Collegiate Wind Competition 2017-2018

Market Team B1

Alana Benson

Anthony Cheslic

Craig Collins

Michael Vogelsang

Leo Segura De Niz

Mitchell Green

PROJECT DESCRIPTION

- Conceptual Market Turbine
  - 3.5 MW wind turbine
  - 120m hub height
  - 70m blades
  - Hybrid concrete-S500 Steel Tower
- Design Completed:
  - No manufacturing required
  - Possible 3D printing
    - Scaled Version the size of test turbine
    - Simplify parts to print
- Finite Element Analysis on tower
  - Tower experiences most loads
  - Tests with loads at 25 m/s
  - Assumptions:
    - Concrete is rigid body
    - Braking will stop all forces after 25 m/s
    - Gravitational forces of just the mechanical parts
  - 152.3 MPa max stress at base of steel (500 MPa Yield)

Figure 1: Market 3.5 MW Turbine

PROJECT DESCRIPTION

COLLEGIATE WIND COMPETITION
U.S. DEPARTMENT OF ENERGY

Sitting Challenge

- Two Separate Elements
    - Element 1: Research and Develop a Plan for a 100-MW Windfarm in the Team's Home State.
        - Select the top three development site within 100 miles of the team's school.
        - Choose one of the three proposed sites and develop a preliminary wind farm design.
        - Finalize a detailed design of the site plan.
        - Community outreach- Propose site plan to government entity.
    - Element 2: Design a Wind Farm During the Competition.
        - Team's will be given a siting challenge packet of the site area with detailed resource information.
        - Team's will have one day to develop a solution to the proposed site.
        - Team's will then develop a preliminary design layout using wind plant siting software and present that to a siting judge.

UPDATES

- **V2G**
  - Begun adjusting V2G example to meet a simulation that matches the business scenario.
  - Will be speaking to Dr. Yaramasu for further help.

- **Electrical System**
  - Have begun talking to EE students on the test team about working on the electrical system.
  - Will be meeting with EE students this week to begin construction of the simulation.

- **Siting:**
  - Considered three sites
  - Picked a site
  - Attained wind data
  - Started learning Windfarmer Analyst
  - Met with County Planners

MOVING FORWARD

COLLEGIATE WIND COMPETITION
U.S. DEPARTMENT OF ENERGY

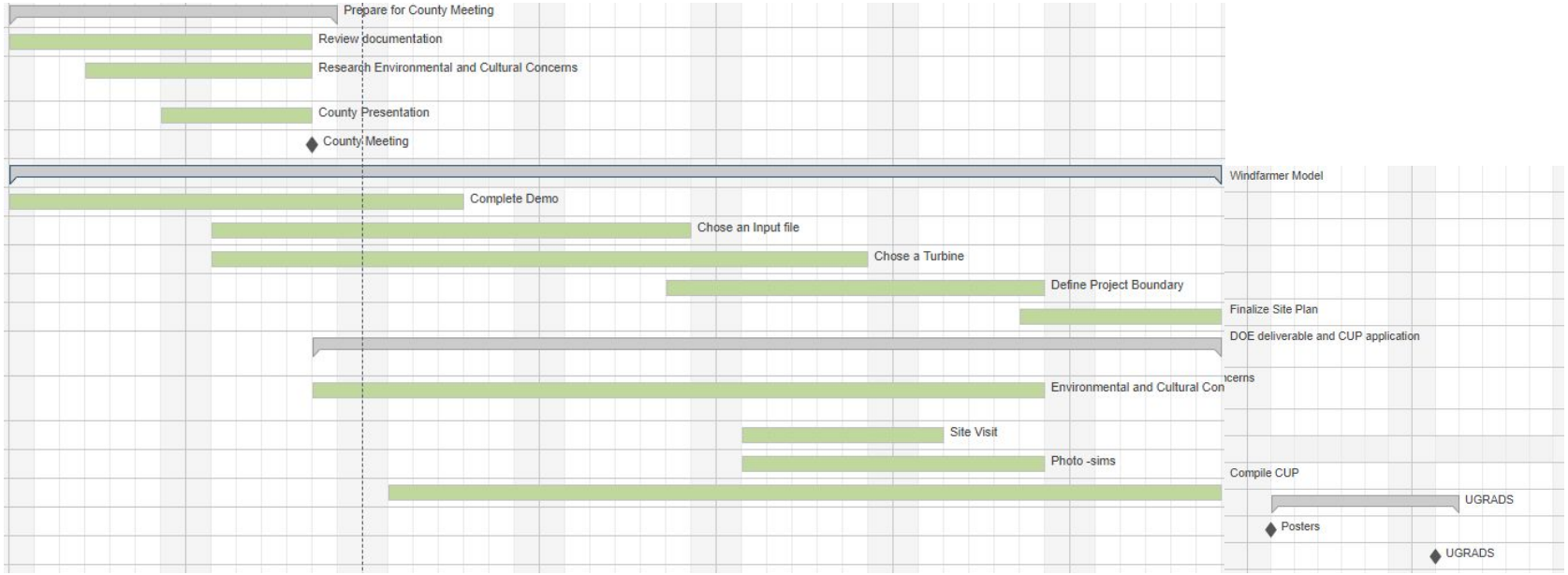
- **Market Overview**
  - No manufacturing or testing required.
  - Electrical topology of turbine, possible 3D Printing
- **V2G**
  - Considering whether to continue to adjust example to match business proposal scenario or begin construction of a separate simulation.
  - Possibly work with EE students.
- **Electrical System**
  - Will be working with EE students over the coming weeks to assemble the electrical system simulation.
- **Siting**
  - Siting poster including a detailed design of the site plan → Windfarmer Analyst
  - Conditional permit application.
    - Coconino county presentation.
  - Considerations: **Wind resource**, **terrain**, **land owners**, **vegetation**, **access to transmission**, transportation access, environmental impacts, and community factors.

