Team 25: Taller Wind Turbine for Low Wind Speed Regions

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Outline

- Project overview
- Full scale design
- Project revenue
- Prototype design
- Budget
- Challenges faced
- Future work

Project Overview

Current 80 meter wind turbines are not cost-effective for use in the Southeastern U.S. due to lower average wind speeds.

Horizontal Axis Wind Turbine

Current Specs:

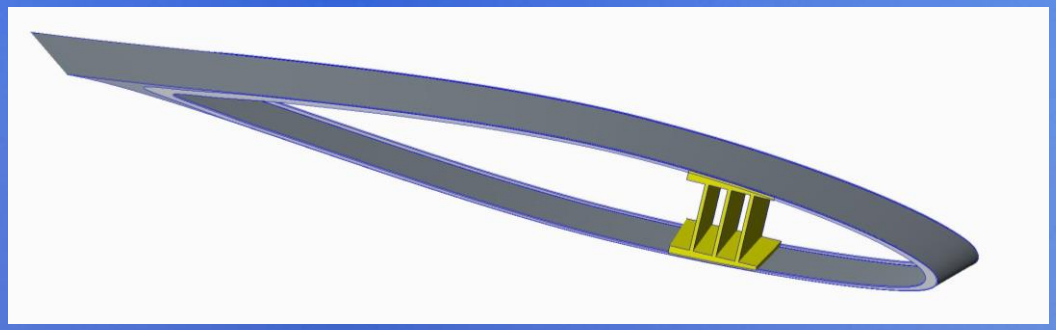
- 1-2 MW
- Avg. 80m hub height
- Blades ~60m long

Project Specs:

- 5 MW
- Taller structure (157.5m)
- Design lighter blades of same size
- Number of blades: 3
- Budget: $2,000

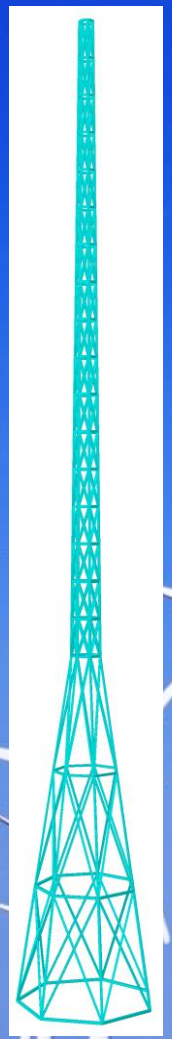
Blade Design

- Blade Length: 61.5m
- Cross-sectional shape: NACA-64
- Varying angle of twist
- Shell Material: E-Glass, 12K Carbon Fiber, Epoxy, Styrene Acrylonitrile (SAN) Foam
- Spar: Triple I-Beam
  - Good distribution of load
  - Lightweight
  - AL-6061



Tower Design

- 157.5m hub height
- Design
  - 7 sides
  - Hollow Structural Steel Tubing (HSST) sections
- Wider base
- Additional Internal bracing
- Modular construction
- Male-Female plugs



