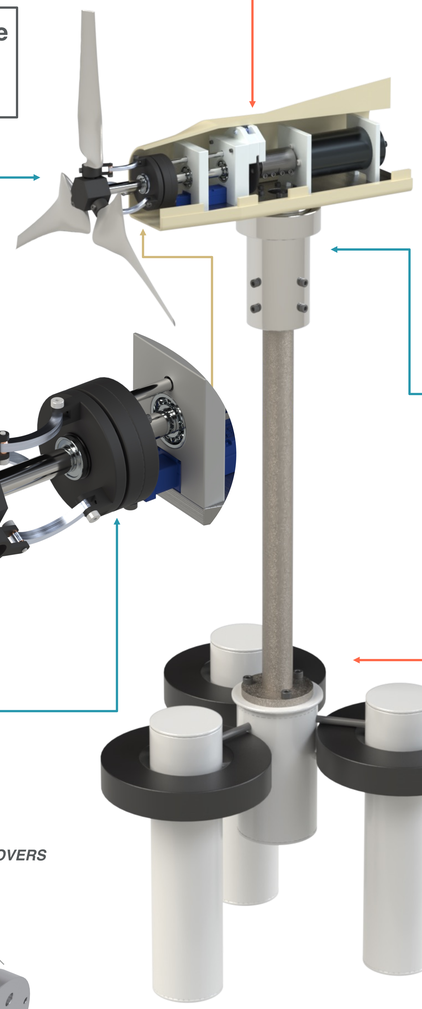
2025 DOE Collegiate Wind Competition
Turbine Prototype and Test Contest

Simon Abrahamse, Nile Brown, Arturo Errejón, L. Quinn Gossett, Isabel Lopez, Anoothi Narayan, Andrew Palmer, Ben Partee, Evan Steinmetz, Camille Thompson, Alden Wade, Bellamy Weibel, Ella Wlodarczk

COLLEGIATE WIND COMPETITION
U.S. DEPARTMENT OF ENERGY

COMPETITION + DESIGN REQUIREMENTS

- ❑ **Design, build, and test a prototype, small-scale off-shore floating wind turbine**
- ❑ **Optimize power generation across wind speeds of 5-13 m/s**
- ❑ **Minimize weight for floating foundation stability**



BLADES

- E216 Airfoil: Optimal glide ratio
- TSR-4: Highest efficiency, FS: 4

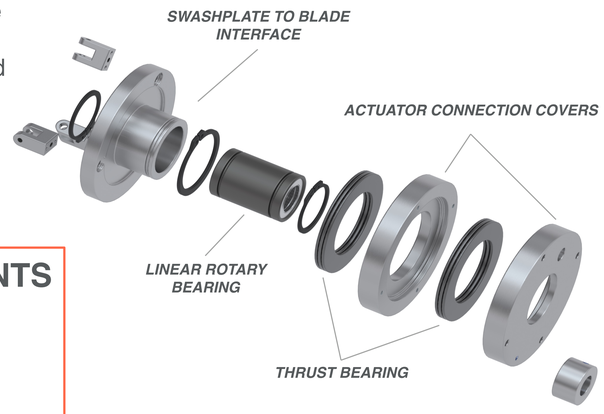
$$TSR = \frac{\omega * r}{V} = \frac{Speed\ of\ Rotor\ Tip}{Wind\ Speed}$$

HUB

- Transmit force from blades to the driveshaft
- Allow blades to pitch with minimal effort
- External pitching mechanism

PITCH + BREAK

- Blade pitching and brake utilize single linear actuator
- Minimize driveshaft binding and frictional power loss
- Friction and drag braking
- 45° of blade rotation



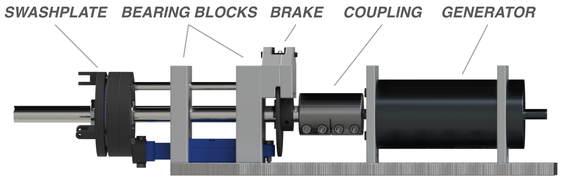
ELECTRONICS

SYSTEM REQUIREMENTS

- Automatic Startup
- Automated Control System
- Emergency Stop
- Maintain stable power outputs

