Design of a Small-Scale Offshore Wind Turbine

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UVU MECHANICAL ENGINEERING

INTRODUCTION AND PURPOSE

RENEWABLE ENERGY

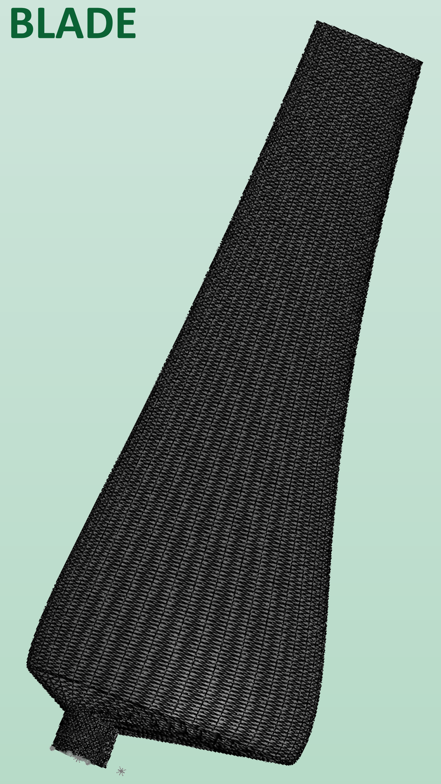
Renewable energy comes from unlimited, naturally replenished resources. These resources can be wave tides, wind and sun rays.
With wind being the fastest growing renewable energy being used within the United States.

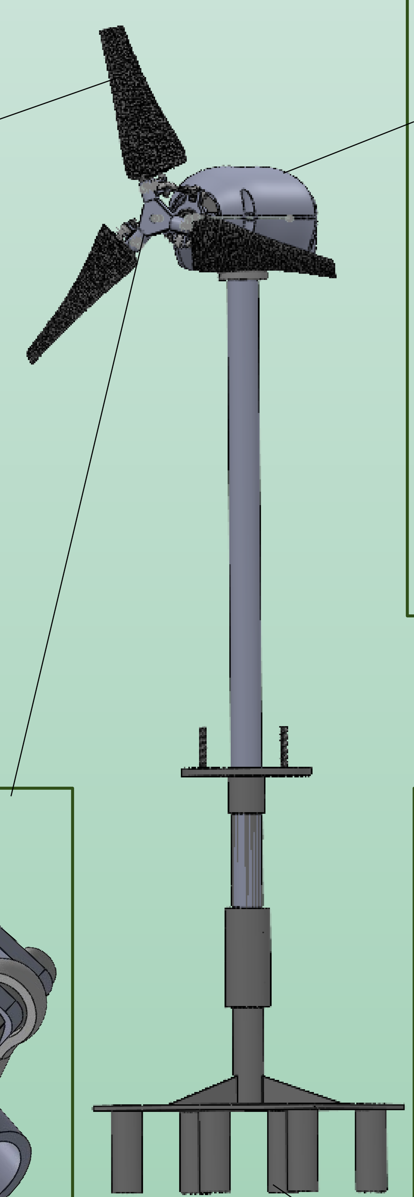
COLLEGIATE WIND COMPETITION

The purpose of this project was to build a wind turbine that meets the specs and requirements of the Department of Energy Collegiate Wind Competition.