Turbine Assembly

- 225m (740ft) tip height
- 123m (404ft) swept diameter

Revenue Calculation

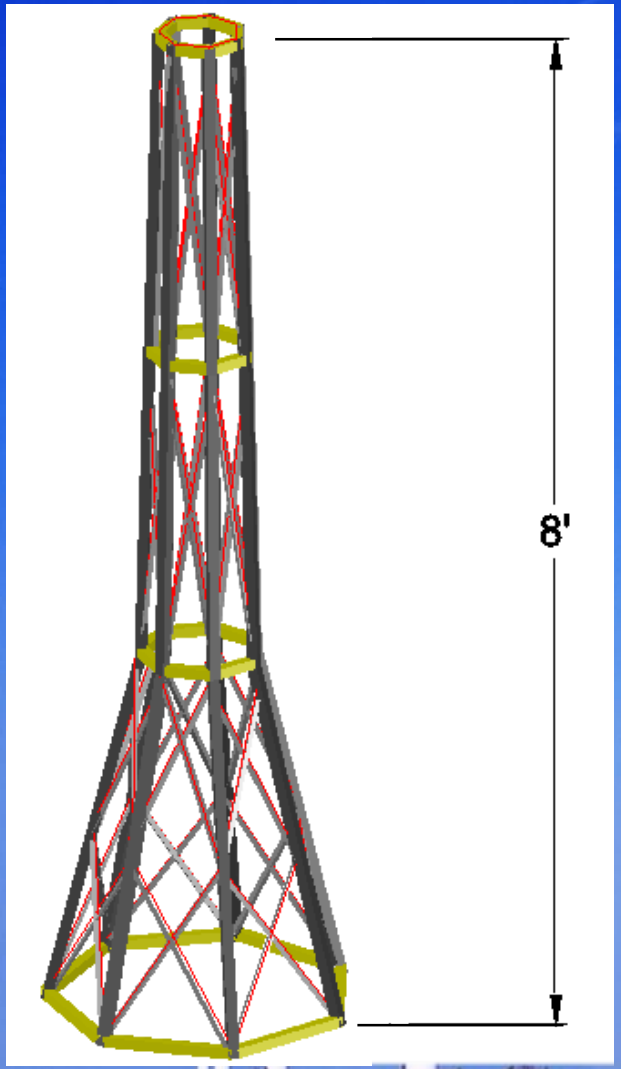
- Obtained hourly wind data from 2014
- Calculated power generated from wind speeds
- Comparing to present data in Boulder, CO

$$LCOE = \frac{Total\ Cost\ (\$)}{Total\ Energy\ Produced\ in\ lifetime\ (MWh)}$$

Levelized Cost of Energy (LCOE) ($/MWh)	
Boulder, CO	157
Lake Okeechobee, FL	134

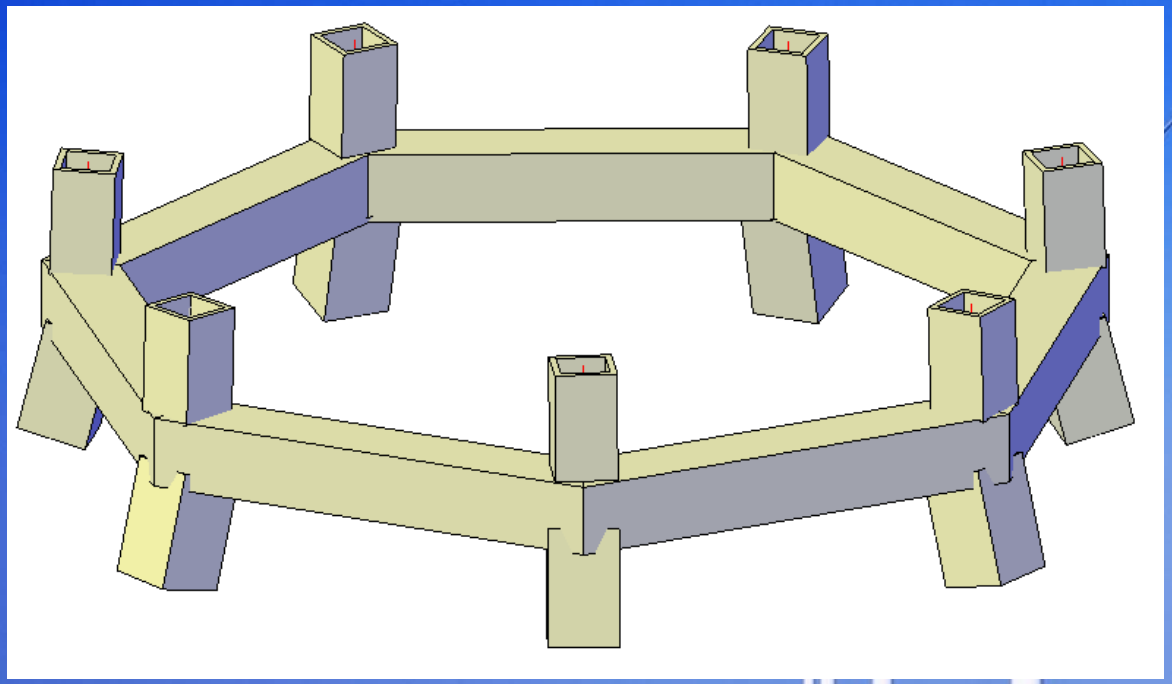
Tower Prototype

- 8-ft Steel Tower
  - Fewer sections (3 instead of 20)
  - General geometry will be properly scaled
    - Exception: unrealistically small members
- Connections
  - Custom design
  - Engineering drawings in progress



