



## ARCUS Vertical-Axis Wind Turbine

Sandia National Laboratories, Keppel FloaTEC,  
American Bureau of Shipping



Sandia National Laboratories

**Keppel FloaTEC**



Principal Investigator: Brandon Ennis

# ARCUS Vertical-Axis Wind Turbine

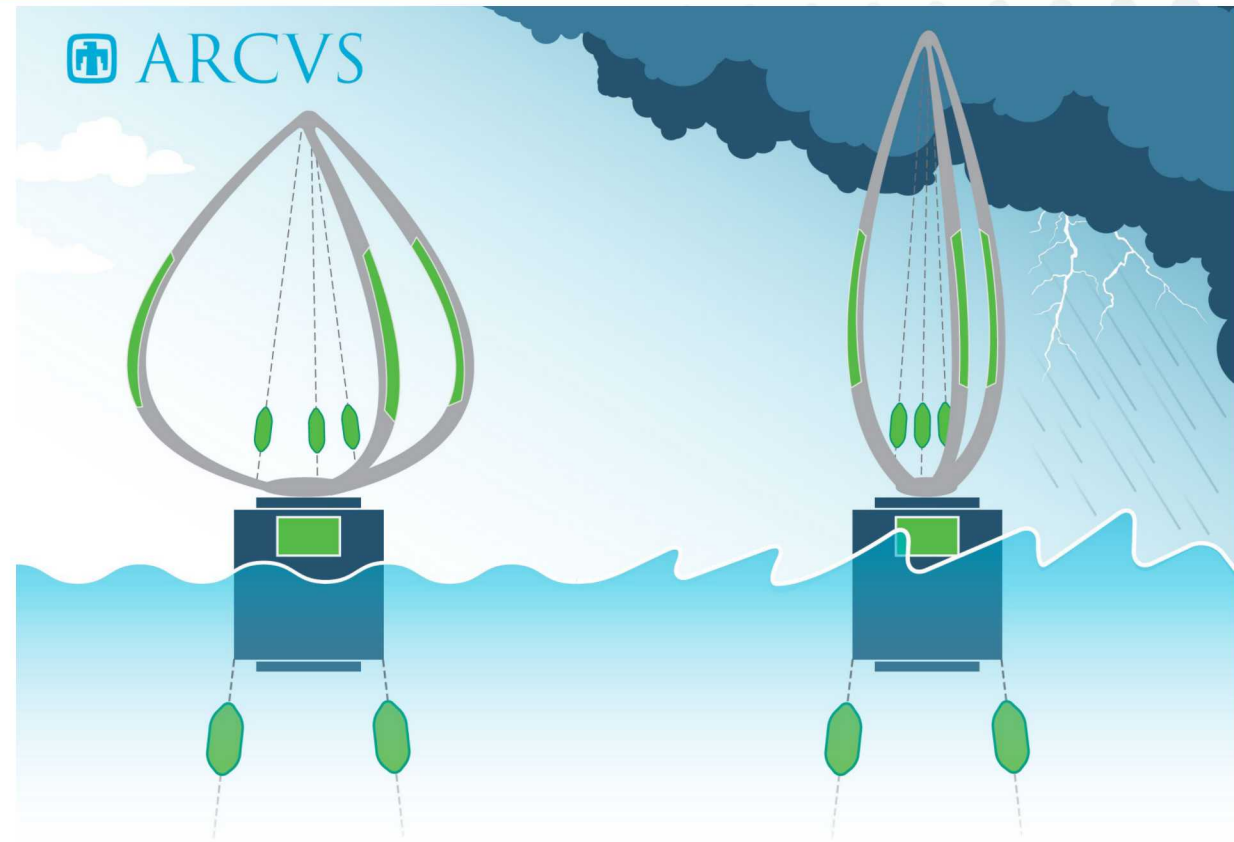
Brandon Ennis, Sandia National Laboratories

## Team members

- Andrew Zhang (FloaTEC), Qing Yu (ABS), Giorgio Bacelli (SNL)

## What is your project?

- *The ideal wind energy system would eliminate all mass and cost that is not directly capturing energy from the wind*
- *VAWTs have inherent advantages over HAWTs for floating offshore wind energy installations*
- *Platform level placement of the drivetrain and improved aerodynamic efficiency greatly reduce system costs*
- *The ARCUS concept replaces the massive center tower with a pre-tensioned rotor and tensioned center supports*



