DEPLOYABLE WIND TURBINES FOR REMOTE MILITARY OUTPOSTS

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U.S. DEPARTMENT OF ENERGY

1. INTRODUCTION

Upwind vs Downwind

Yaw Control

Number of Blades

Pitching Control

Gearbox/ Generator

"Energy availability is a major concern on today's battlefield. Reducing the need for fuel resupply in operations cuts costs and reduces combat risk associated with moving and protecting convoys." (US Army Engineer Research and Development Center, 2013)

Providing reliable electricity to military operation posts has become of increasing concern over the last decade as diesel costs and transportation risks have risen new alternatives are needed. With the increase in reliability and decrease in costs, small wind projects are quickly becoming very promising to integrate saving both money, lives, and the reducing the military's carbon footprint.

The goal of the summer is to come up with a rough embodiment design for a small scale (< 50 kW) wind turbine designed specifically with military requirements in mind. This entails the cost of energy ($/kWh), availability, high reliability, ease of use and operation, simplicity, and ease of deployment.

2. GOALS

The summer has been split into two main components

1. Design tradeoff choices for small scale wind
   - Number of Blades
   - Upwind vs. Downwind
   - Pitching Control
   - Yaw Control
   - Rotor Diameter
   - Generator / Gearbox
   - Turbine Material
   - Economics
2. Wind turbine operations model
   - Diesel Fuel Savings
   - Site Assessment
   - Grid Stability
   - Wind Energy Integration into Microgrids

3. METHODS

A majority of the work is achieved using FAST (Fatigue, Aerodynamics, Structures, and Turbulence) an aeroelastic simulator developed and supported by NREL (National Renewable Energy Laboratory). This allows us to predict both dynamic operation and loadings on a horizontal axis wind turbine. The base model used is a Vestas V27-225kW turbine in which the input parameters can be altered to model operation of the design cases.

The operations model will be accomplished using convex optimization techniques to model the dispatch of the turbines in the military grid. This will be resource dependent and factor in grid reliability, ramp rate constraints, and diesel generator parameters.

3. RESULTS

The first of three months of the design process have been accomplished. Shown below is the work in progress on the wind turbine design tradeoffs

Economics

Current Diesel Generator

$$\frac{\$9\text{–}\$45}{gal} \times \left(\frac{1}{128{,}450}\frac{gal}{btu}\right) \times \left(7{,}176\,\frac{Btu}{kWh}\right) = \mathbf{\$0.50 - \$2.51\ /kWh}$$

- Even with a high efficiency diesel generator the fuel costs alone account for a variable cost **x 5 to 25** times more than grid price.

$$(12.3\ kWa) \times \left(8760\frac{hr}{yr}\right) \times \frac{(\$0.50 - \$2.51)}{kWh} = \frac{(\mathbf{\$54{,}000 - \$270{,}000})}{\mathbf{gen * yr}}$$