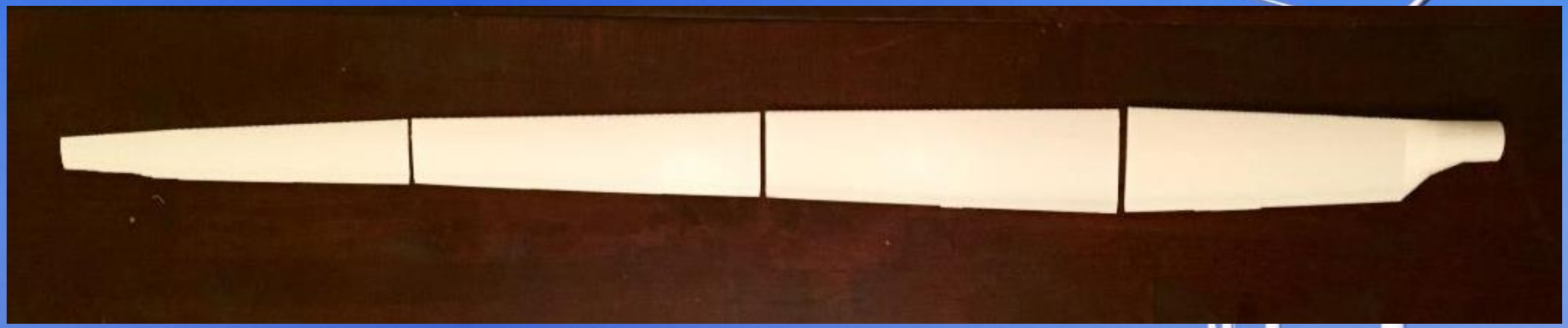
Manufacturing Tower Prototype

- Fabricate sections in machine shop
- Welded “heptagonal rings” at end of each section
- Plugs for connections
- Wrap tower in fabric



Blade Prototype

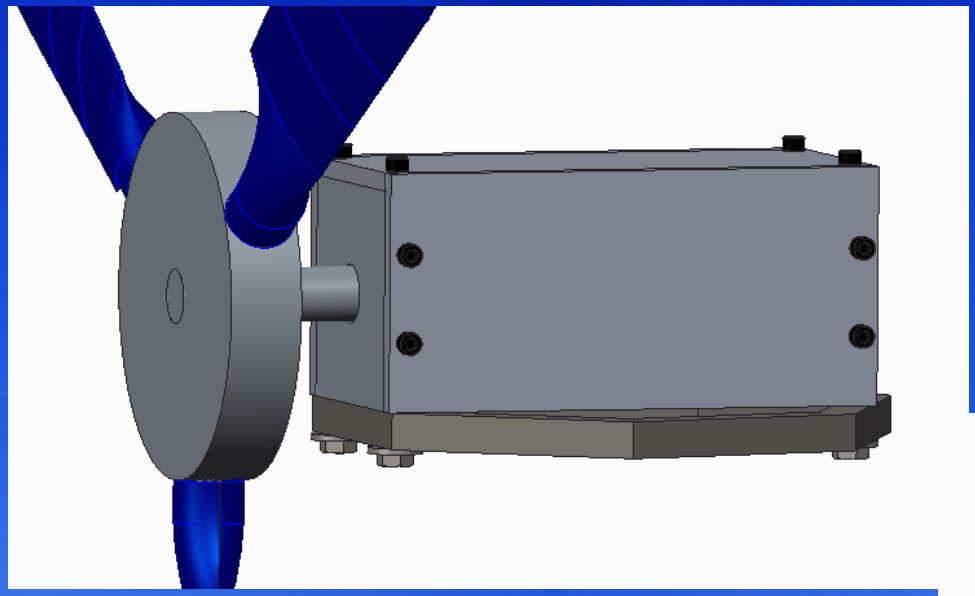
- 3-D printed blades
  - 3ft blades broken into 9in sections
    - Section attached to hub have solid fill
    - Three remaining sections have low density fill
  - 3 blades have arrived