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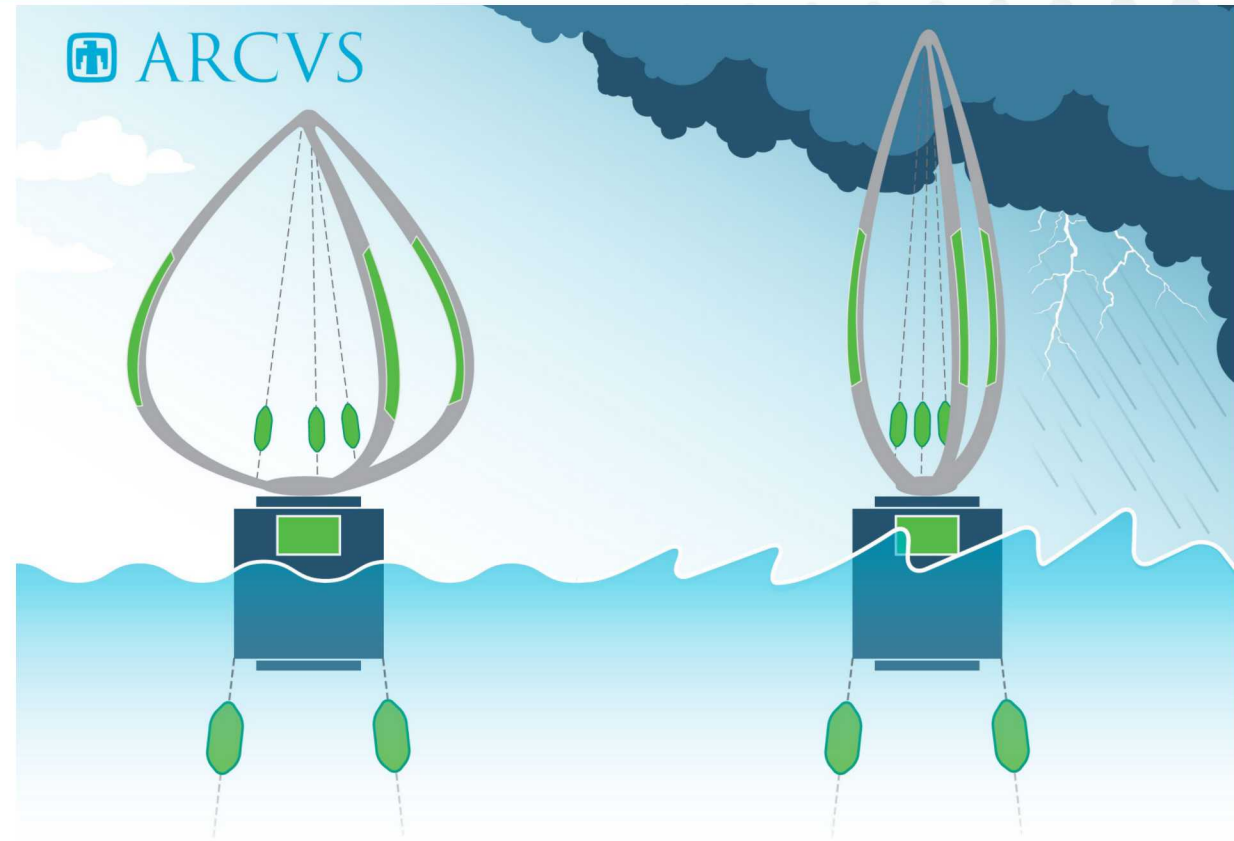
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## What is your project?

- The objective of the ARCUS design is to eliminate mass and cost that does not directly capture energy through concurrent optimization of the coupled system
- Instead of designing the platform to eliminate motion of the turbine, the team will design the oscillating turbine-platform system to operate safely within the operational response
- The project team will develop advanced models and optimization routines with varying fidelity levels to simulate the coupled system at speeds required for optimization studies



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## How is your project transformational?

- *In the previous 5 MW VAWT studies at Sandia the tower accounted for over 80% of the rotor mass*
- *The ARCUS design can result in a rotor mass that is 50% lighter than traditional Darrieus VAWT designs*
- *Keppel FloaTEC and ABS bring industrial experience to design and approve the tension leg platform, greatly reducing the uncertainty around this major cost component*
- *The project team will study four control elements to identify which have potential to reduce system LCOE (generator, rotor area, active aerodynamics, and mooring control)*
- *Cross-collaboration tasks:*
  - *Comparison of HAWT with VAWT*
  - *VAWT code OWENS incorporated in OpenFAST/WEIS*
  - *Methodology to develop scaled floating VAWTs*
  - *VAWT scale model design and test at Umaine*
  - *Model testing of active TLP – collaboration definition*



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## What challenges do you anticipate?

- *Removal of VAWT tower has never been demonstrated and doing so at a 15 MW scale will require a significant engineering effort*
  - *This risk will be mitigated by exploring options for wire rope center support locations and blade number and material to provide additional stiffness*
- *The complexity of the optimization routines and the large number of variables required in the design space poses a challenge to ensure that you reach a global optimum solution while accurately predicting the system lifetime performance*
  - *This risk will be mitigated through the use of multi-fidelity/multi-level analysis capabilities developed within the project*

Performance Metric	ARCUS value	Baseline value
Power generation efficiency, M1	0.4378	0.3943
Mass equivalent area, M2	0.002288	0.001060
Rotor equivalent mass, Ar/m1	0.0111	0.0123
Hub equivalent mass, Ar/m2	0.4057	0.0202
Nacelle equivalent mass, Ar/m3	0.0090	0.0055
Tower equivalent mass, Ar/m4	0.1389	0.0152
Floating platform equivalent mass, Ar/m5	0.0046	0.0019
Mooring system equivalent mass, Ar/m6	0.2938	0.1382
Anchor system equivalent mass, Ar/m7	0.1485	0.0582
Wind farm power density, WFPD	4.9	3
Levelized Cost of Energy, LCOE	0.0719	0.1362

The ARCUS rotor enables mass and cost reductions across most turbine components (excluding the rotor) compared to a baseline HAWT design. Performance benefits also contribute to achieve a low LCOE.