An Electro-Mechanical, Wind Energy System Design for the Historic Shelter Island Windmill

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WPI

Background

- Sylvester Manor Educational Farm (SMEF) is located at the eastern end of Long Island on Shelter Island, NY.
- SMEF serves its community through its dedication to historical preservation, education, and sustainability. Their mission is “to preserve, cultivate and share historic Sylvester Manor to ensure that food and art remain connected to community and the land”.
- As part of these efforts, SMEF began renovating the 1810 Shelter Island Windmill, a 210-year-old wind-powered grist mill located on their grounds.
- SMEF hopes to expand upon its sustainability efforts by restoring the windmill so that it can produce flour for the local community and promoting the idea of renewable energy and wind energy on their property.

SYLVESTER MANOR
EDUCATIONAL FARM

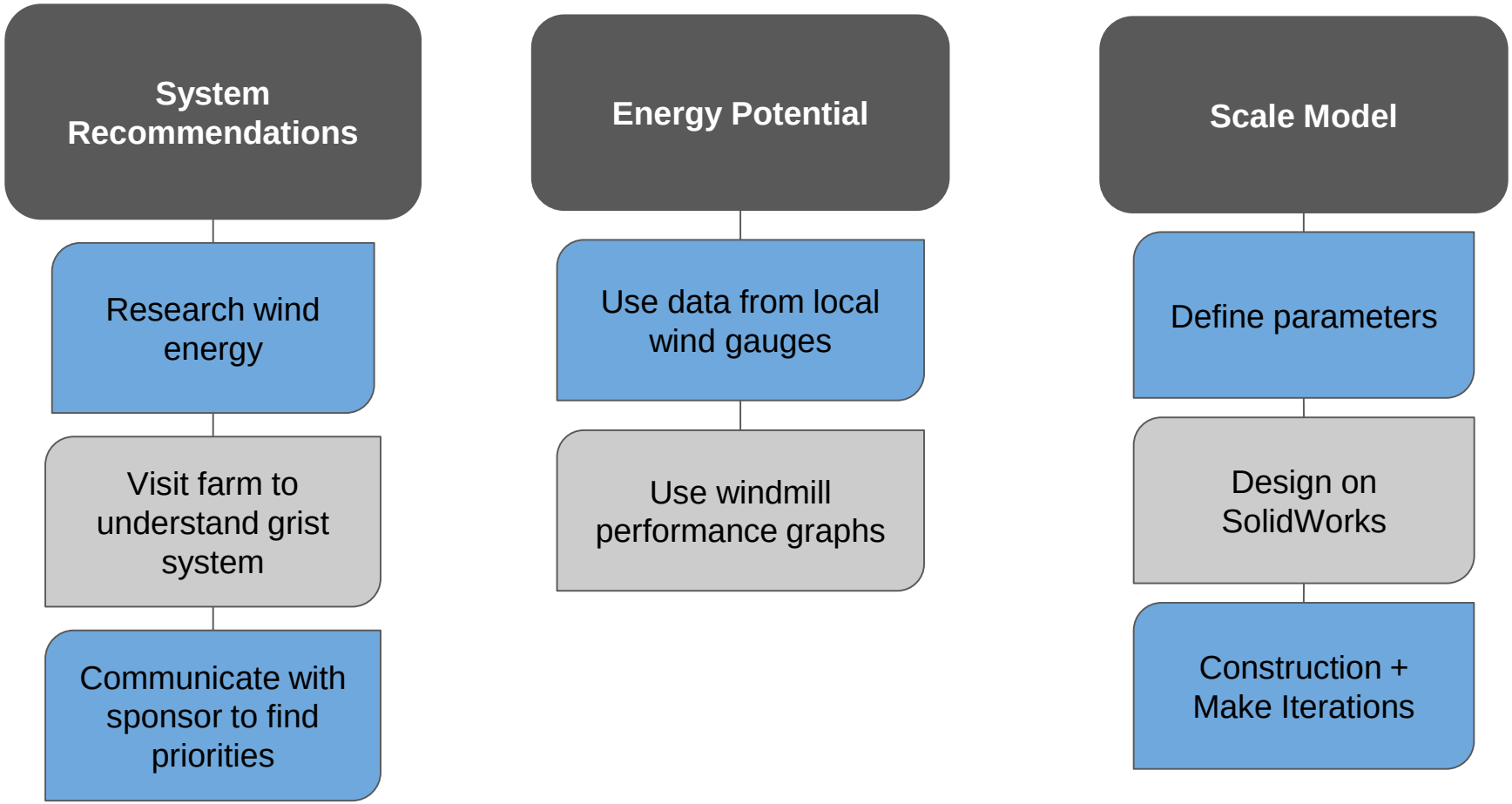
Objectives

1. **Design an electro-mechanical system that**
   a. **Produces electricity from energy harnessed from the wind**
   b. **Interchangeable with grist system**