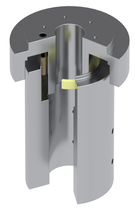
NACELLE

- Transmit shaft torque into generator while mitigating vibration
- House the generator and sensors
- Align the center of gravity with the tower and foundation



$$Power_{Rotor} = C_P * KE_{Wind} = \omega * \tau_{Shaft}$$

YAW

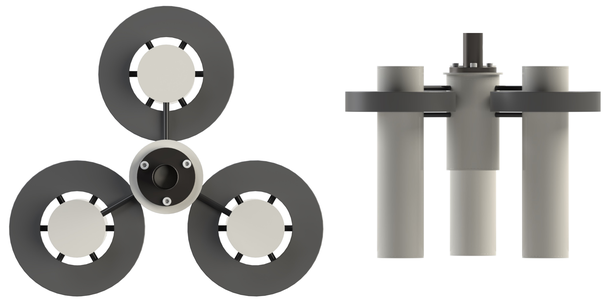


- Passive system to align with wind
- Quick disconnect between nacelle and tower
- Internal design protects components and wiring
- Design inspired by LEGO

FOUNDATION + TOWER

- 15 m/s winds, under 15 degrees of tilt
- Semi-submersible and spar-buoy float design
- Chain mooring lines connect foundation to anchors

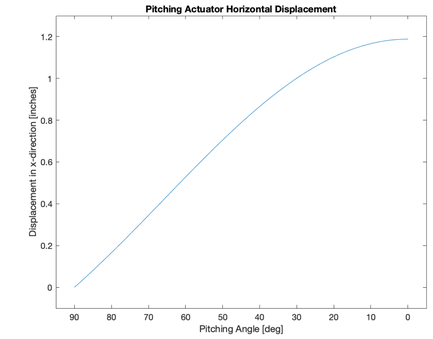
$$F_{Buoyancy} = \rho_w * g * V_{disp} \rightarrow \%_{Submerged} = 67.21\%$$



TESTING

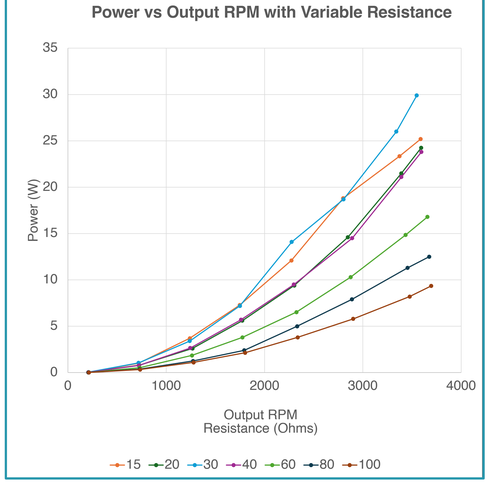
MECHANICAL

- E-brake Test
- Power-curve performance
- Pitch Angle Test



ELECTRICAL

- Generator Power Curve
- Emergency Shutdown
- Automatic Startup



CONTROL SYSTEMS

Stage 1: Startup
No power generation

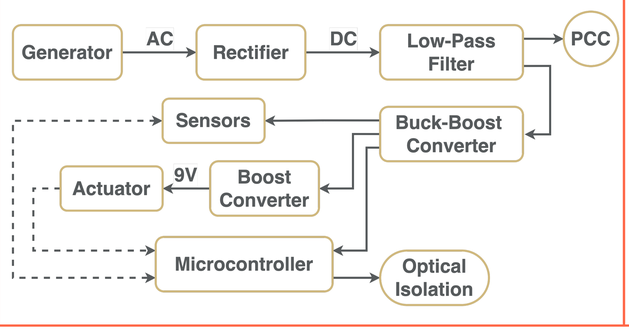
→ **Stage 2: Cut-in**
Maximize rotor efficiency
Increase RPM

Stage 3: Nominal Power
Constant power operation
Mitigate output to protect electrical system

