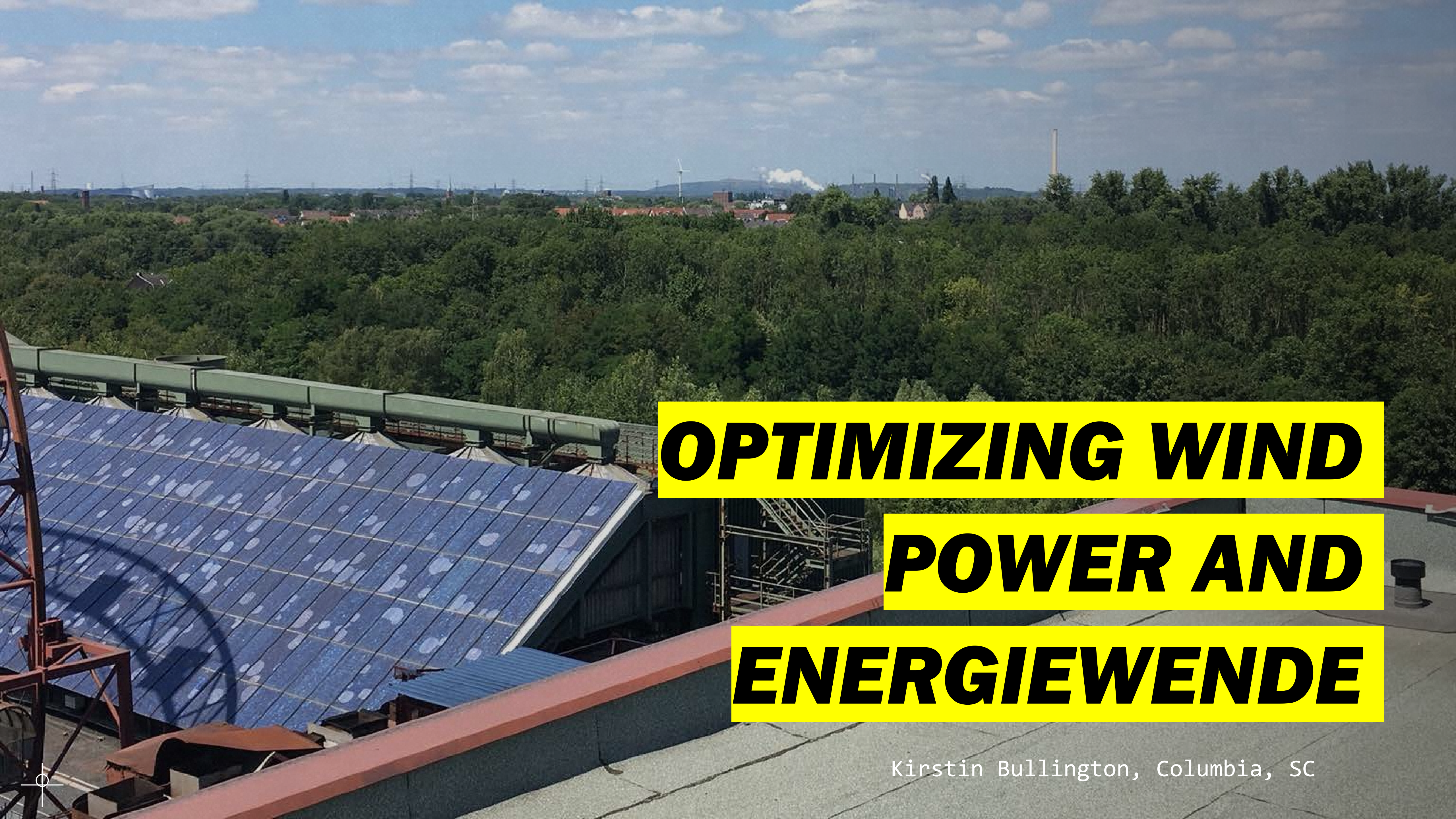
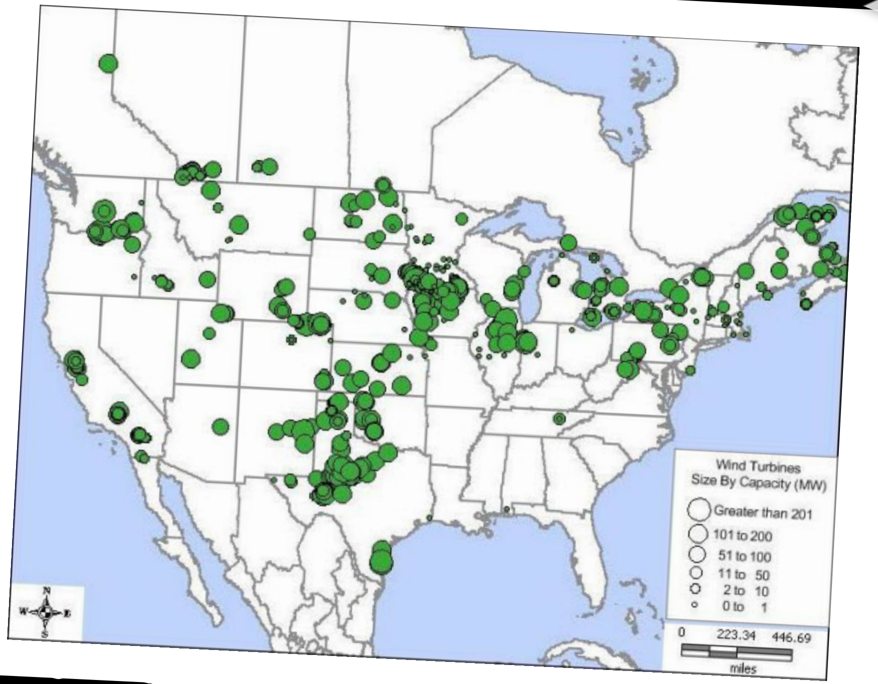