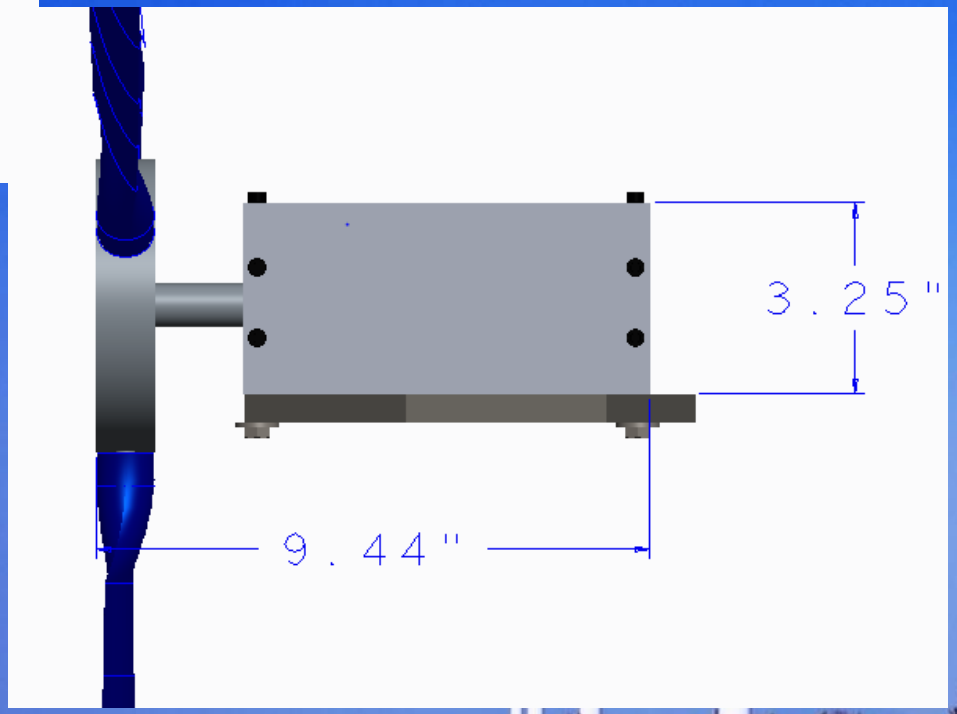
Manufacturing Prototype Blades

- Epoxy putty will connect sections
- E-glass and epoxy will be used to reinforce the blades

