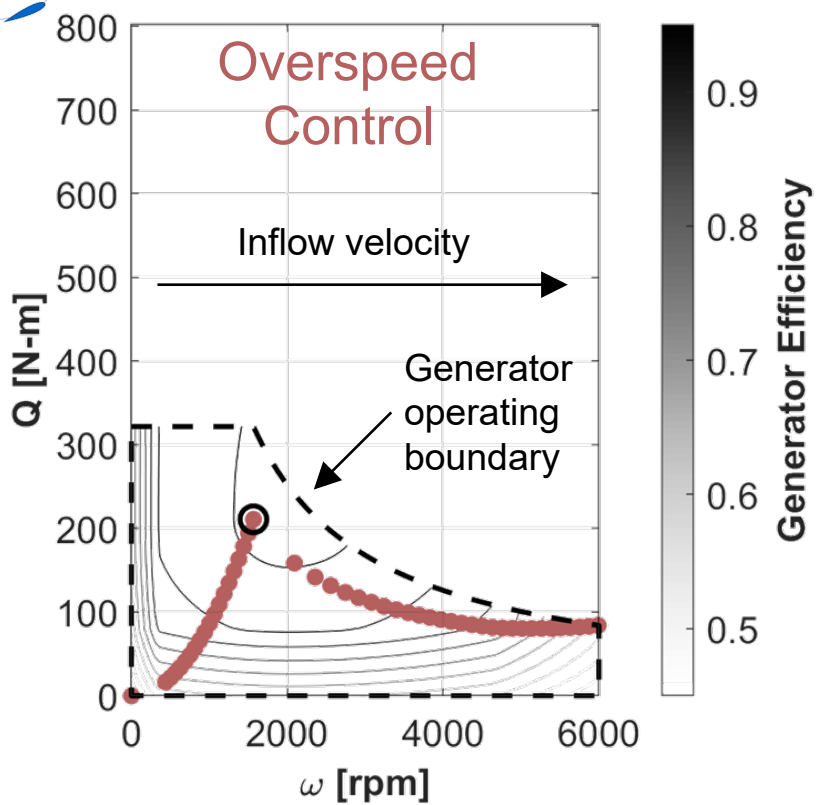


Underspeed Control
(constant rotation)

