# Layout and Design Considerations for a Confinement-Exploiting Array of Cross-flow Turbines

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# Project Objectives

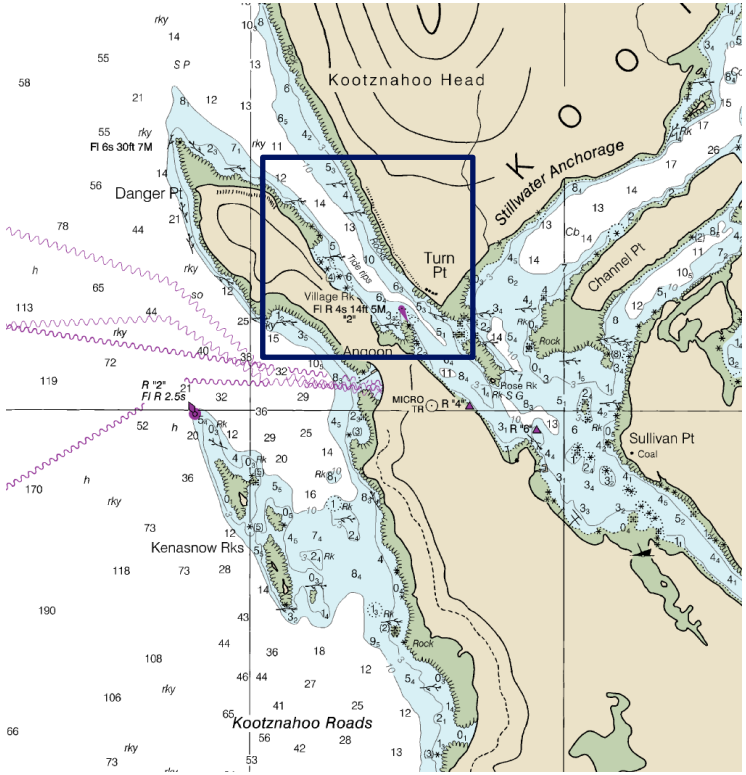
- Confined flow…