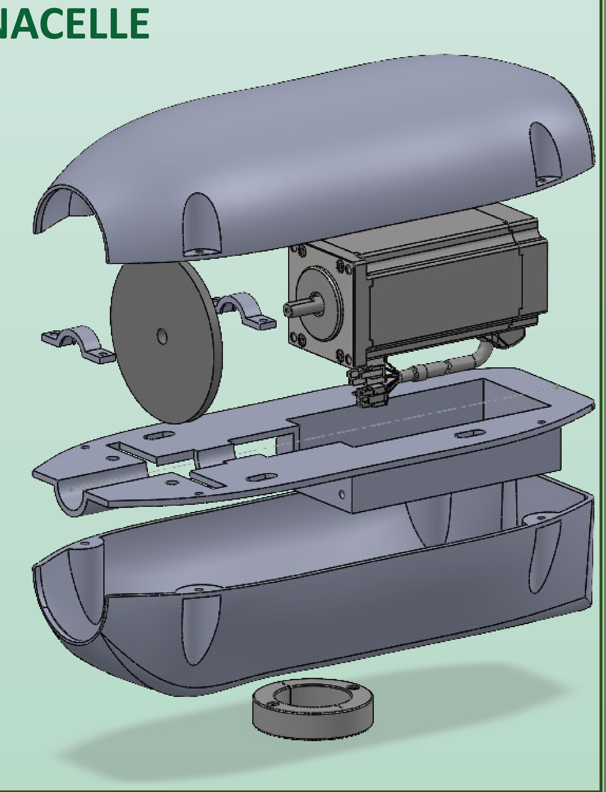
RESULTS

BLADE

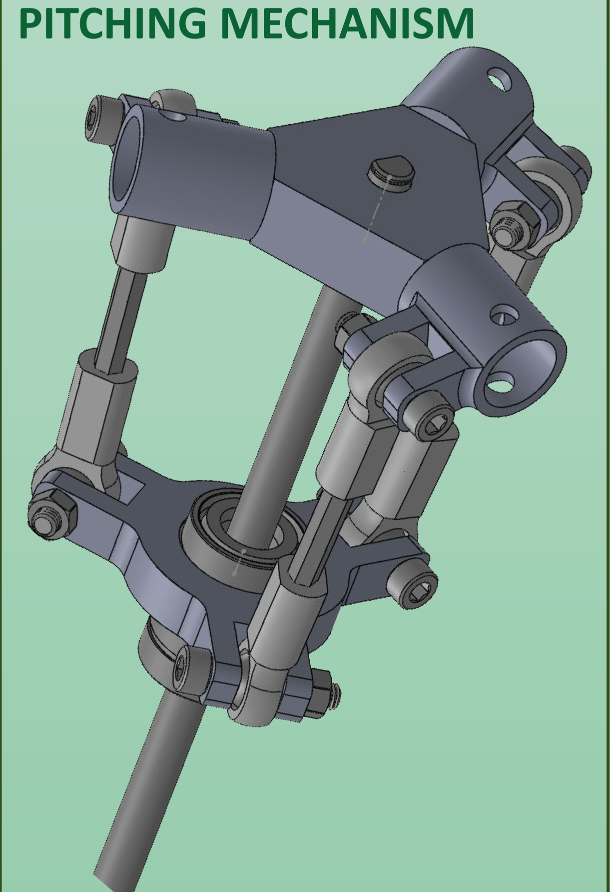




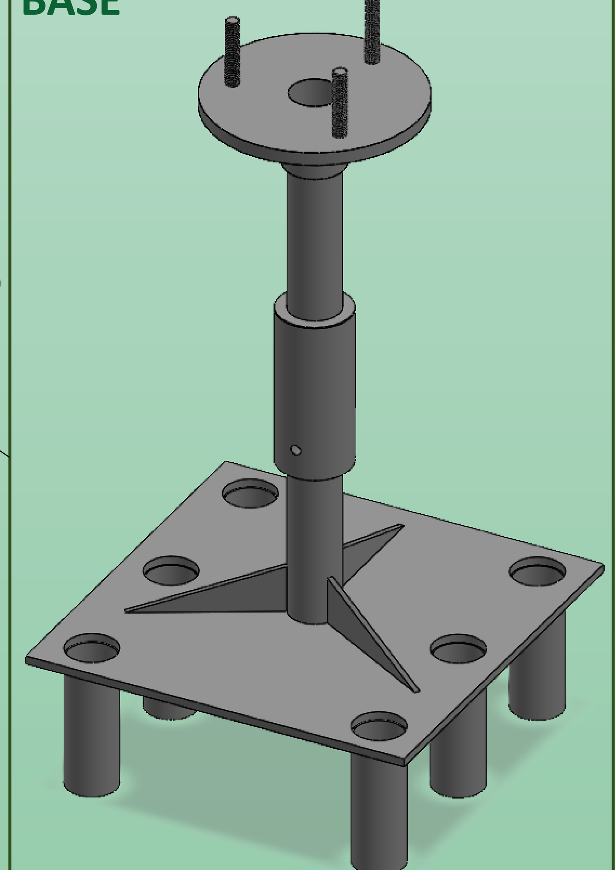
NACELLE



PITCHING MECHANISM



BASE



DESIGN PROCESS

DESIGN REQUIREMENTS

The wind turbine's base must be light weight and deployed without the use of any tools that encounter the sand or water. This is to replicate offshore conditions. The base also needs to resist deflection from the wind. The base has as max size restriction of 30x30 cm.