Stage 4: Cut-out
No power generation
Trigger mechanical braking

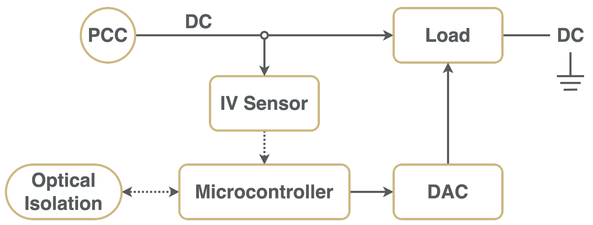
NACELLE SIDE

- Component control and power management



LOAD SIDE

- System control and power dissipation



2024-25 CU WIND TURBINE: FAST FACTS

1:430 *SCALE*
204 *TOTAL PARTS*
50 INCHES/127 CM *TOTAL HEIGHT*
4 *TYPES OF BEARINGS USED: PLAIN, ROTARY, THRUST, LINEAR ROTARY*

OUTCOMES

- ✓ **Withstand wind speeds up to 15 m/s**
- ✓ **Generate constant power output over varying wind speeds**
- ✓ **Maintain balanced center of gravity over tower**
- ✓ **Utilized variety of manufacturing processes to custom build eight subsystems**

Paul M. Rady Mechanical Engineering
UNIVERSITY OF COLORADO BOULDER

Special thank you to Dr. Julie Steinbrenner, Dr. Daria Kotys-Schwartz, Roark Lanning, CeramicSpeed, CU Idea Forge, CU ITLL, and Engineering Excellence Fund

DESIGN CENTER COLORADO

2025 DOE Collegiate Wind Competition

Project Development Contest

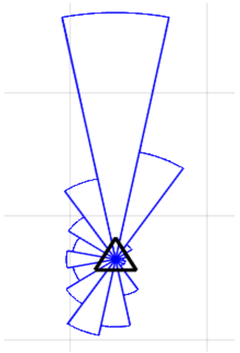
Simon Abrahamse, Nile Brown, Arturo Errejón, L. Quinn Gossett, Isabel Lopez, Anoothi Narayan, Andrew Palmer, Ben Partee, Evan Steinmetz, Camille Thompson, Alden Wade, Bellamy Weibel, Ella Wlodarczk

COLLEGIATE WIND COMPETITION
U.S. DEPARTMENT OF ENERGY

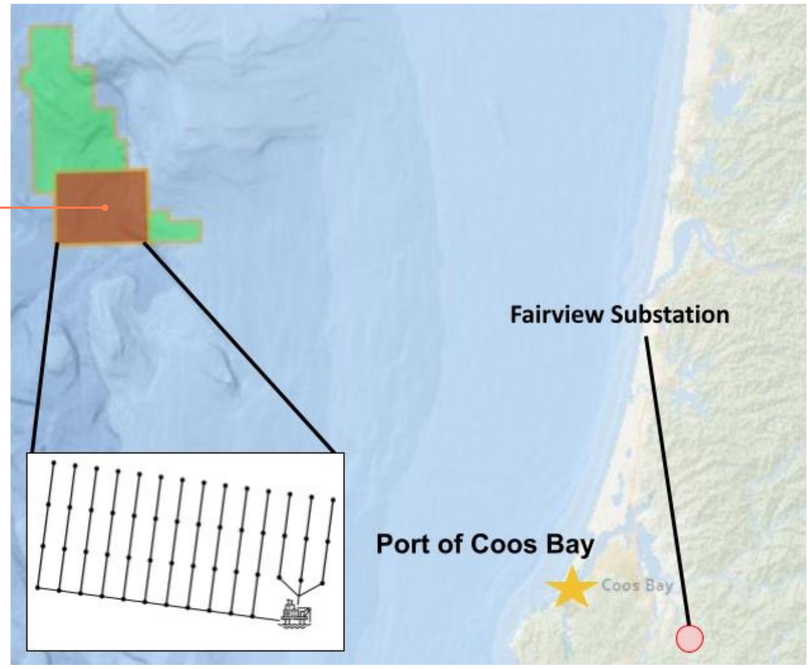
COMPETITION REQUIREMENTS

- ❑ Assess wind farm development opportunities off the Oregon Coast
- ❑ Create rough development plan
- ❑ Conduct assessment of 30-year project economics