2. **Determine energy potential**

3. **Design and build scale model**

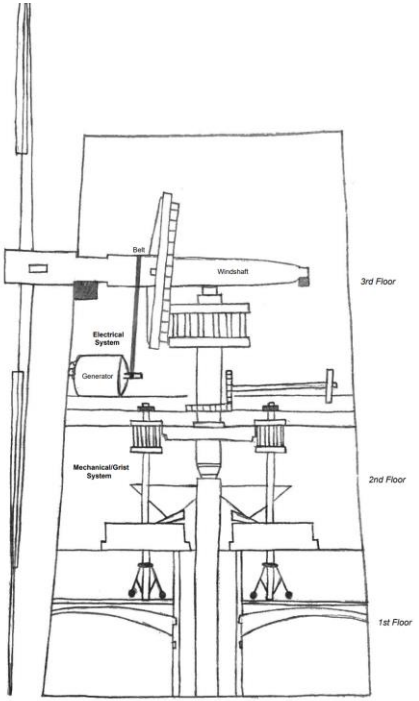
Methodology

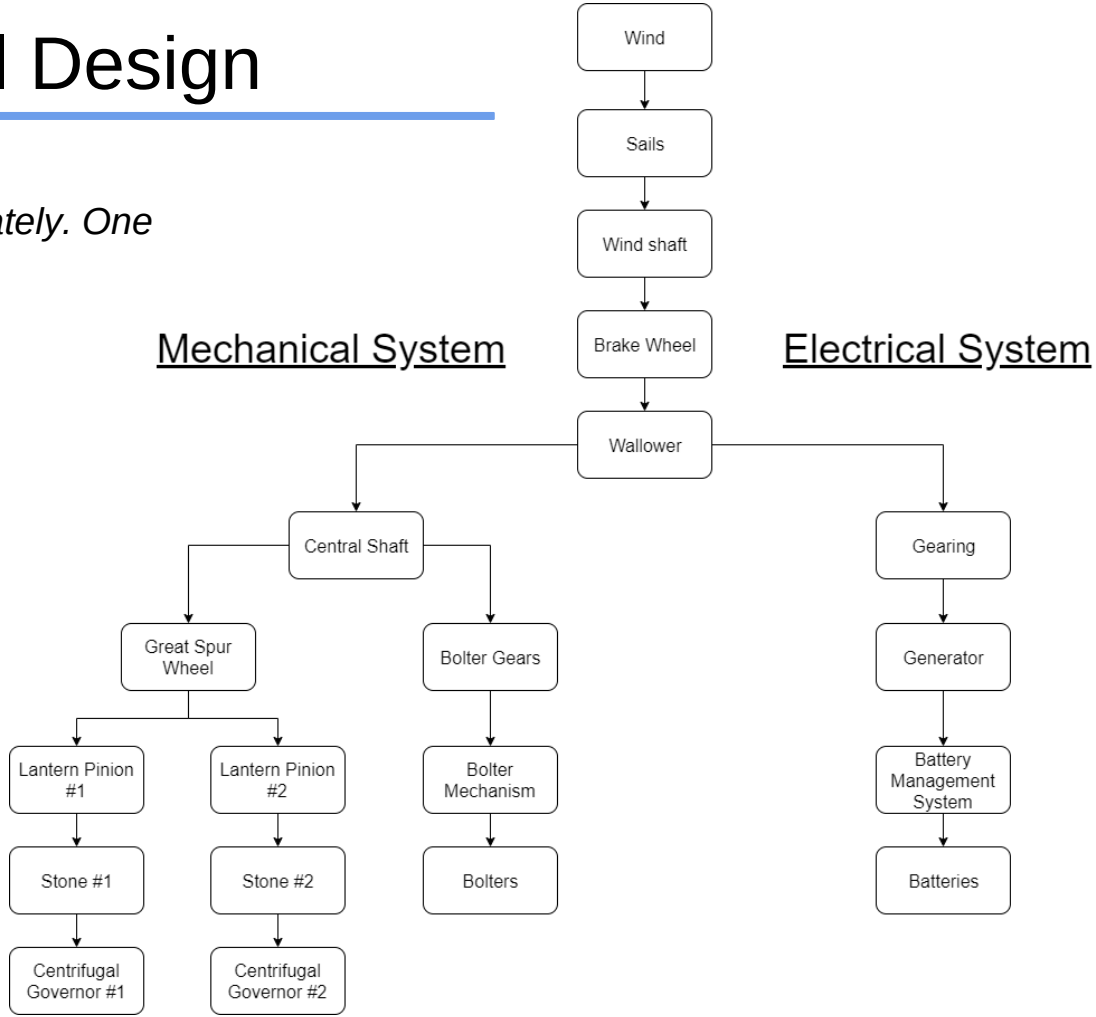


The Electro-Mechanical Design

Layout and Energy Flow-Chart

The two systems are designed to run separately. One cannot run while the other is in use.