Modern 30kW Wind Turbine

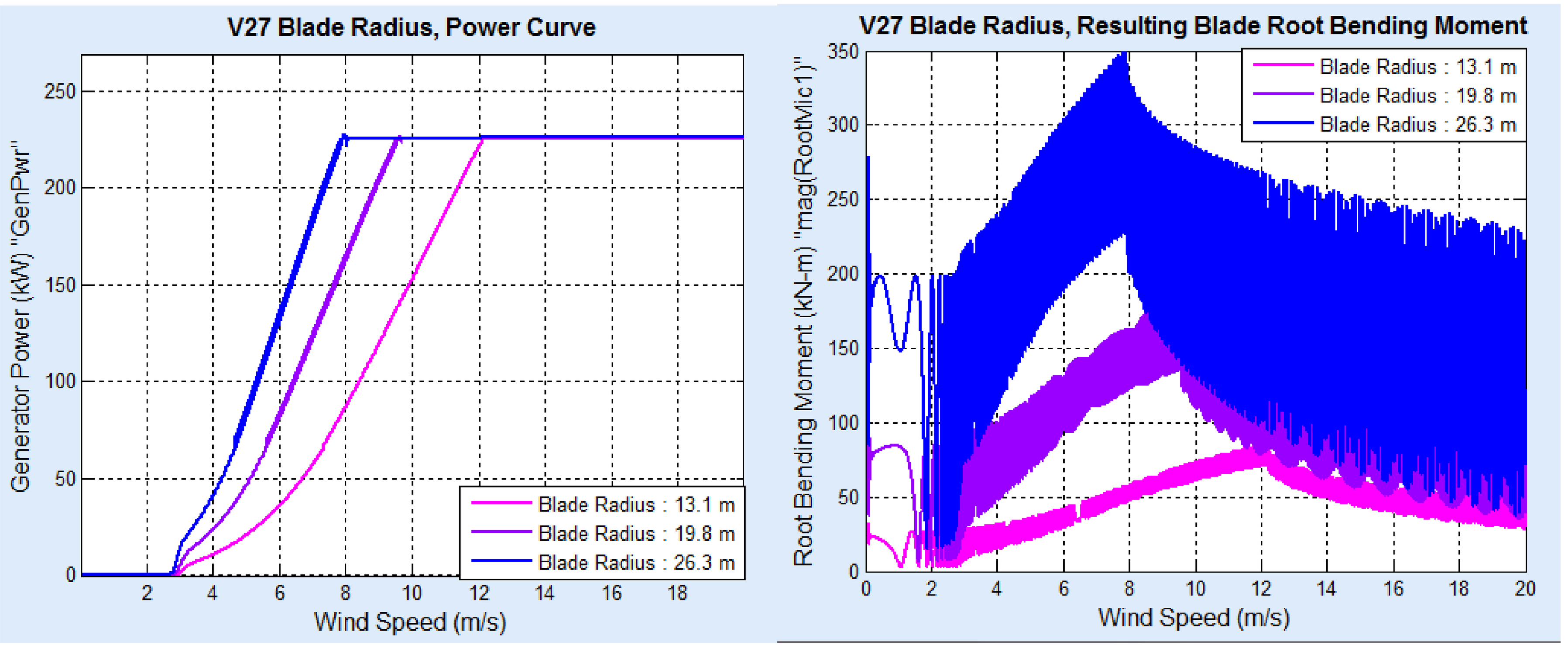
$$(30kW) \times (30\%) \times \left(8760\frac{hrs}{yr}\right) \times \left(\frac{\$0.20}{kWh}\right) = \frac{\$15{,}700}{turbine * yr}$$

Annual Savings = **\$23,500 – \$182,000 /turbine * yr**

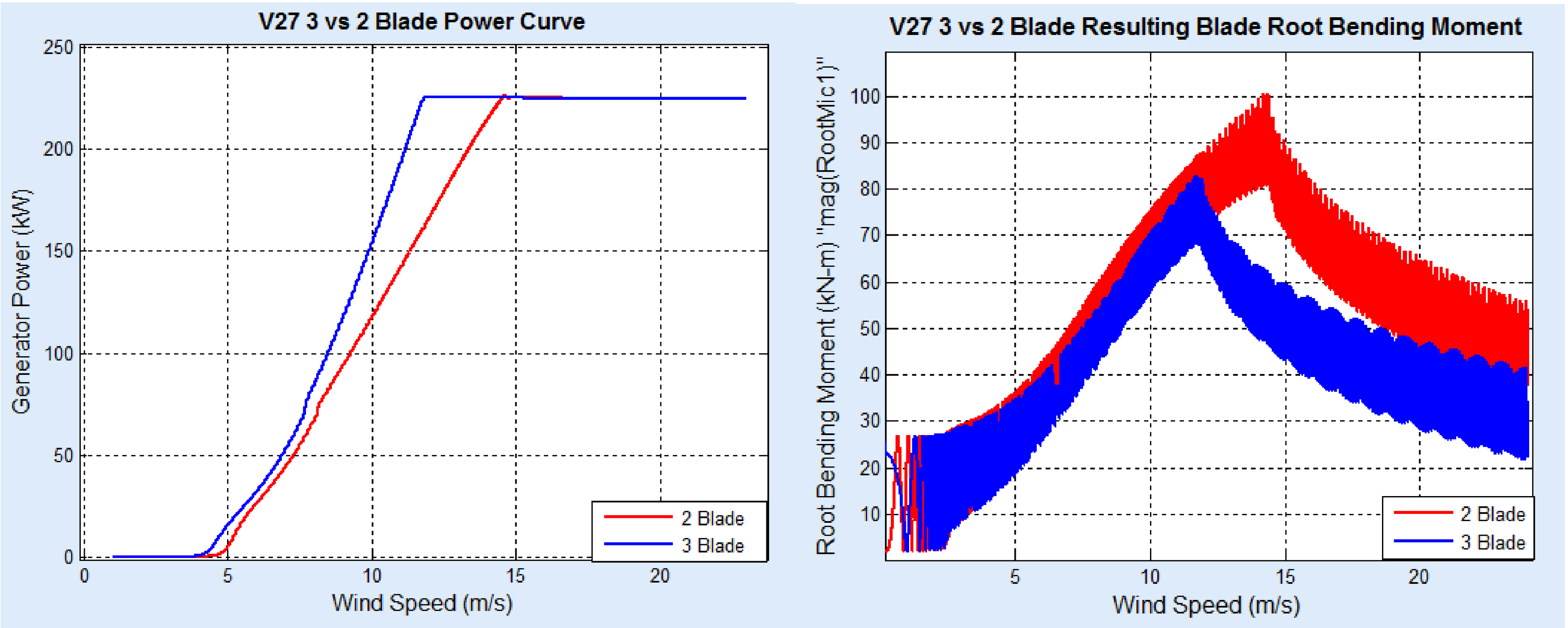
Wind can easily compete!