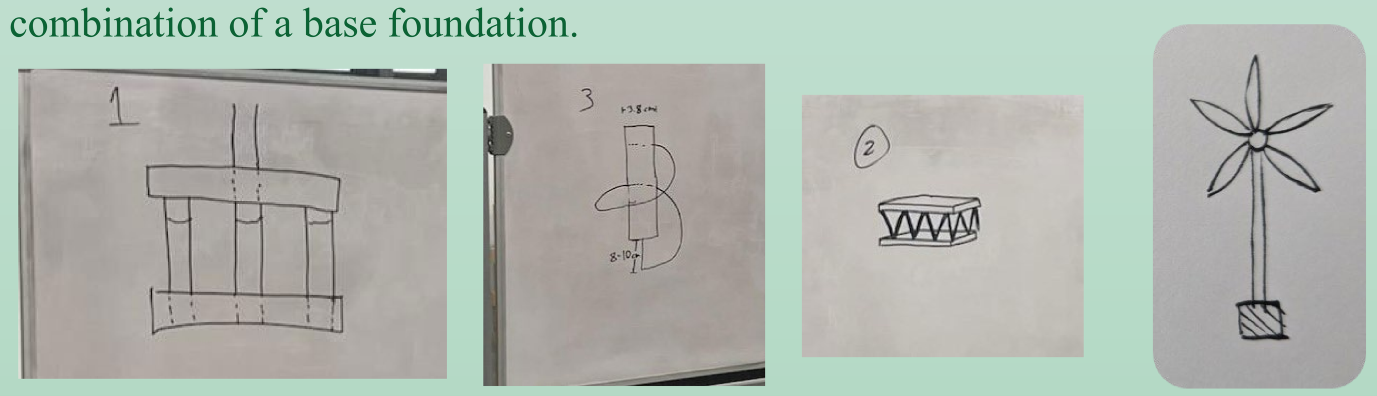
The system needs to have access to an emergency brake.

There needs to be a variable pitching system in place to adjust the blades that will control the power generation throughout the different wind speeds.

The blades and nacelle must fit within a 45x45x45 cm box when completely assembled.

CREATIVE IDEATION

Using other school's previous projects that are available through the U.S department of energy website for the competition to help get an idea of how to approach this project.
The team was able to with the BYU team to see their wind turbine in person and spoke to them about the competition kicked off the brainstorming.
The pitching system was created using a similar system of that of a helicopter swash plate.
Concept base designs were sketched out by all team members. Utilizing every possible combination of a base foundation.



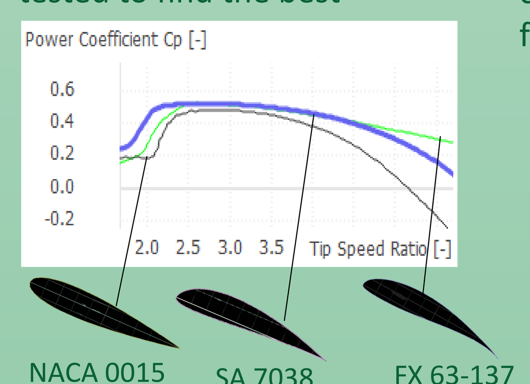
SOLUTION SELECTION

Base: Survey was used to vote on the top 3 best designs and those designs tested/modified.

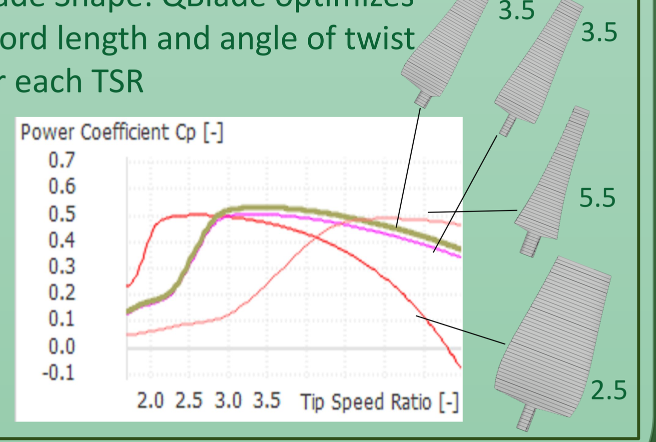
Pitching System:
Utilizing 3D printing, many prototypes were produced to test the effectiveness of the shoulder bolt system. This system was chosen for its simplicity and quick prototyping testing.

Blades:
QBlade Analysis
An airfoil and blade shape were chosen using QBlade, a wind turbine simulation software. The blades were optimized for a tip speed ratio (blade tip velocity/windspeed) of 3.5.