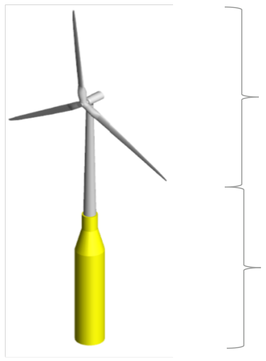
SITE SELECTION



COOS BAY WIND ENERGY AREA	
Average wind speed	9.35 m/s
Mean water depth	1178 m
Distance from shore	51 km
Site area	247.6 km^2



TURBINE SUBSTRUCTURE

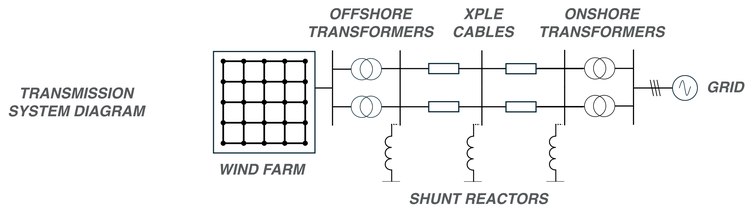


- Vestas V236-15.0MW
- 236m diameter
- Cut-in wind speed 3m/s

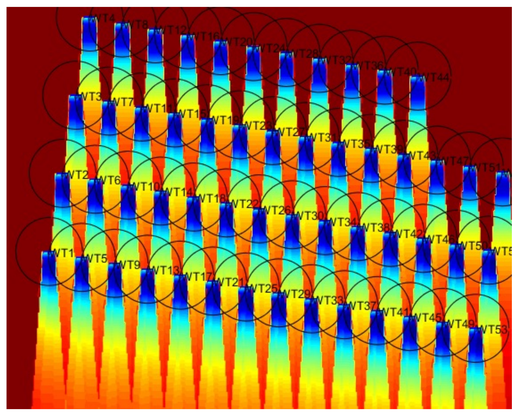
- Spar buoy foundation
- Lower costs
- Less mooring line requirements

COLLECTION + TRANSMISSION

- HVAC floating substation
- 66kV (inter-array) & 220kV (export)
- Power compensation shunt reactors: 3
- Power received by Fairview Substation

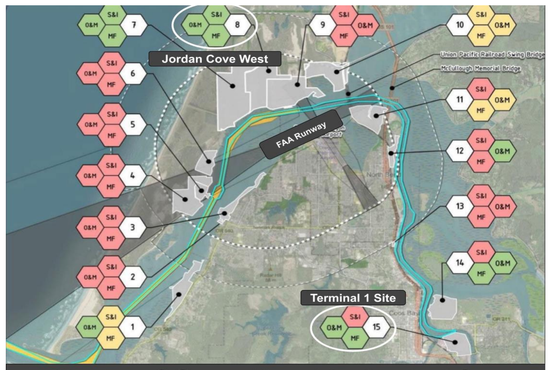


WIND FARM SITE DESIGN	
# of turbines	53
Nameplate capacity	795 MW
Capacity factor	~ 56%
Active + reactive power losses	9.62 MW



NAUTICAL LOGISTICS

- DP Vessels, DriX submarines, SOVs
- Feeder barges for Jones Act



Ports of Coos Bay Evaluated for Staging, O&M, & Construction

ENVIRONMENTAL ASSESSMENT

- NEPA/EPA requirements
- Permitting matrix
- Action/No Action

PERMITTING MATRIX		
FEDERAL	**STATE**	**LOCAL**
Airspace, navigable waters, federally protected animals, incidental take, and federal air and water pollution regulations.	Construction effecting state land, state protected animals, roads, air and water pollution regulations.	Shoreline construction, electrical, public works, and city sound and noise ordinances.