OPTIMIZING WIND POWER AND ENERGIEWENDE

Kirstin Bullington, Columbia, SC

Introduction and Session Outline

1. Wind power and its role in Energiewende
2. Virtual wind turbine design
3. Wind Turbine Blade Design challenge (Optmimizing Tip Speed Ratio)



What do we already know about wind power in Germany and the US?

Choose the article or video that most interests you on wind power in Germany

I. Vertical Axis Wind Turbine development (video)

II. Germany and Norway Inaugurate Clean Energy Undersea Link

III. Germany's Energiewende, 20 years later

IV. Sun and Wind Alter Global Landscape, Leaving Utilities Behind (Video, NYT)

After you read or watch your chosen topic (5 minutes):

1

Identify one point of interest that you want to share with everyone **OR a question you have after reading/watching your topic;**

2

Open Google Jamboard and create a sticky note **with your fact or question**;

3

Move your sticky note to your **topic** quadrant.

Wind Turbine Blade Design

How can we design a wind turbine blade to optimize Tip Speed Ratio?

Wind Turbine Blade Design

CLEAN ENERGY STUDENTS

1. Calculate Tip Speed Ratio (TSR) for a reference design blade.
2. Optimize other variables on the wind turbine for TSR.
3. Design and test a unique blade design to improve TSR.