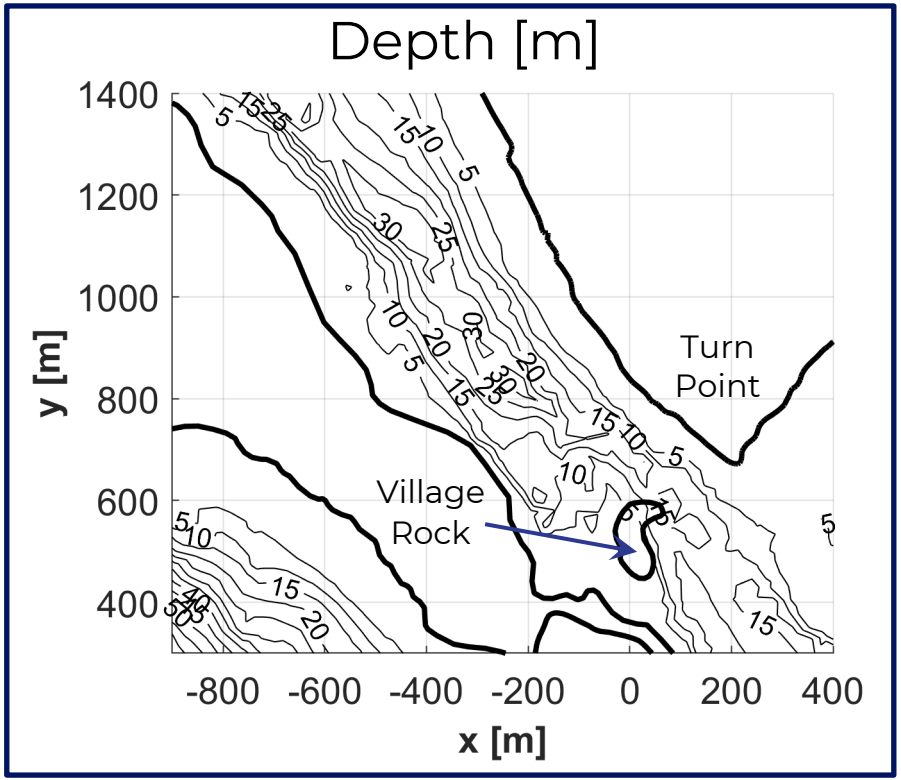
  …increases power coefficients

  …increases force coefficients

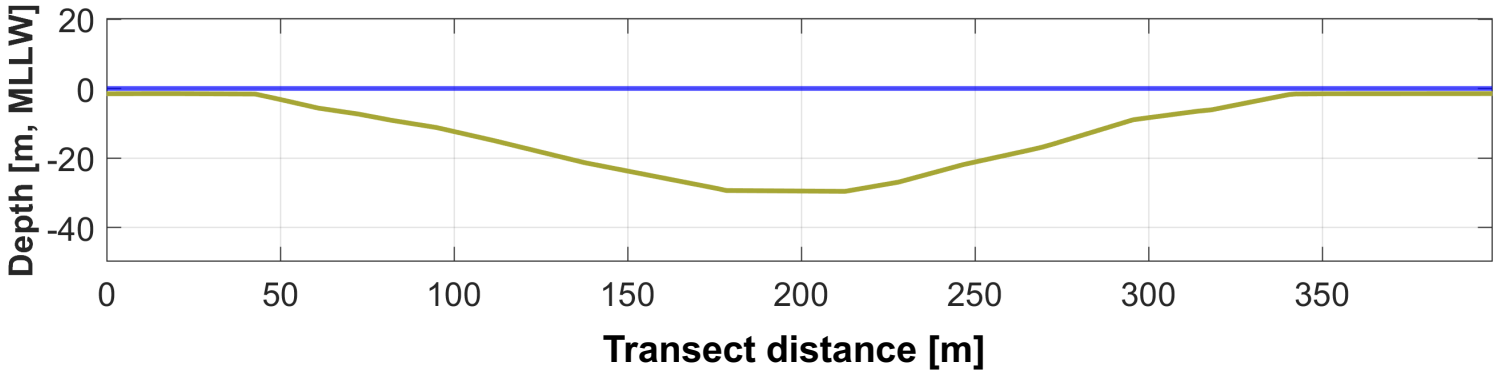
Balance these trade-offs for arrays of cross-flow turbines to reduce levelized cost of energy