MOVING FORWARD: BUDGET

Travel Budget Collegiate Wind Competition Market Team 2018					
Description	**Type**	**Unit Cost**	**Quantity**	**Amount**	**Notes**
Flight on Delta/United	Transportation	$256.00	3	$ (768.00)	3 Students: depart 5/7, return evening of 5/10
Hotel at least expensive official conference hotel available ($240/night including tax)	Lodging	$240.00	2	$ (1,440.00)	3 students, 2 Students per room, 2 rooms total:
Flag to PHX shuttle and return shuttle to Fla	Transportation	$ 96.00	3	$ (288.00)	3 Students
shuttles or trains in Chicago	Transportation	$ 80.00	3	$ (240.00)	Per person estimate: 3 students train to Hotel Monday and shuttle back to airport Thurs
Food not covered by event	Food	$120.00	3	$ (360.00)	$30 per day per student, 4 days (Mon -Thurs)
Total Cost				**$ (3,096.00)**	
ASNAU AWARD				**$ 750.00**	
Balance costs				**$ (2,346.00)**	
Undergrad student travel award (3 teams going to		$1,100		**$ 366.67**	Award is being shared in 3 equal parts.
ME Department travel award		$200		**$ 600.00**	$200 being awarded per student
Karin's Travel Fund		?		**?**	
Fundraising at Bigfoot and Pay n' Take		?		**?**	
Remaining Costs to Cover				**$ (1,379.33)**	

MOVING FORWARD: SCHEDULE

- **Siting**
  - County Presentation, Windfarmer Models, Poster - Alana, Anthony, and Leo
- **V2G**
  - V2G understanding and Model - Mitchell and Michael



HR2: BLADES AND SITING

- **Structural and performance analysis of blades.**
  - Lower Cp than expected. Higher TSR than expected.
    - Model does not account for pitch regulated systems.
  - Average power output ~3.65MW.
- **Siting**
  - **Wind Resource:** 15.7 - 16.8mph average wind speed.
  - **Turbine Selection:** 3 - 4.8MW off the shelf.
  - **# Turbines:** 20 - 33 turbines for 100MW power plant output.