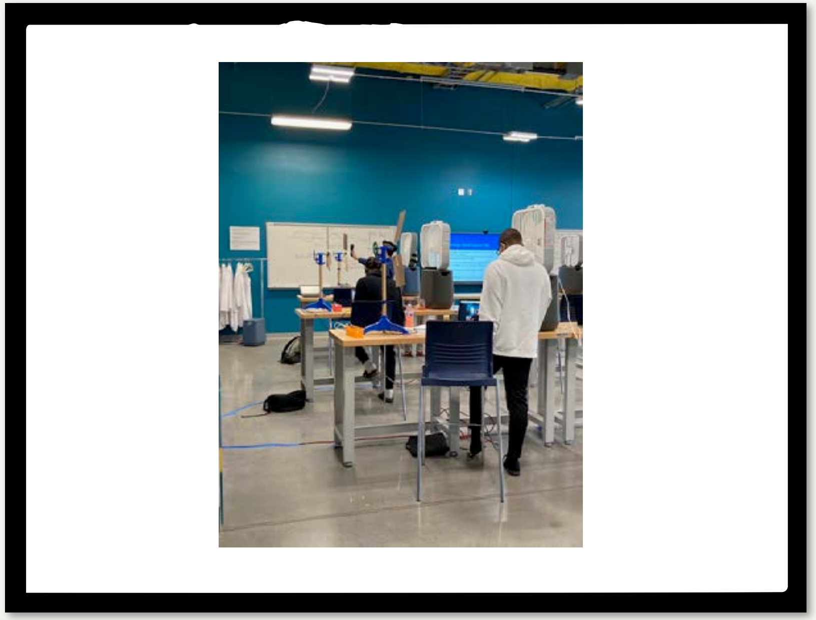
MODIFICATIONS FOR YOUNGER GRADES

- Challenged students to change variables to get an LED to light up
- Focused solely on one component (like pitch angle) and power (V*I)
- First designed paper airplanes for lift/drag principles, then had younger students create new blades and get the wind turbine running.

Adaptations for virtual and hybrid classes this year

Challenge: Students were only in-person once a week in fall semester (and two classes in spring had no in-person students at all).

Solution: In-person students (and I) acted as the technicians and made adjustments in real time with spreadsheet.



3M Virtual Wind Energy Lab

Go to Virtual Wind Energy Lab link in session document

Click on "Begin" and follow the instructions to design a wind turbine that will power the most homes

How many homes could you power? What variables do you think have the greatest impact on power generation?

From virtual model to prototype...

- I am going to be your technician and help you maximize Tip Speed ratio for your prototype.
- First, we will walk through calculating Tip Speed Ratio with the reference design.
- Then, through the chat or unmuting, you will make recommendations to what variables you want to change.
- Finally, we'll change the blade design and determine its effect on tip speed ratio.

Calculating Tip Speed Ratio

Tip Speed Ratio (TSR) is the measurement most often used to determine the efficiency of a wind turbine.

$$TSR = \frac{\text{Tip Speed of Blade (m/s)}}{\text{Wind Speed (m/s)}}$$

Wind speed can be found with an anemometer; tip speed takes a few conversions, starting with the period of the generator

Measurments, Calculations, and Conversions needed for TSR

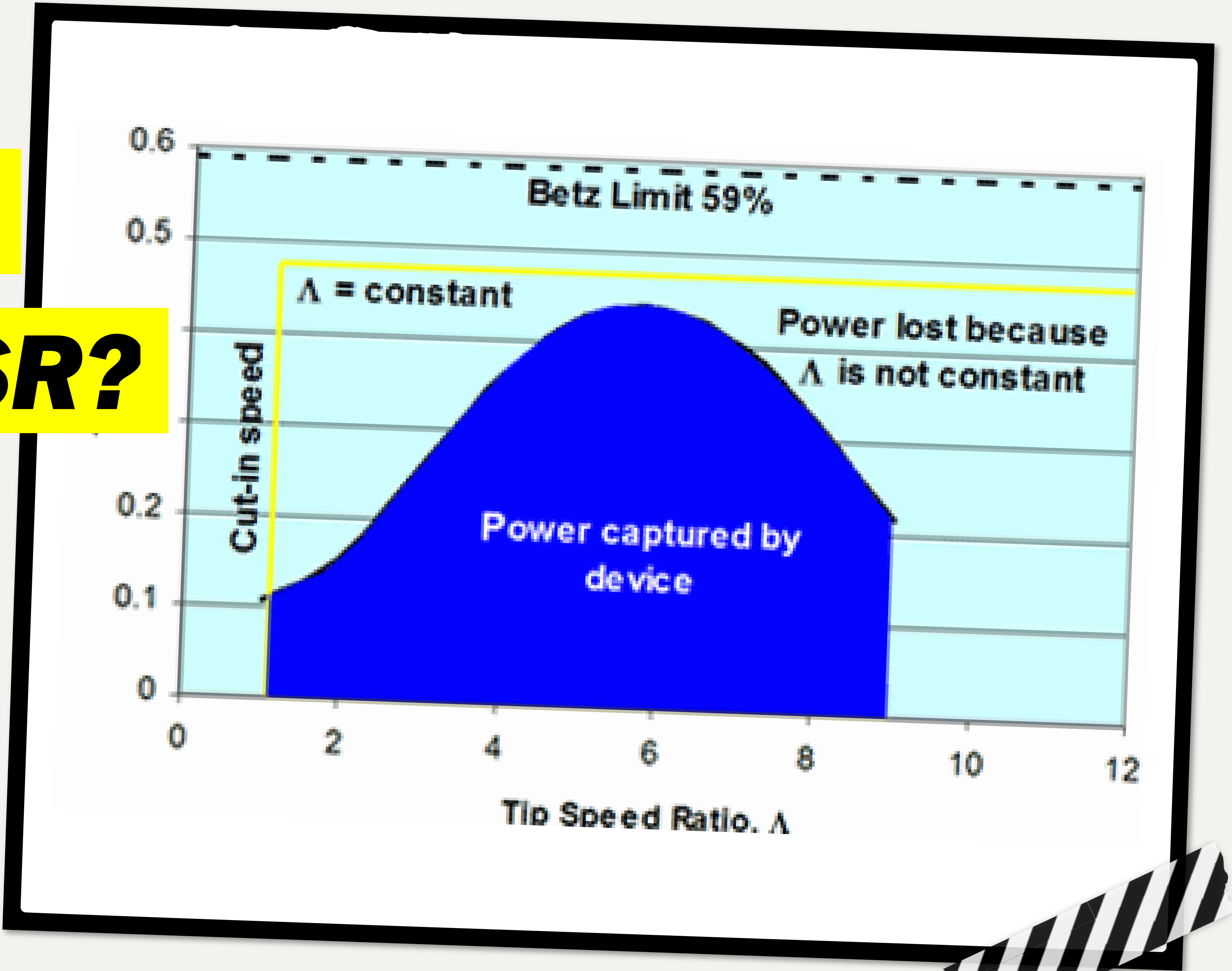
Measure	Measure wind speed with anemometer in m/s.
Measure	**Measure** the period of the motor using the myDAQ sensor and LabView Oscilloscope in ms. •The motors used with the wind turbine are 3 pole motors; 1 full turn of motor = 3 full wavelengths.
Convert	**Convert** period from ms to seconds.
Calculate	Calculate frequency of the motor (rev/s)
Convert	Convert frequency of motor to RPM
Convert	Convert motor RPM using the gear ratio to determine the RPM of rotor.
Calculate	Calculate Tip Speed (m/s)
Calculate	Calculate TSR.