# Scenario Location: Angoon, AK



# Layout Constraints



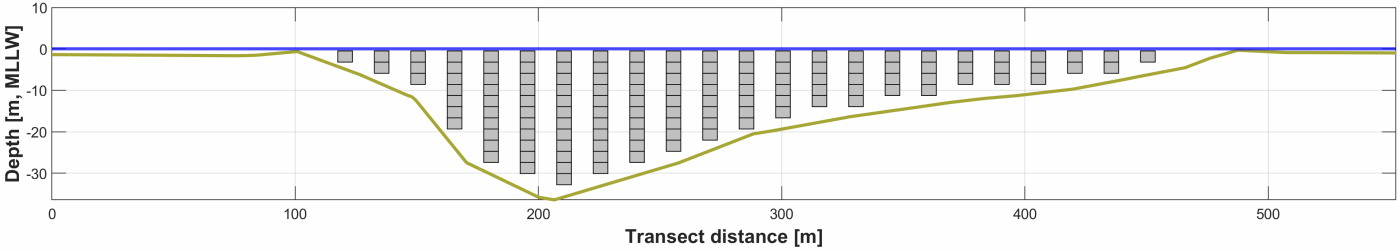

W: 2*N* x 3.01 m

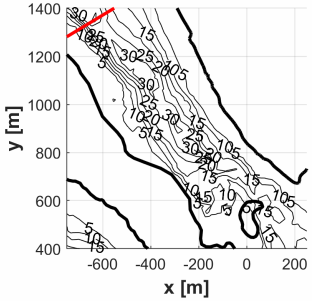
H: 2.69 m

**Module**: Turbines, Powertrains, and Support Structure

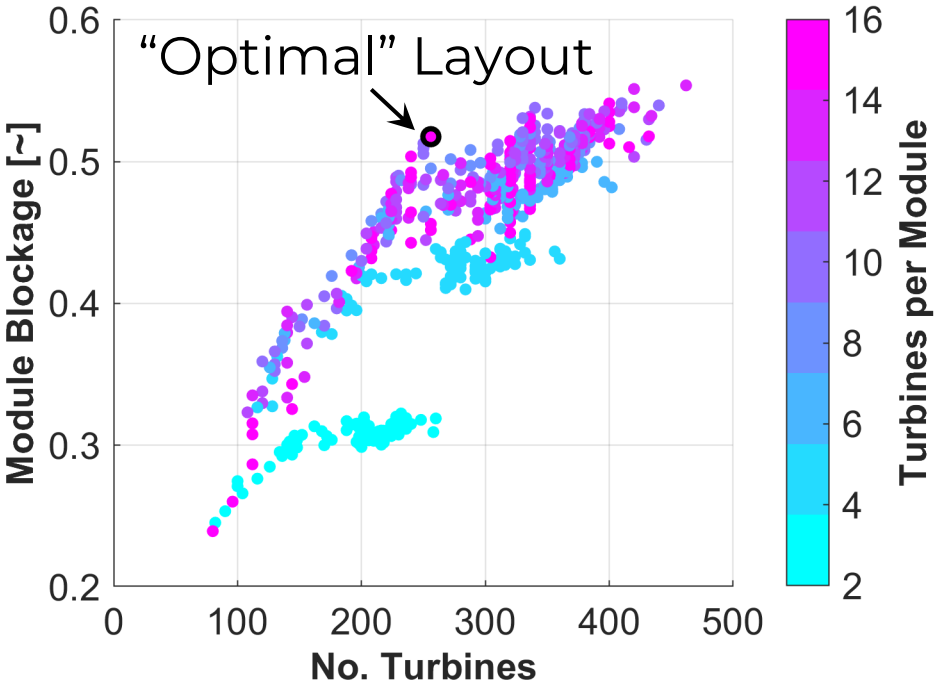
# Layout Evaluation

- ≥ 1 m clearance with seabed
- 0.5 m clearance with surface
- Gap between stacks equal to 3x module height