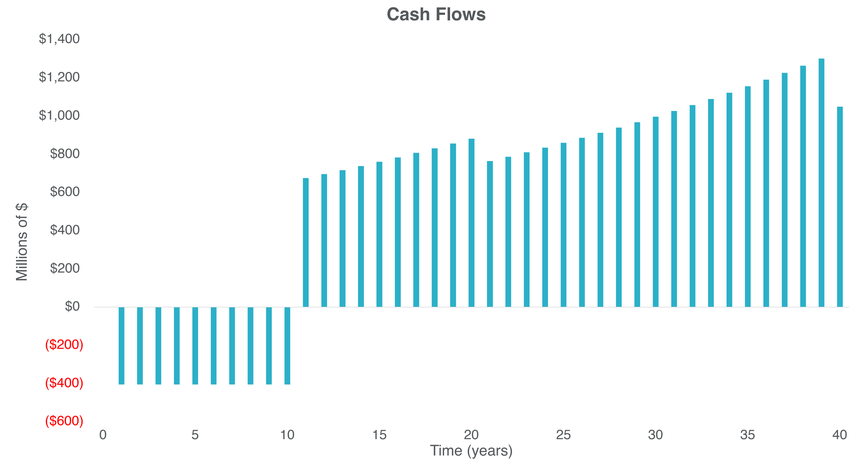
IMPACT TOPIC	PROPOSED ACTION/IMPACT
Fisheries	Loss of area and new navigation pathways
Marine Life	Forced migration and behavioral changes
Topography	Sediment transport, habitat destruction, and shoreline alteration
Acoustic Environment	Long and short-term noise
Invasive Species	Introduction and food web changes

FINANCIAL OVERVIEW

SITE FINANCING	
Initial Capital Costs	$4.1b
Annual OpEx	$96m
IRR with IRA tax credits	11%
IRR w/o IRA tax credits	9%
Levelized Cost of Energy	$75/MWh

FINANCING PLAN

- Investors initially own 80%
- Investors receive 99% of tax credits to recover investment
- Ownership shifts once investors are paid back



Paul M. Rady Mechanical Engineering
UNIVERSITY OF COLORADO BOULDER

Special thank you to Dr. Julie Steinbrenner, Dr. Daria Kotys-Schwartz, Roark Lanning, CeramicSpeed, CU Idea Forge, CU ITLL, and Engineering Excellence Fund

DESIGN CENTER COLORADO

2025 DOE Collegiate Wind Competition
Connection Creation Contest

Simon Abrahamse, Nile Brown, Arturo Errejón, L. Quinn Gossett, Isabel Lopez, Anoothi Narayan, Andrew Palmer, Ben Partee, Evan Steinmetz, Camille Thompson, Alden Wade, Bellamy Weibel, Ella Wlodarczk

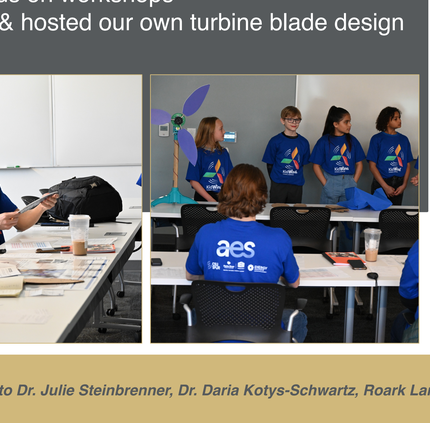
COLLEGIATE WIND COMPETITION
U.S. DEPARTMENT OF ENERGY

COMPETITION REQUIREMENTS

- ❑ **Foster connections between students, educators, and industry within the wind energy sector**
- ❑ **Bridge technical, societal, and political divides impeding the clean energy transition.**
- ❑ **Community outreach, education, and job placement**

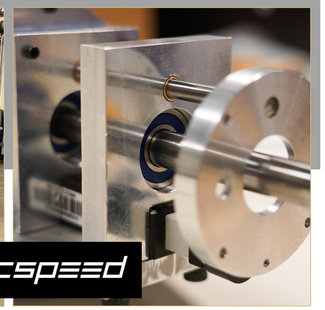
ENERGY FRONTIERS CAREER FAIR

- Opportunity for students to connect and network with over 10 renewable energy companies
- Partnered with CU Energy Club and Hydropower Team