TSR Steps 1 and 2: Finding the wind speed and period of the motor.

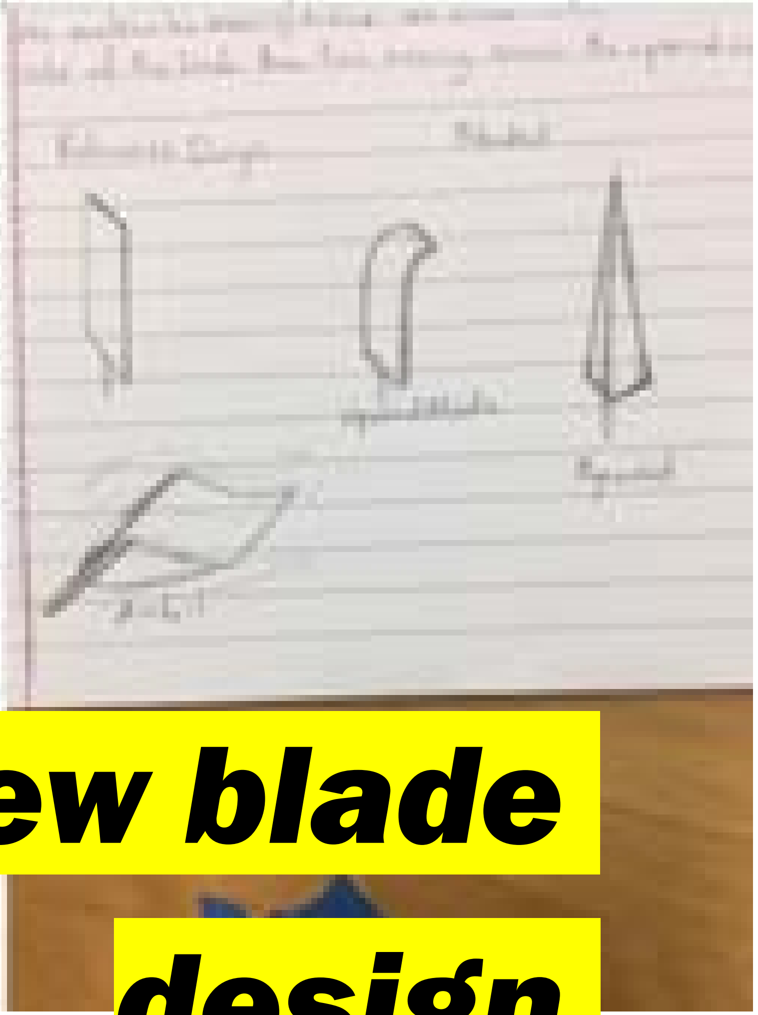
Variables to test:

- Pitch (Angle of blades)
- Yaw (Angle of tower)
- # of blades (no more than 6)
- Gear ratio
- Motor (currently using high torque; low torque also available)
- Dowel length
- Distance from Fan
- Fan speed

What is a "good" TSR?



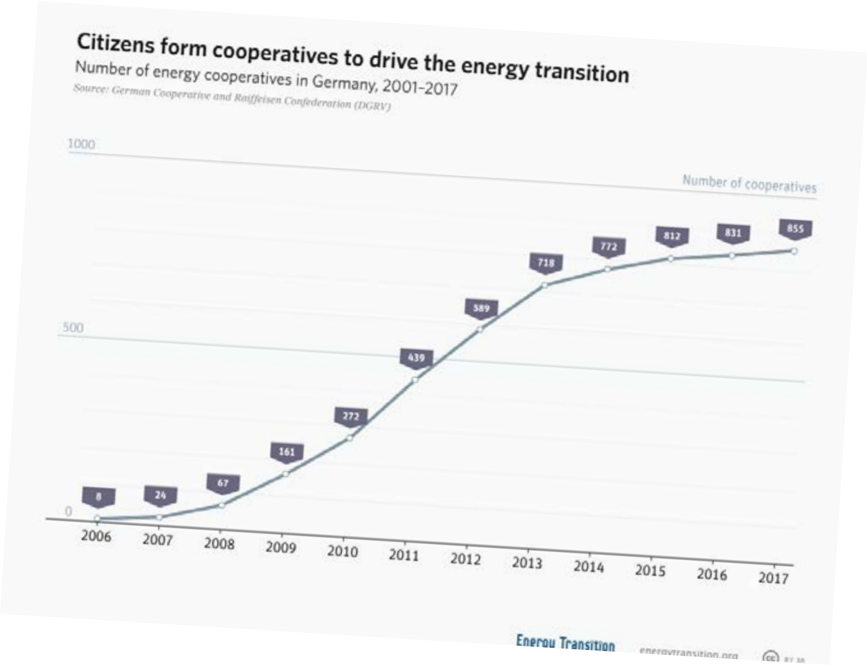
	Airfoil	Upwind	Pyramid
Criteria			
Ease of Assembly	7	9	5
Less Drag	8	3	5
Compactness	4	9	6
Versatility	8	4	6
Total	27	25	22



Choosing a new blade design

New Frontiers to explore with students

- Vertical Axis Wind Turbines
- Use of AI to predict maintenance and optimize grid
- Microgrids and cooperatives



Resources

- US, https://www.eia.gov/todayinenergy/detail.php?id=2470 (2011)
- Germany, https://www.bmwi-energiewende.de/EWD/Redaktion/EN/Newsletter/2018/04/Meldung/direkt-answers-infographic.html (2018)
- https://energytransition.org/
- http://www.reuk.co.uk/wordpress/wind/wind-turbine-tip-speed-ratio/
- VAWT https://p.dw.com/p/3k0lt
- Germany/Norway energy exchange: https://techxplore.com/news/2021-05-germany-norway-inaugurate-energy-undersea.html
- Germany's Energiewende, 20 years later: https://spectrum.ieee.org/energy/renewables/germanys-energiewende-20-years-later
- https://www.nytimes.com/2014/09/14/science/earth/sun-and-wind-alter-german-landscape-leaving-utilities-behind.html
- Sun and Wind Alter Global Landscape, Leaving Utilities Behind
- https://www.vernier.com/product/kidwind-advanced-wind-experiment-kit/ (KidWind Advanced Wind Experiment Set)

- Questions or feedback? Contact me at kbullington@richland2.org

Thank you TOP for the opportunity!