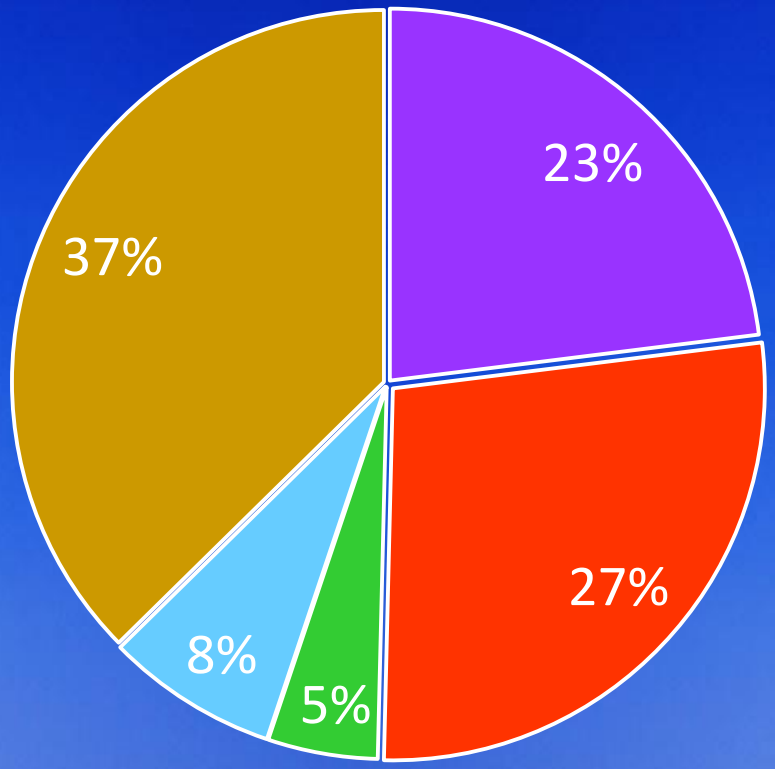
Nacelle Prototype



- Drawings have been submitted to Machine shop



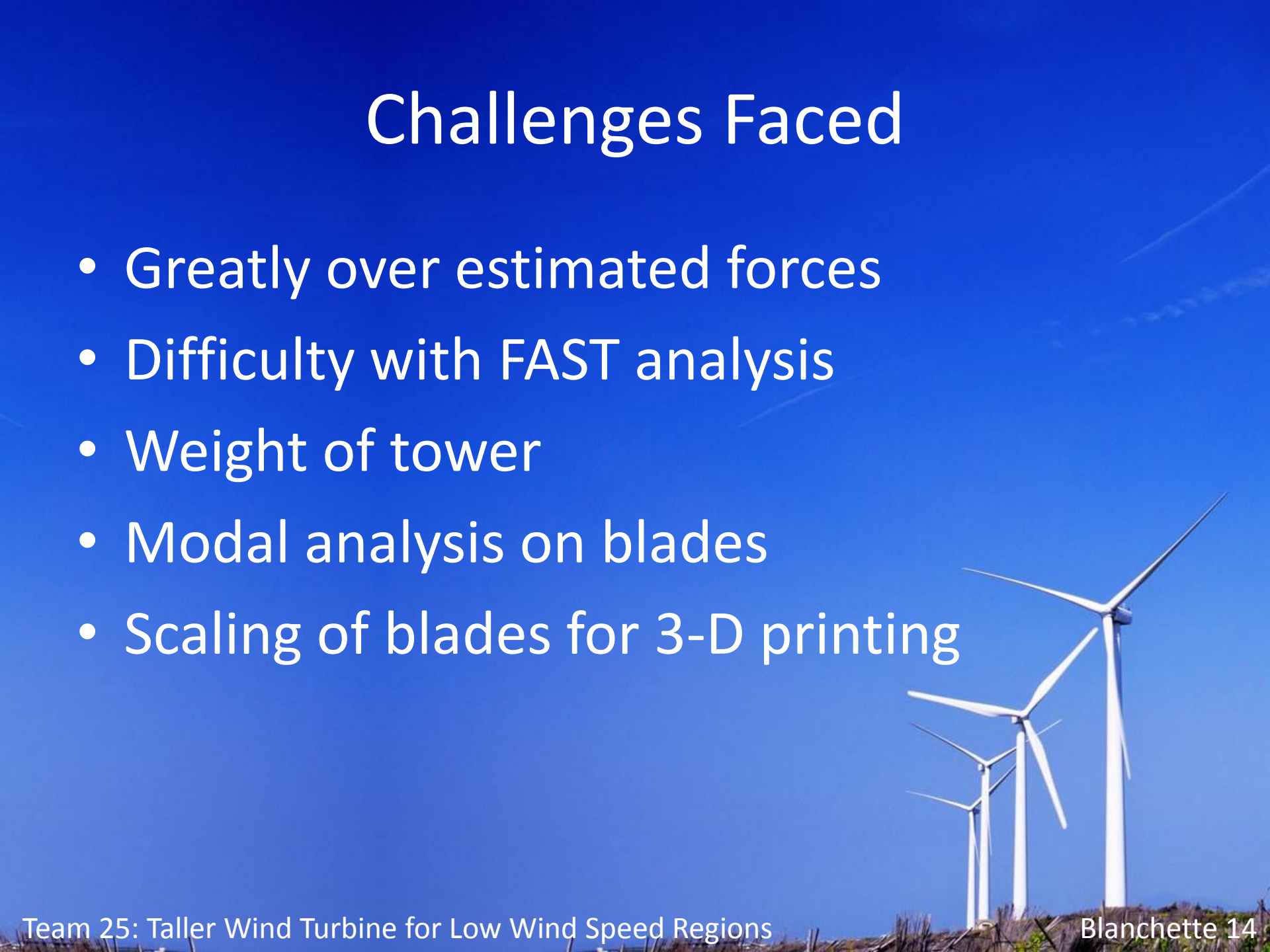
Budget



Material	Cost ($)
Steel	460.49
Blades	547.20
E-glass & Epoxy	95.50
Additional Parts	149.49
Remaining	**747.32**

