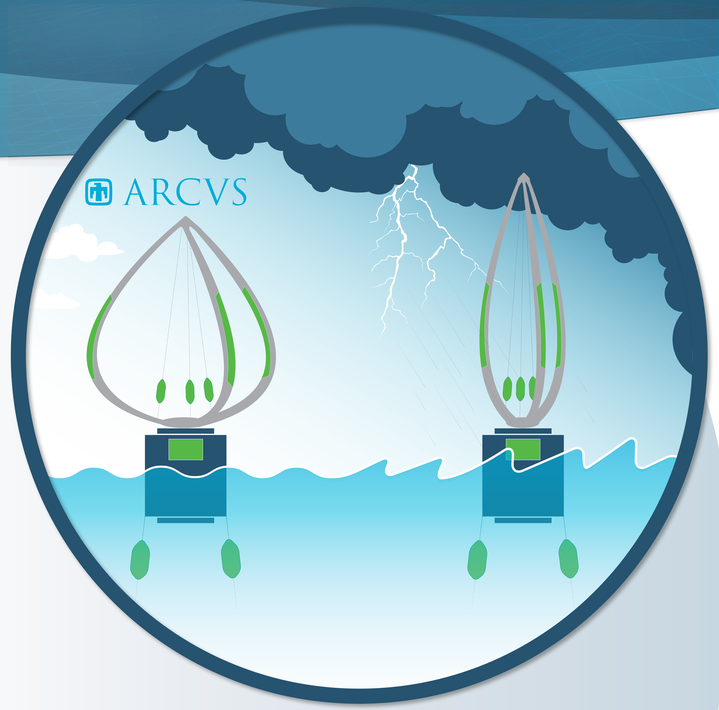
A VERTICAL-AXIS WIND TURBINE OPTIMIZED TO REDUCE THE COSTS OF FLOATING OFFSHORE WIND ENERGY

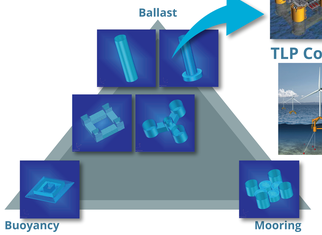


A turbine designed for offshore sites

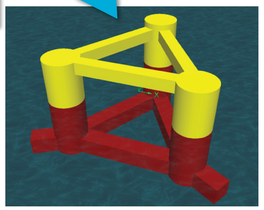
- The ideal wind energy system would remove all mass and cost not directly capturing energy from the wind
- For floating offshore wind energy, this objective is even more significant as increased mass above the water level must be supported by larger and more expensive floating platforms
- ARCUS is a Darrieus VAWT that replaces the traditional rigid tower with pre-stressed blades and tensioned center supports (patent-pending), like a bow, which:
  - Enables an efficient usage of material
  - Enables rotor area control for high wind speed load reduction
  - Results in up to a 50% rotor mass reduction

An optimal platform paired with an optimal turbine

TLP Concepts currently in Operation for Oil and Gas Production



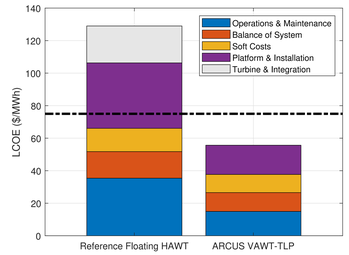
TLP Concepts developed for HAWT designs



- The low drivetrain placement and mass properties of the ARCUS VAWT, compared to a horizontal-axis wind turbine (HAWT), make it optimally suited for a tension-leg platform, identified as a cost-optimal platform architecture with additional performance benefits
- Tension-leg platforms (TLP) have the lowest hull mass compared to alternative architectures and are ideally suited for both shallow and deep-water sites in the U.S., scalable to beyond 1000m
- An optimal TLP hull architecture was identified through discrete design studies that minimized mass while meeting the design requirements (quayside integration, self-stable during tow out)

Lower costs, higher energy capture

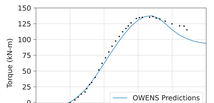
ARCUS initial LCOE calculation, excluding turbine

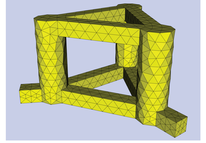


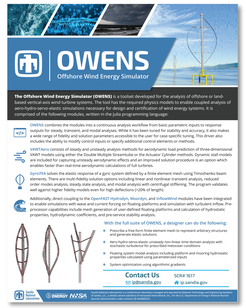
- The project team has the expertise to perform detailed design of the turbine-platform system with accurate cost estimation
- Subsystem design optimization studies reveal opportunity for the ARCUS-TLP system to perform better than the target levelized cost of energy (LCOE) of less than $75/MWh
- Full system control co-design optimization will be used to identify the optimal system (physical and controls), resulting in further LCOE reductions

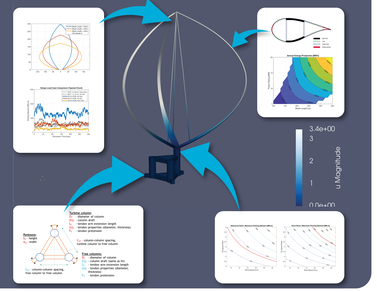
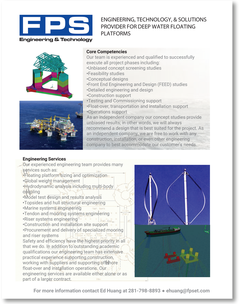
An analysis tool capable of design and optimization of floating VAWTs

- In order to design floating VAWTs, a tool is needed that can model arbitrary rotor and platform architectures while simulating the coupled dynamic response to wind, waves, and structural displacement
- Sandia has developed the Offshore Wind Energy Simulator (OWENS) to address this need, while ensuring the computational efficiency necessary for complex optimization studies
- There can't be a floating offshore vertical-axis wind turbine industry without a trusted tool like OWENS







System optimization to exploit complex cost-performance tradeoffs

- In the traditional approach to platform design, platform mass and inertia are used to ensure operational stability for a fixed turbine design, resulting in heavy and expensive platforms
- The optimal ARCUS turbine, platform design, and control approach will be identified through designing the rotor, platform, and controls concurrently using a control co-design methodology developed within the project
- Design tradeoffs will be balanced to find the optimal relationship between loads, energy capture, and dynamic response that minimizes the system levelized cost of energy