Design Tradeoffs

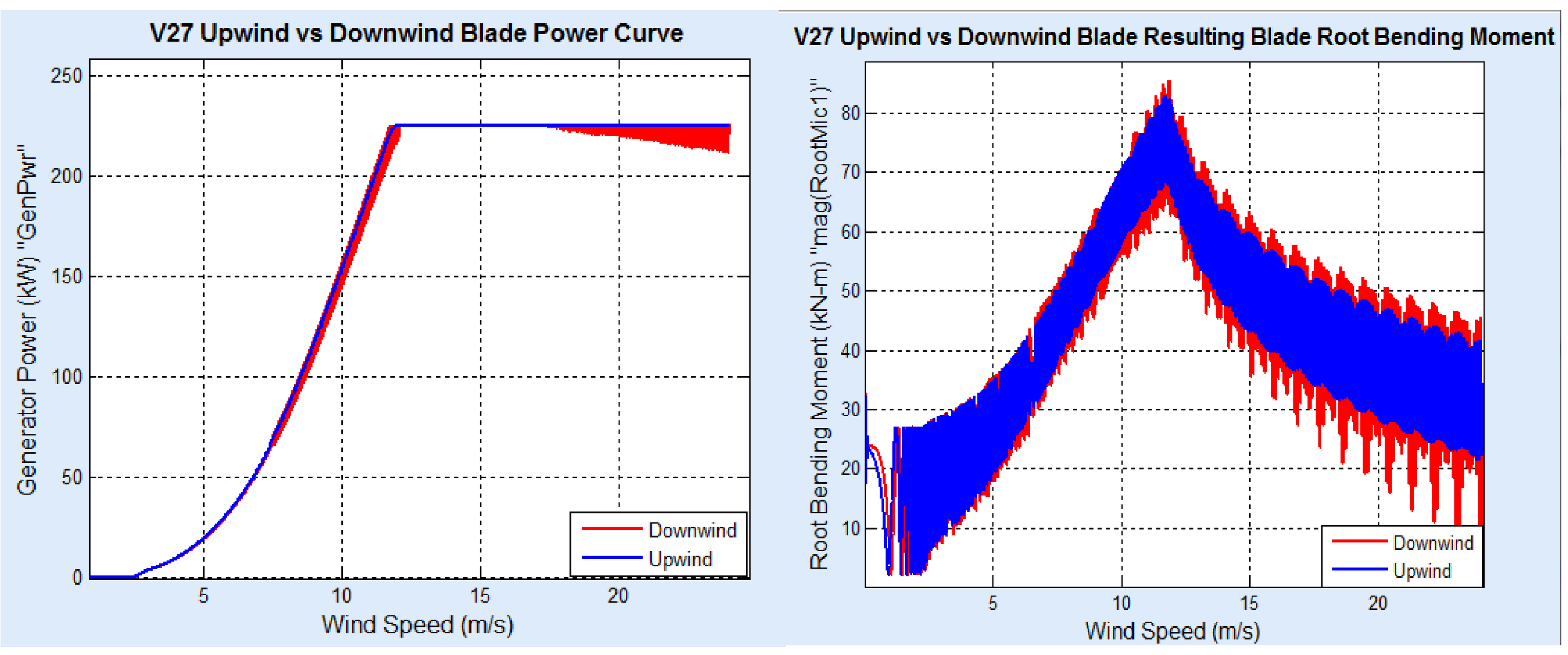
Rotor Diameter



Number of Blades



Upwind vs. Downwind



4. FUTURE WORK

Lots of exciting work to still accomplish over the remaining 2 months

1. Finish running all design iterations
2. Conduct design review with panel of wind turbine experts
3. Rough embodiment design of turbine
4. Test its value as an electricity generation resource for DOD
5. 3D print design

Results of this project will be disseminated to Department of Defense at the Pacific Defense Energy Summit in September 2014 followed by a panel presentation at the Defense Energy Summit in November 2014.

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