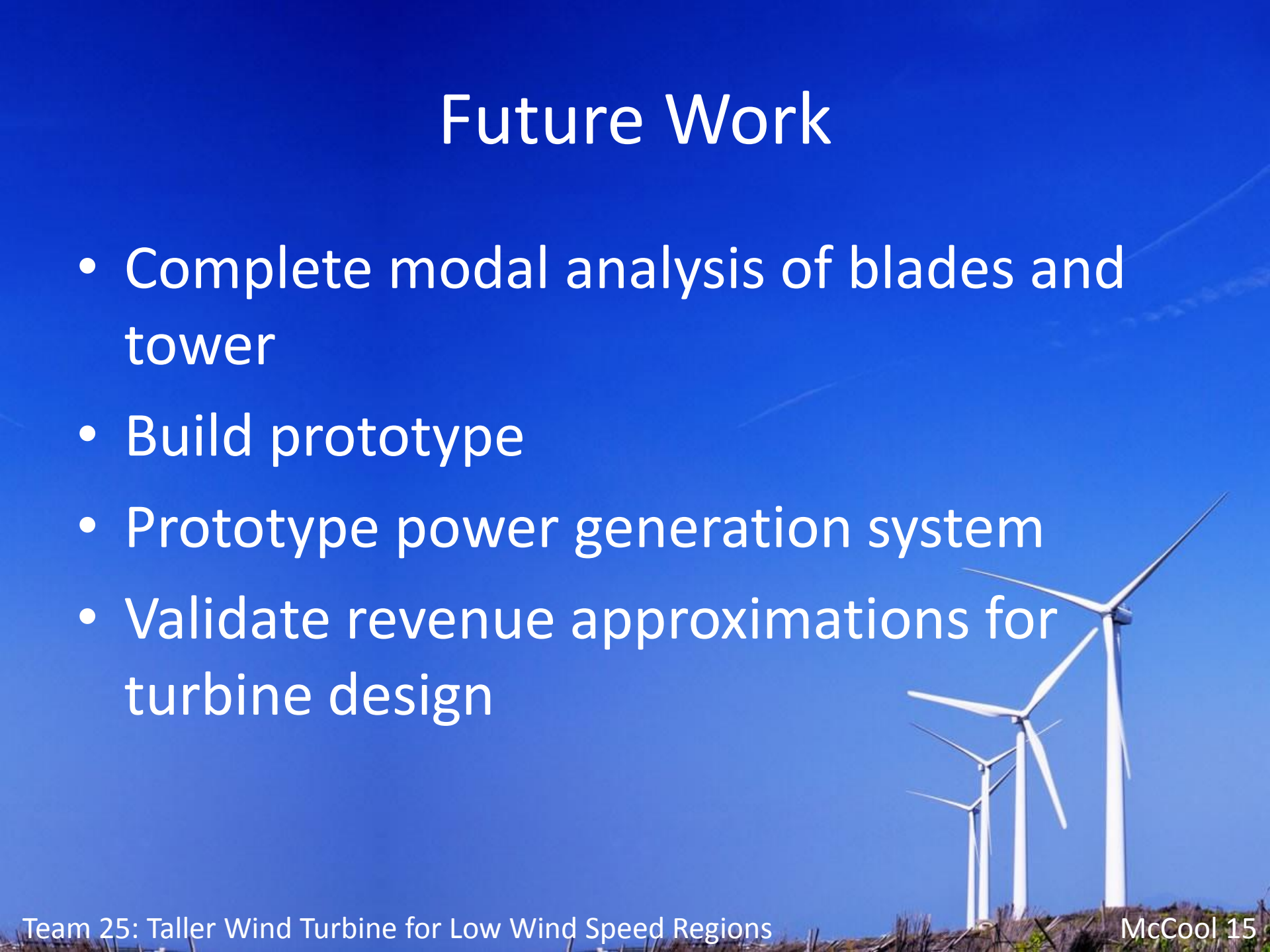
Challenges Faced

- Greatly over estimated forces
- Difficulty with FAST analysis
- Weight of tower
- Modal analysis on blades
- Scaling of blades for 3-D printing



Future Work

- Complete modal analysis of blades and tower
- Build prototype
- Prototype power generation system
- Validate revenue approximations for turbine design



Summary

- Low wind speeds in southeast US inspired desire for taller wind turbine
- Final designs were chosen for tower structure and blade design
- Prototype materials ordered
- Next Steps
  - Complete revenue analysis
  - Build prototype