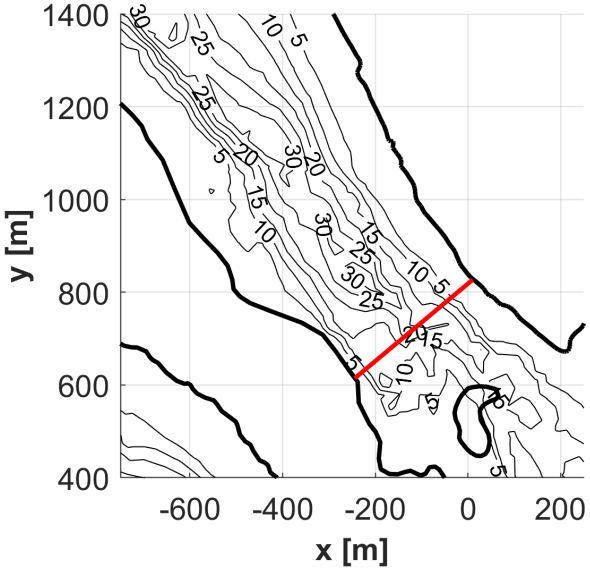



# Layout Selection



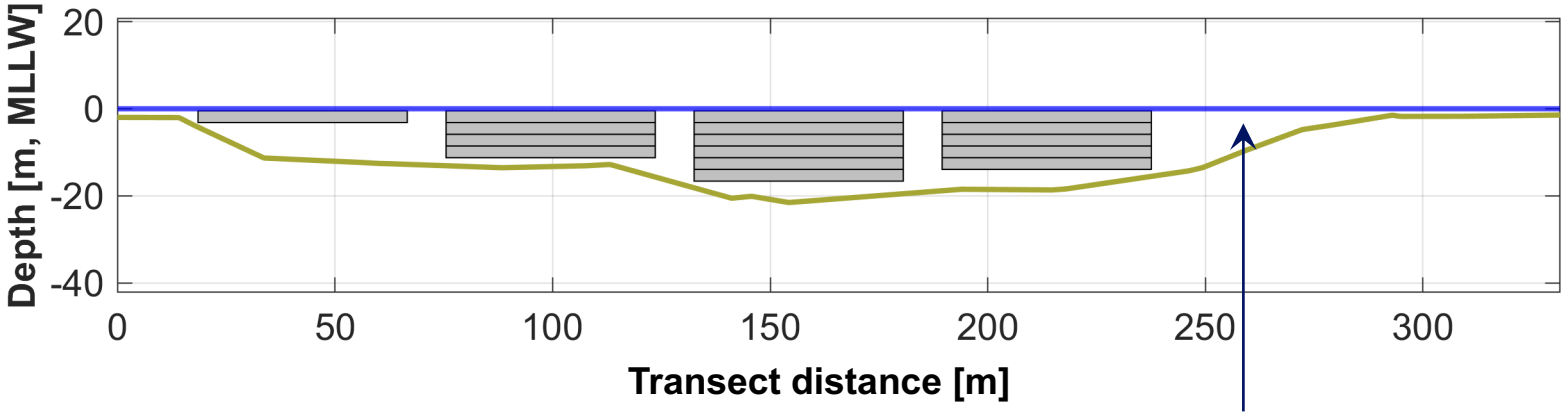

Objective function:

- 60% Module Blockage
- 40% 1/(No. Turbines)