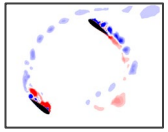


Powertrain Design

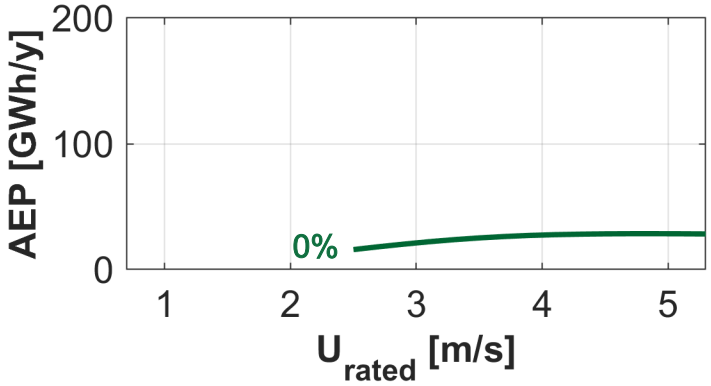




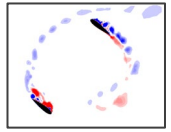
Economic Implications



Underspeed



Economic Implications



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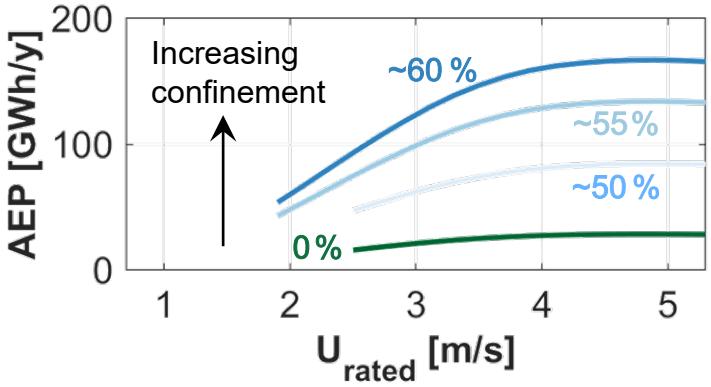
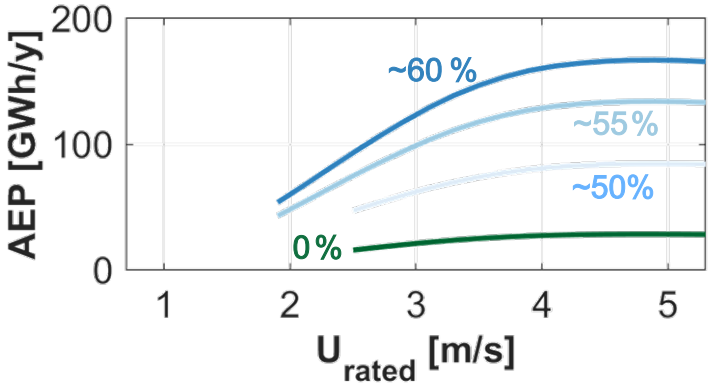
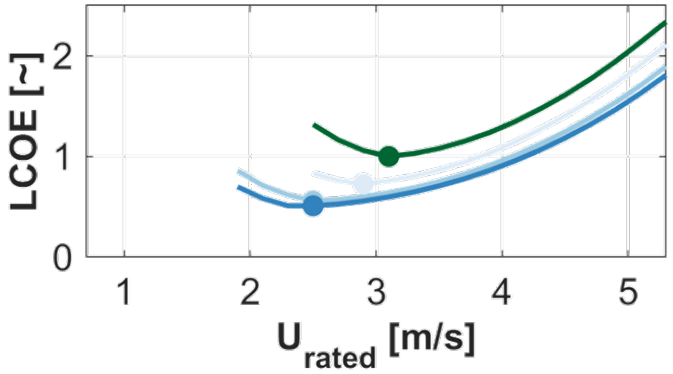


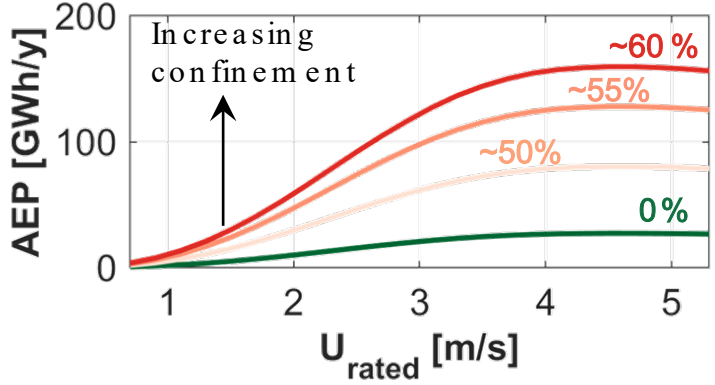
Economic Implications

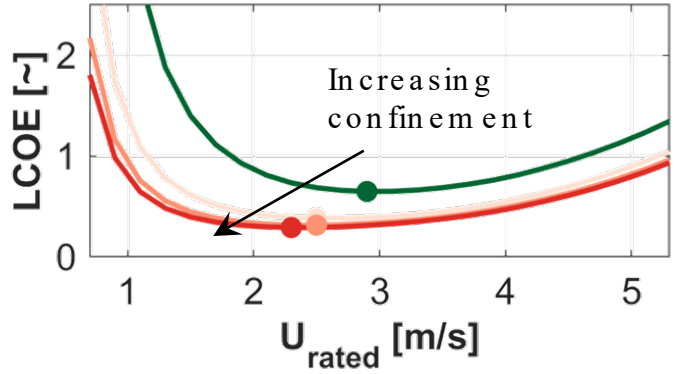
Underspeed





Overspeed





Conclusions to Date

- Relative to an unconfined array with the same number of turbines, confinement offers ~50% reduction in LCOE with control co - design

- Trade -offs for overspeed and underspeed control – powertrain and structure

Acknowledgements

Dr. Jen Franck (UWisc)

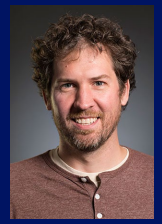
Dr. Owen Williams

Dr. Richard Weibe

Dr. Marc Wiseman (Oberon Insights)

Elena Baca (NREL)

Tina Ortega (NREL)



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Rithwik Kandakuri (UWisc)

Mukul Dave (UWisc)

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Tony Clay