CERAMIC SPEED SPONSORSHIP

- CermanicSpeed is an industry leader in high performance bearings
- Utilized CS bearings in multiple assemblies within the turbine



KIDWIND

- National organization dedicated to educating future generations about the clean energy transition through hands on workshops
- Attended CSU Spur KidWind event & hosted our own turbine blade design competition for students

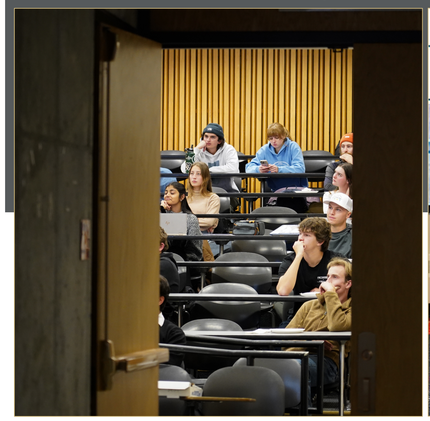
STUST PARTNERSHIP

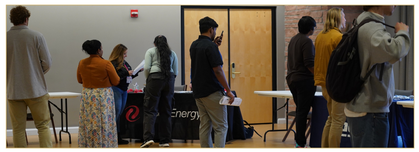
- Education exchange with Southern Taiwan University of Science & Technology (STUST)
- Participated in International WindRock + KidWind Event

南臺科技大學
Southern Taiwan University of Science and Technology
研發技轉｜教育訓練｜政府計畫

ON CAMPUS EVENTS

- Partnership with CU Energy and Wind Energy Clubs
- Hosted speaker events with renewable energy professionals
- Promoted Wind Team and provided networking opportunities for students






OUTCOMES

- ✓ **Partnerships with three student clubs and two industry partners**
- ✓ **Hosted four guest speakers, led three wind competition nights, and planned one campus-wide career fair**
- ✓ **Successfully recruited new team members**
- ✓ **Social media outreach over 100 community members**

2024-25 CU WIND TEAM

The CU Wind Team is a multidisciplinary team of senior engineering students at CU Boulder. Each member hails from a unique background, including Mechanical and Environmental Engineering, Energy Engineering, Applied Mathematics, Engineering Physics, Engineering Management, Robotics, and Mechatronics.

2024-25 CU Wind Team
Nile Brown, Ben Partee, L. Quinn Gossett, Simon Abrahamse, Evan Steinmetz, Andrew Palmer Camille Thompson, Bellamy Weibel, Isabel Lopez, Anoothi Narayan, Ella Wlodarczyk, Arturo Errejon

DOE COLLEGIATE WIND COMPETITION

Launched in 2014, the U.S. Department of Energy's Wind Energy Technologies Office created the Collegiate Wind Competition (CWC) for college students across the U.S. The CWC helps multidisciplinary teams of undergraduate students prepare for jobs in wind and renewable energy through three contests:

COLLEGIATE WIND COMPETITION
U.S. DEPARTMENT OF ENERGY

PROJECT DEVELOPMENT CONTEST

Teams research wind resource data, transmission infrastructure, and environmental factors to create a site plan and financial analysis for a hypothetical wind farm. This year's competition had teams develop the wind farm off the coast of Oregon.

TURBINE PROTOTYPE AND TESTING CONTEST

Teams design, build, and present a unique, wind-driven power system based on market research and test the wind turbine in an on-site wind tunnel. In the 2024-25 competition, teams were faced with a new challenge of designing a floating foundation. The turbine is tested in a wind tunnel over speeds of 5-13 m/s.

CONNECTION CREATION CONTEST

Teams conduct outreach with the wind energy industry and local media outlets to raise wind energy awareness and promote their accomplishments. New for this year, the team fostered international connections with Southern Taiwan University of Science and Technology.

Paul M. Rady Mechanical Engineering
UNIVERSITY OF COLORADO BOULDER

Special thank you to Dr. Julie Steinbrenner, Dr. Daria Kotys-Schwartz, Roark Lanning, CeramicSpeed, CU Idea Forge, CU ITLL, and Engineering Excellence Fund

DESIGN CENTER COLORADO