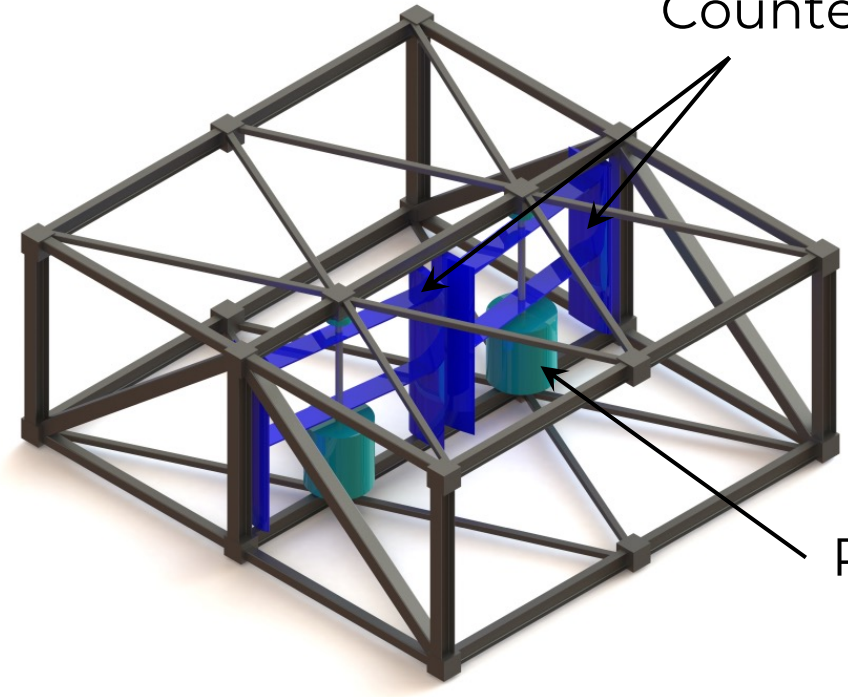
# Layout Selection

Blockage = 52%




Vessel Passage

# Conceptual Layout Realization



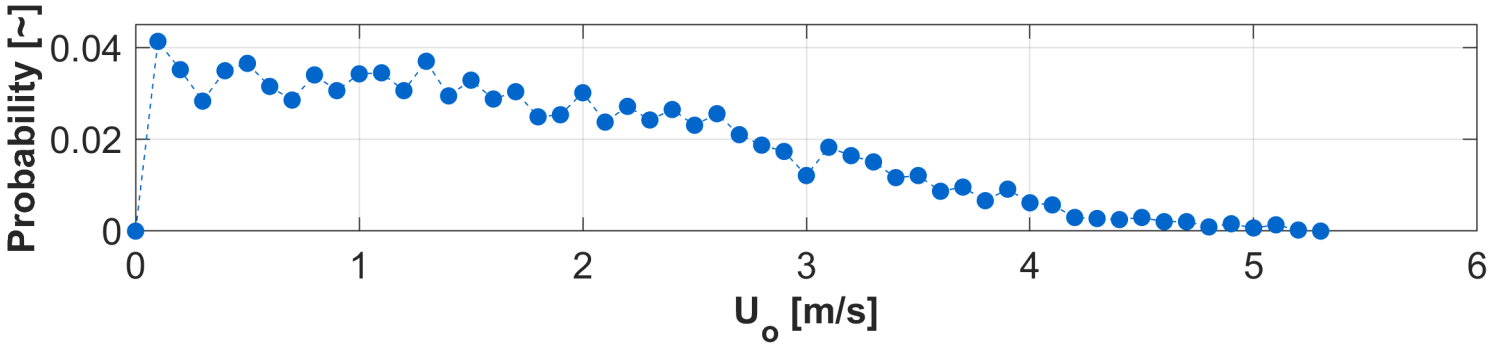
Counter-rotating cross-flow turbine pair