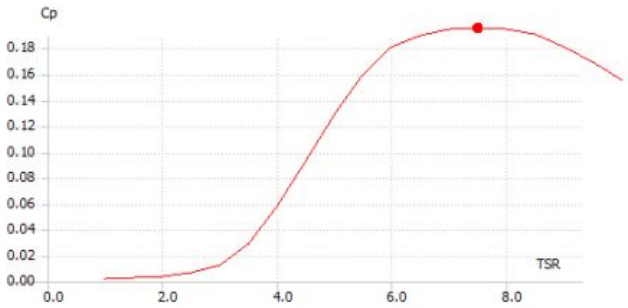


Figure 2: Cp vs TSR

Figure 3: Site Location

HR2: V2G and Design FEA

- **V2G Simulink Model modified to match our population**
  - 1000 Electric Cars- 40MW Storage (1000X40kW)
    - Consumption and Energy Storage
  - 150MW Residential Load (About 200,000 homes)
    - Usage profile with most the load in morning and evening
  - 100MW Wind farm
    - Nominal Wind Speed of 13.2 m/s
    - Wind Speed from 0-25m/s
  - Scopes Show the System is usable
    - Coal and Diesel Power plants still in use

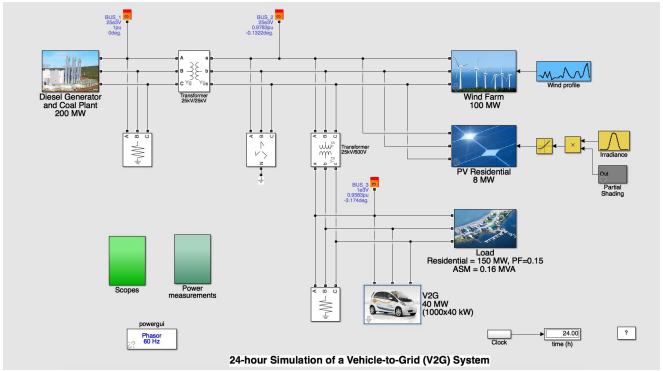


Figure 5: Modified V2G Model

- **Conceptual Design of 3.5 MW Wind Turbine Finalized with FEA**
  - 1.5 meter tower deflection at 25 m/s where braking is initiated
  - Max stress of 152.3 MPa at base (Yield=500 Mpa)