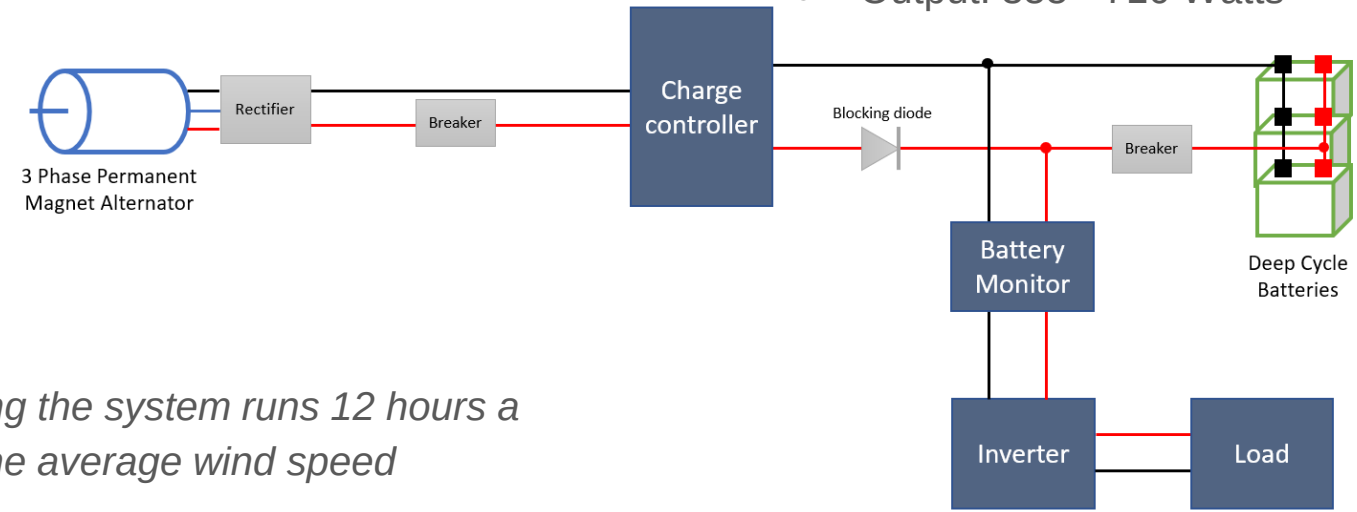




The Electro-Mechanical Design

- 24 volt system
- 3 days of autonomy
- Rated up to 2000 watts
- Generator and windshaft connected through belt
- To be used when grist operations are disengaged

- Cost of materials for isolated system: $7,600 (AGM) or $16,000 (lithium)
- Cost of materials for grid connected system: $9,500 (AGM) or $17,800 (lithium)
- Payback period: 14.7 years (AGM) or 30.9 years (Lithium)
- Efficiency: 0.71
- Output: 355 - 710 Watts



Assuming the system runs 12 hours a day at the average wind speed

Recommendations

- Batteries
  - 3 days of autonomy costs $5,700 for AGM and $14,250 for Lithium
  - Depending on how critical the load is the days of autonomy can be reduced and thus the cost
  - Find a company to donate batteries so that the farm can promote sustainability
- Isolated battery only system
  - Flexibility in design, can use a pure sine or modified sine wave inverter instead of a grid tied inverter.
  - Less service cost and possibly outsource skilled trades jobs to younger professionals looking for experience.

Our Recommendation

Once enough wind data is collected from the wind gauge and it is confirmed that there is enough wind energy, we recommend going with the isolated batteries only system and using it for non critical loads (such as lights). We suggest buying the batteries last to test if the system works correctly and then purchasing (or finding company to donate) four 100ah lithium batteries (just under one days autonomy worth of batteries) configured as two sets of series batteries in parallel.

Energy Potential

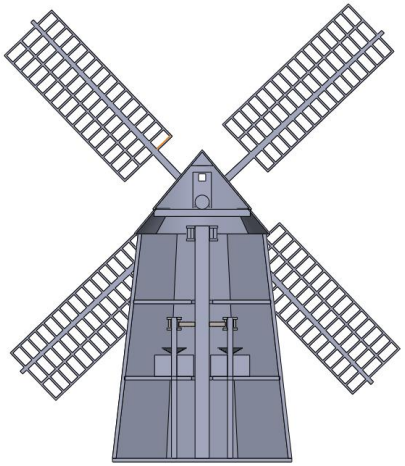
- The energy potential was determined with Equation 1, which represents the power produced, and Equation 2, which represents wind velocity
- In our calculations we had to make some assumptions about the windmill and the surrounding area
    - We determined the average wind velocity to be 3.42 m/s, but recommend that a wind gage be used to gather more wind data for the exact point where the windmill is located
- The power output range was found to be 56-1122 Watts

$$P_m = 0.5 * \rho * A * V_w^3 * C_p * \eta_{total}$$ *Equation 1*

$$V_2 = V_1(\frac{Z_2}{Z_1})^{\alpha}$$ *Equation 2*

Scale Model

Educational Poster to accompany scale model demonstrations



Conclusion

- This unique project is a perfect opportunity for SMEF to not only renovate the existing windmill and symbol of their community to its working condition, but explore the power of renewable energy and add to their sustainability efforts.
- We hope this project serves as a great example of how wind-energy technology has evolved over the last 200 years and how modern technology can complement historic systems in order to accomplish sustainability goals.
- It also emphasizes the importance of sustainability efforts and how there are endless opportunities for organizations like SMEF and everyone to practice and educate about historic preservation sustainability.