Modular superstructure

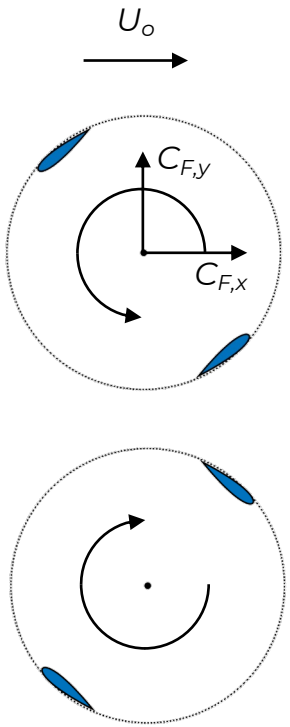
Powertrain inside rotor swept area

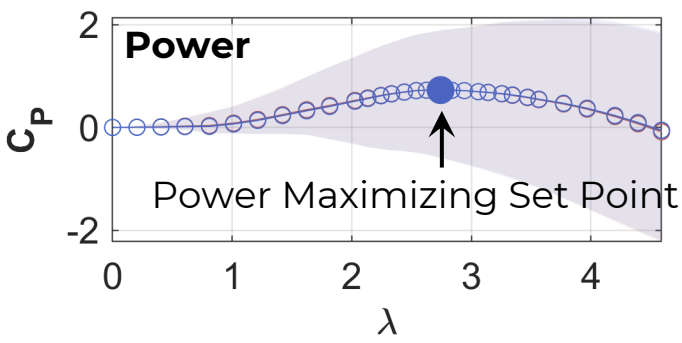
Rotor infill: ~75%

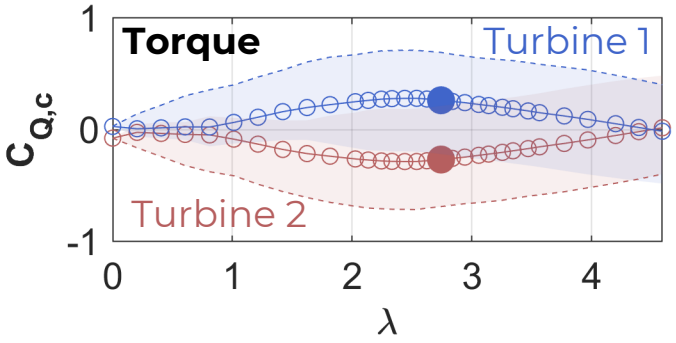
# Operating Strategy

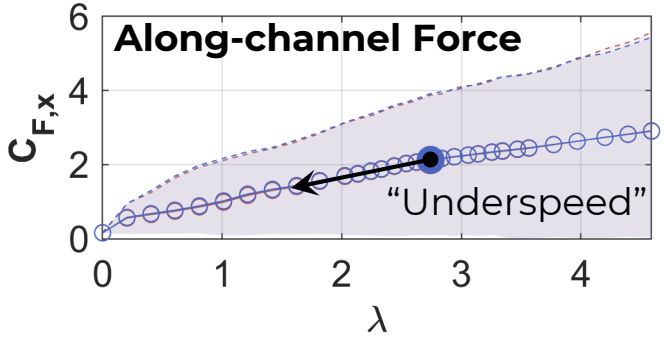


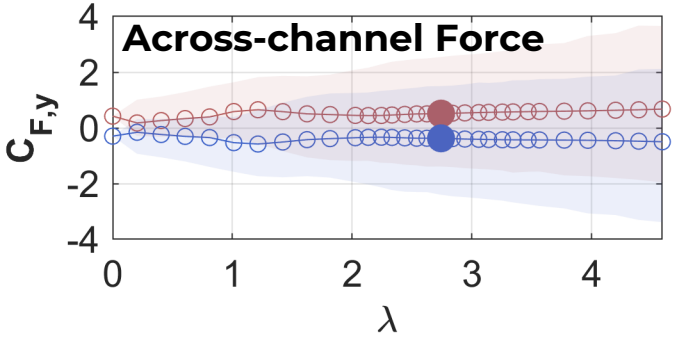
# Non-dimensional Performance



# Dimensional Performance

**Mechanical Power**

$$P = \frac{1}{2}\rho U_o^3 A C_P(\lambda)$$

Fluid Density

Projected Area

$$\lambda = \frac{R\omega}{U_o}$$

Rotor Radius

Rotation Rate

**Structural Loads**

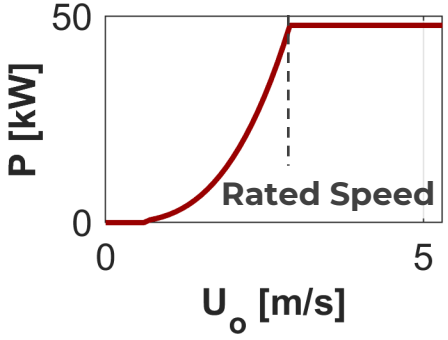
$$\vec{F} = \frac{1}{2}\rho U_o^2 A \max\left(\vec{C}_F(\lambda)\right)$$

