

Objective

To demonstrate Calvin's interest in alternative energy by developing a short-term plan to implement a demonstration wind turbine and a long-term plan to determine the feasibility of a larger turbine for the future.

Significant Impact

Both aspects of the project should be carefully selected to provide a *significant impact* on the campus as defined below:

- Short Term – Provide educational opportunities for the college and community, demonstrating that wind power is a viable source of energy.
- Long Term – Supply a significant amount of power to the college while showing economic feasibility over the lifespan of the turbine and providing more educational opportunities for the college and surrounding community.

Short-Term Turbine Choice

The turbine selected for the short-term project is the Skystream 3.7, manufactured by Southwest Windpower, shown in Figure 1.



Figure 1: Skystream 3.7 by Southwest Windpower

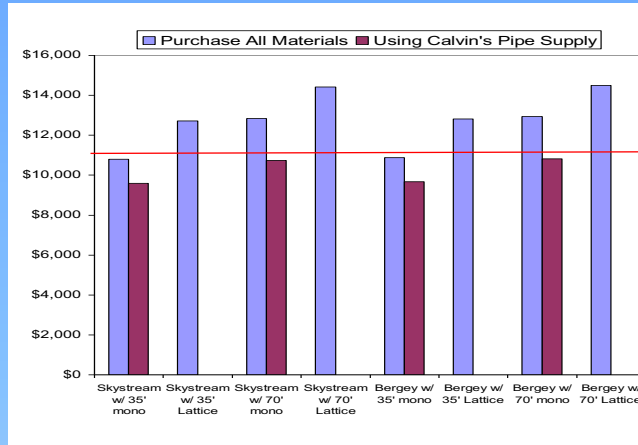


Figure 2: Cost comparison of turbine options

Skystream 3.7 Details

Turbine Details

- Total Height: 45 ft
- Power Output: 1.8 kW
- Cut-in Speed: 8 mph
- Optimal Wind Speed: 20 mph
- Blade Diameter: 12 ft
- Pole Type: 35 foot Monopole

Cost Details

- Turbine: \$5,000
- Pole: \$1,850
- Grid Connection: \$4,045

Total Cost: \$10,895

Factors Influencing Turbine Decision

The Skystream 3.7 has the highest output for the lowest cost. It is rated for 1.8kW at 20 mph wind speed, with 40% output at 12 mph. It does not require a gearbox, and has a built in inverter. Calvin's wind site produces an adequate wind speed at a height of 35'. The optional SW 35' Monopole is not a threat to birds, and has the smallest footprint.

Short-term Turbine Location

The Calvin College demonstration turbine will be located on the east side of campus near the Gainey Athletic Facility, as shown in Figure 3. The turbine will be located inside Calvin College's Ecosystem Preserve. The Ecosystem Preserve has a fence separating it from the road shown in the map. This fence will be used as a means of preventing unauthorized people from accessing the turbine. Additionally, the placement of the turbine in the Ecosystem Preserve demonstrates Calvin's commitment to sustainability



Figure 3: Short-term turbine location

Summary

The Skystream 3.7 wind turbine is the best option for Calvin College's short term wind energy project. This option will purchase a 35-foot monopole from a supplier to keep its warranty active.

Long-Term Project Solution

The solution to the long-term project explores two different Enercon turbines. The benefits of Enercon wind turbines are summarized in the following points:

- Over 10,000 turbines installed worldwide
- A gearless design minimizes maintenance costs and eliminates the need for gearbox replacement.
- Innovative blade design allows for greater power from a smaller blade diameter and reduces aerodynamic noise.
- Enercon focuses on single turbine projects as opposed to large-scale wind farms.
- Variable power factor increases grid stability

Why Two Turbine Options?

- Calvin's campus is a sensitive site due to its proximity to residential areas.
- We chose two different turbine sizes to allow for differences in external restrictions while taking the turbine payback periods into account.
- The E53 has the shorter payback period versus the E33 but is pushing the limits on overall height.

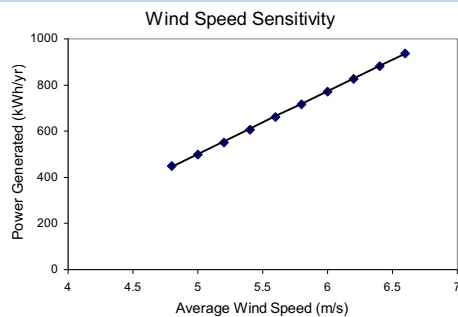


Figure 4: Affect of average wind speed on power generated by E33 wind turbine

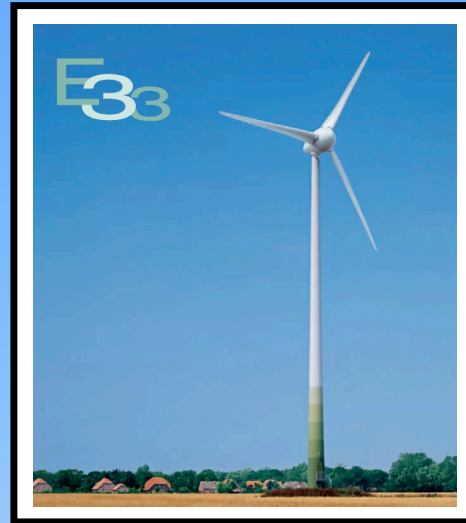


Figure 5: Enercon E33 wind turbine

Enercon E33 Details

- Rated Power: 330 kW
- Rotor Diameter: 110 ft
- Hub Height: 164 ft
- Cut-in Speed: 6.75 mph
- Breakeven point: 15.2 years
- Net Present Value: \$23,000
- Yearly Power: 670 MWh/yr
- Offset: 565 tons CO₂/yr

Long-Term Location Selection

The location of this turbine was selected based on the following criteria:

- 300m radius away from residences to minimize acoustic and shadow effects
- Ease of accessibility with protection from bystanders
- Ground obstruction

The turbine location is selected close to the access road at the Gainey Athletic Fields as seen in Figure 3 to account for these criteria.

Enercon E53 Details

- Rated Power: 800 kW
- Rotor Diameter: 174 ft
- Hub Height: 240 ft
- Cut-in Speed: 4.5 mph
- Breakeven point: 10.8 years
- Net Present Value: \$820,000
- Yearly Power: 2,053 MWh/yr
- Offset: 1732 tons CO₂/yr



Figure 6: Enercon E53 wind turbine

Summary

The study performed on the long-term project reveals that this project is in the initial planning stages and further research must be performed before the college considers a large scale wind turbine.

- Wind data should be collected for at least one to two years to estimate the college's wind generating potential.
- The generating potential of a turbine is proportional to the cube of the average wind velocity.
- As Figure 4 shows, a change in wind velocity from 5 m/s to 6 m/s results in an approximate power production increase of 54%.