Airfoil: 26 airfoils were tested to find the best

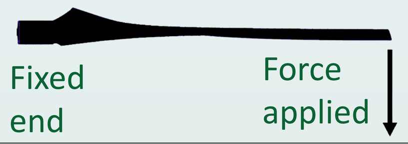


Blade Shape: QBlade optimizes chord length and angle of twist for each TSR



DESIGN VERIFICATION

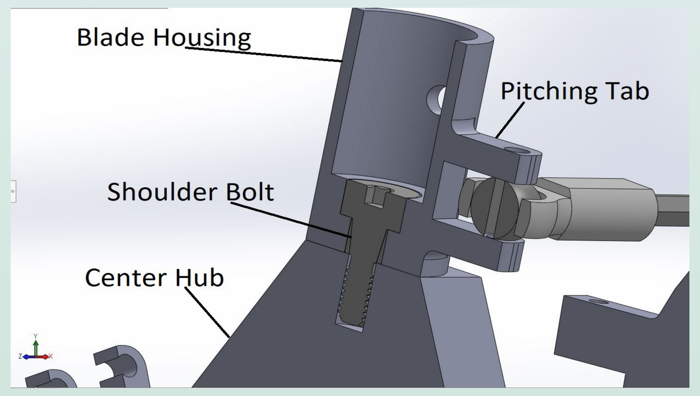
BLADES



	PLA	PLA+	PETG	RESIN
	Smooth	Smooth	Smooth	Strong Flexible Smooth
	Flexible	Strong Flexible	Strong Flexible	N/A
	Strong Flexible	N/A	N/A	N/A

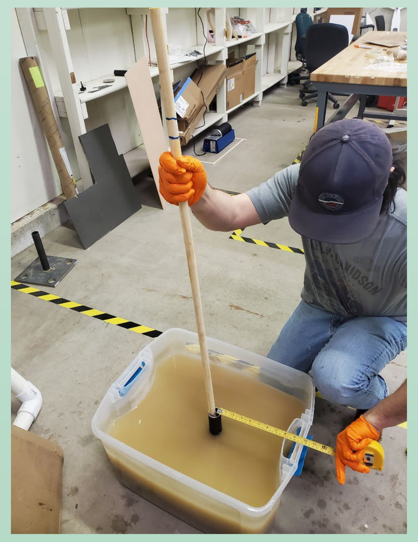
PITCHING MECHANISM

Using Qblade to find the lift force generated by the blades, the smallest allowable shoulder bolt was determined. The shoulder bolt is the main pivot point for the blades ability to change the angle of attack against the wind.



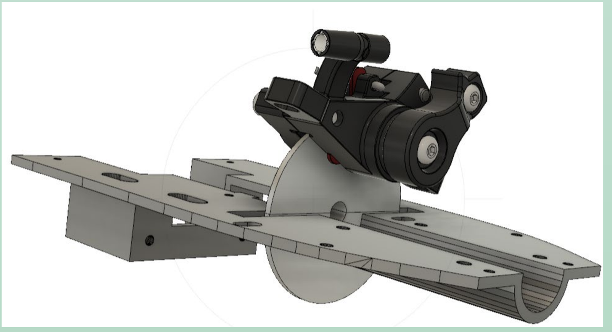
BASE

Tested final concept design in bin full of sand and water, was able to withstand at least 50 N before max deflection.



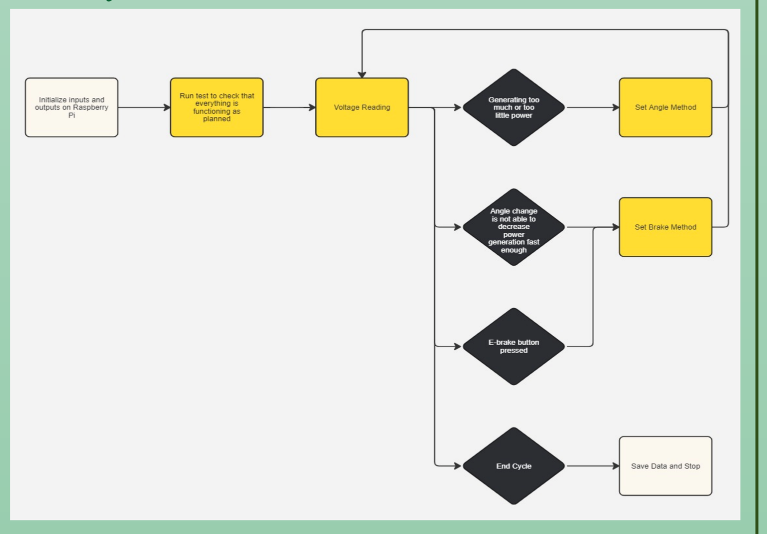
BRAKE

A disc-brake system was chosen due to its compact size and clamping force. It's able to connect to a servo motor and be controlled from outside the turbine.



CONTROLS

A simple control system was created using a Raspberry Pi, a voltmeter, 2 servos, the brake assembly, and the pitching mechanisms.
A simplified flowchart for the control systems is shown below.



BYU TESTING

Testing was conducted using the BYU wind tunnel.
The testing was successful surviving wind speeds from 1-22 m/s.
The pitching system was able to adjust the angle of attack under load.
The base deflection was minimal at max windspeed.