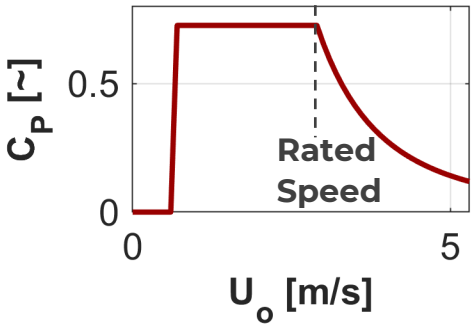
**Powertrain Torque**

$$Q_c = \frac{1}{2}\rho U_o^2 A R \max\left(C_{Q,c}(\lambda)\right)$$

Augment $U_o$ by 1.3*x* for turbulence

# Dimensional Performance



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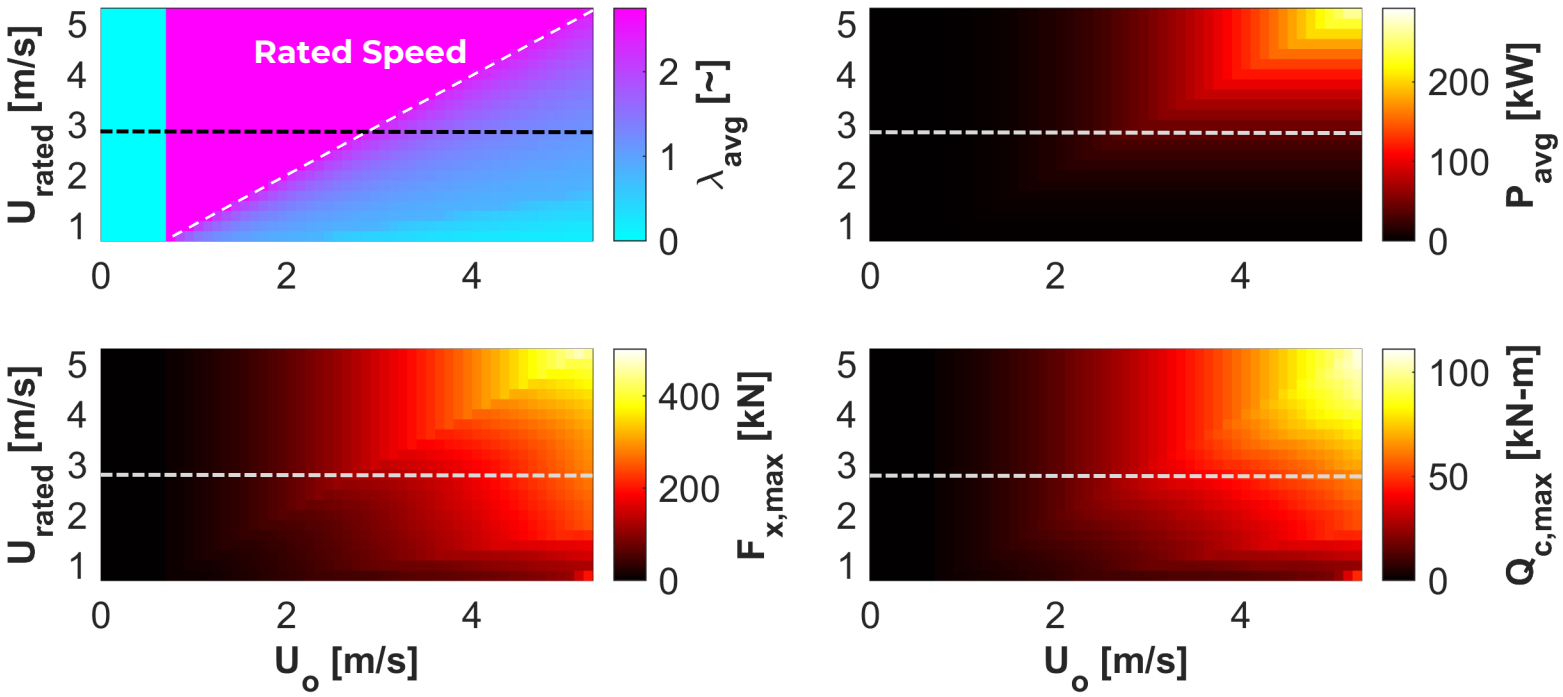

# Conclusions

- *Theoretically* possible to achieve > 50% blockage in natural channels with uniform modules
- Non-dimensional and dimensional performance metrics may move in different directions

# Next Steps

- First stage in economic analysis pipeline
  - Maximum torque and loads → component sizes
  - Powertrain analysis → annual energy production
- *Increasing* dimensionality
  - Control strategies (e.g., intracycle)
  - Turbine geometries
  - Scenario locations

# Acknowledgements

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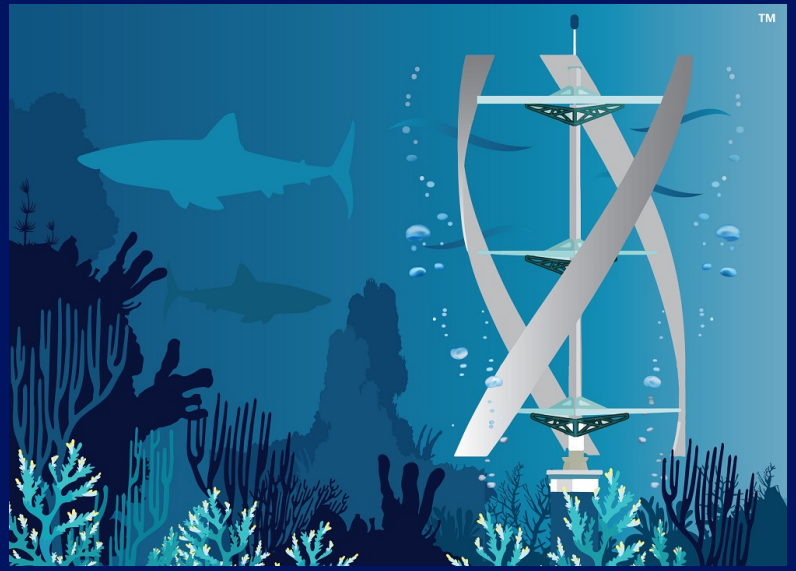

# Questions?