References

- http://www.nrel.gov/docs/fy09osti/38060.pdf
- http://wind.nrel.gov/public/bjonkman/TestPage/FAST.pdf
- http://www.gettyimages.com/detail/news-photo/aerial-view-of-field-taken-from-goodyear-blimp-above-news-photo/457716040
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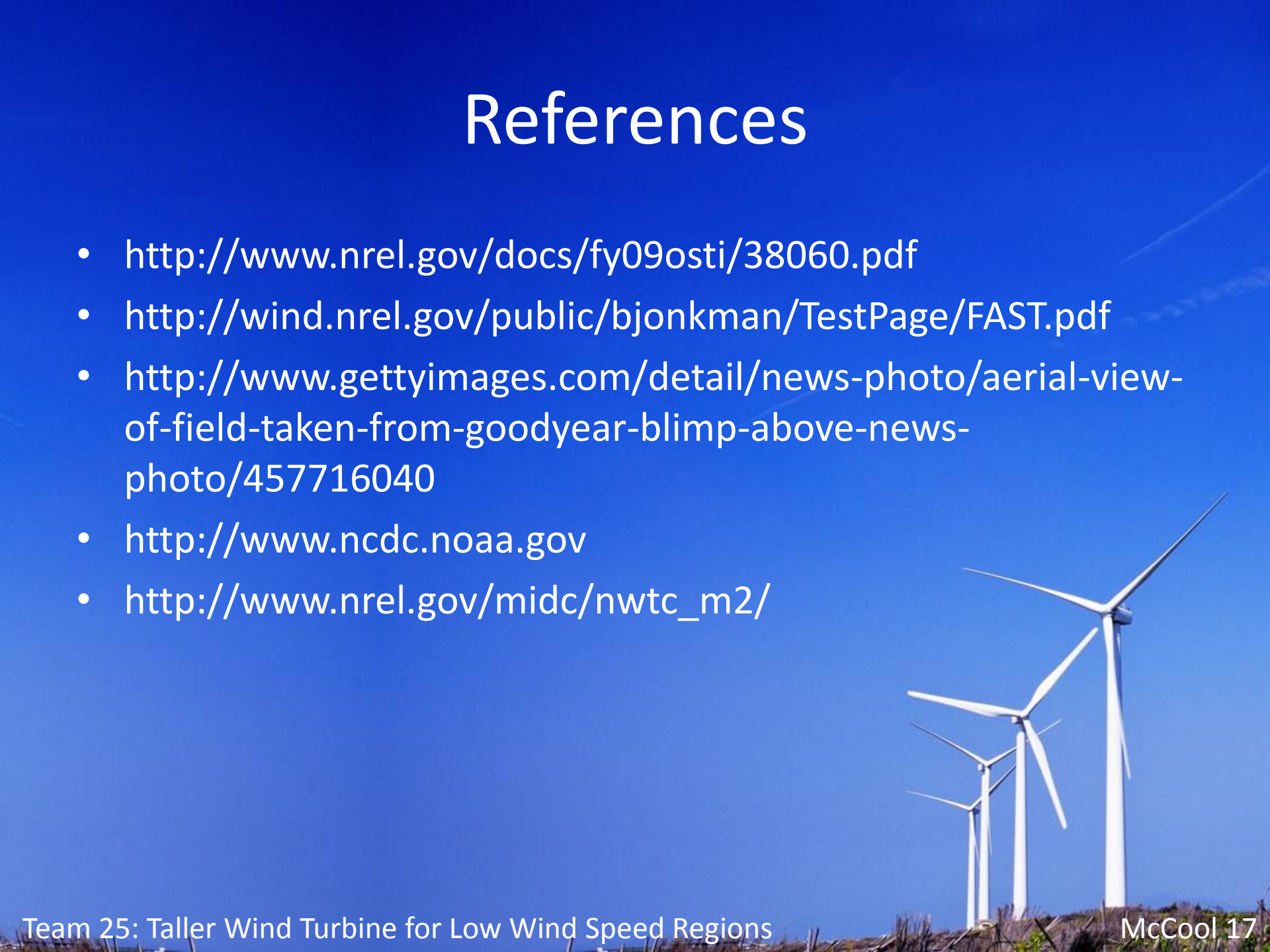

Questions?