Figure 6: Final Design

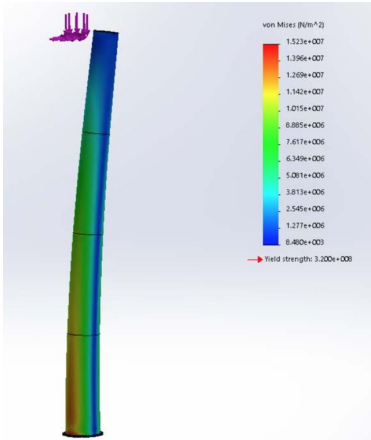


Figure 7: Von Mises Stresses

HR2: Mitchell

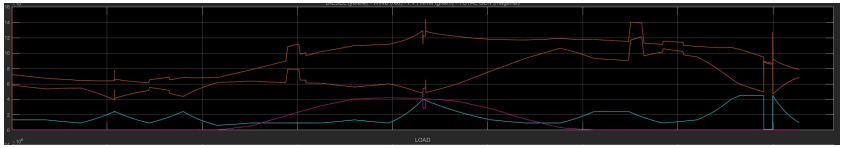


Figure 3: Results of V2G Grid Example

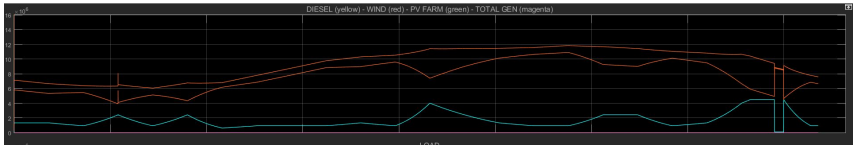


Figure 4: Adjusted Grid Example

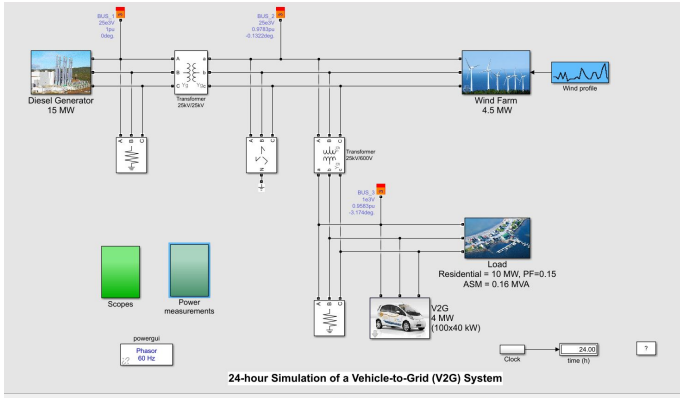


Figure 5: V2G Grid Example

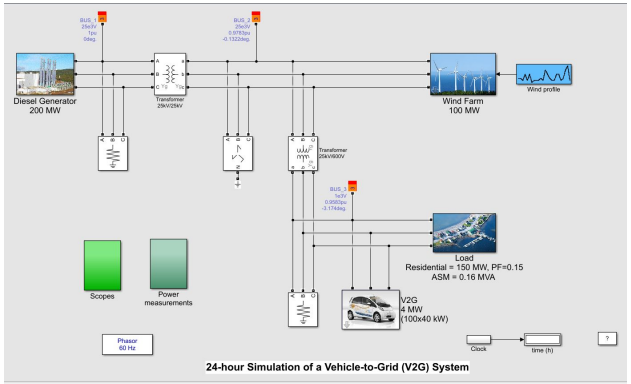


Figure 7:Adjusted Grid Simulation

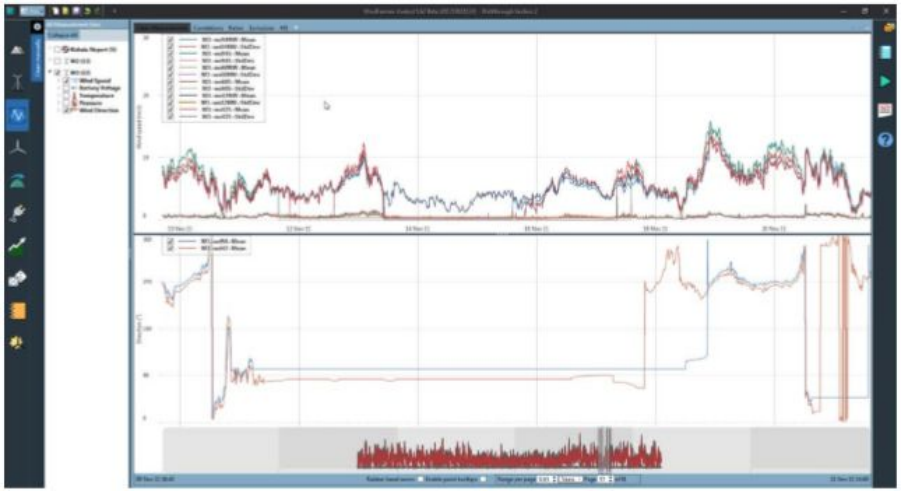
HR2: System Advisory Model and Siting

- **System Advisory Model**
  - Analysis created using business model, in order to create financial figures.

Table 1: User Defined Turbine Inputs	
Rated Output:	3500 kW
Rotor Diameter:	140 m
Maximum Cp:	0.20
Maximum Tip Speed:	80 m/s
Maximum Tip Speed Ratio:	7.8
Cut-In Wind Speed:	4 m/s
Cut-Out Wind Speed:	25 m/s
Drivetrain Design:	Direct Drive
Blade Design:	Advanced Design
Tower Design:	Advanced Design

Table 2: SAM Outputs	
Annual Energy Production (Year 1)	320,223,776 kWh
Capacity Factor (Year 1)	37.3%
Levelized Cost of Energy	6.62 cents per kWh

- **Siting Challenge**
  - Obtained wind resource data for planned area.
  - WindFarmer Analyst Tutorials
  - Meeting with Coconino County Community Development Advisory Group



HR2: Windfarmer Theory and County Meeting

Windfamer Theory important points:

- Input Files
- Energy Calculations
  - Net Yield calculations
  - Modeling Losses as efficiencies
- Wake Models
  - Modified PARK
  - Eddy Viscosity
- Turbulence Estimations
  - Can be designed around IEC standards
- MCP methods
  - Least Squares method
  - PCA method

County Meeting Important Points:

- Windfarms and Met towers are processed as Conditional Use Permits (CUP's)
- The most important aspects to consider in this county are the environmental and visual aspects of the wind farm.
  - Game and Fish
  - Photo-sims
  - Neighbor outreach
  - Motion sensor lights