Description

Task: Access to a small village in Costal Slombovia is only available by boat. The rocky coast makes the landing perilous, especially at night. A lighthouse is needed to guide the boats to the harbor. Unfortunately electricity is not available at the proposed lighthouse location. However there is a steady ocean breeze and wind may be used to power the light. Pre-manufactured components are hard to find in Slombovia, but luckily natural resources, recycled products, and several 3-D printers are available. The recycled products are items typically found in a household and could include, but is not be limited to items such as food/drink containers, wire, small nails or brads (18 gauge max diameter), flat sheet metal, prefabricated gears, ball bearings, etc.

During the design process, the fan that will be used on test day will be made available to all the teams. It is encouraged that teams be familiar with the fan output and use it throughout the design process.

Requirements:

- A device must be constructed which includes a tower with a windmill, generator and light mounted at the top.
- The tower must be of Lattice (truss) type construction and be a minimum of 30 inches in height to the lowest point of windmill blade. The tower must be constructed so that where the legs touch the table, they are within a 1.25 ft² envelope.
- The tower must be able to withstand a minimum static load of 25 lb in the vertical direction. A hook, extension rod, and weight tray will be used to support the 25 lb weight. A hook will be provided to each team and should be mounted in the center on the underside of the platform supporting the windmill. Also directly below the hook, a 1 inch in diameter clear area should be provided to the base of the tower. Space for the weights does not need to be considered in the design. During this part of the test, the tower will be sitting on a table and the weights will be suspended below the table.
- The tower must be able to withstand a horizontal wind load in all four directions without sliding or tipping. The lattice tower will be free standing without mechanical fasteners or adhesives that attach the device to the surface.
- The windmill must be able to generate an electrical current to light the provided light bulb. Electrical amplifying devices such as inductors are not allowed.
- Tower materials must be naturally occurring (e.g. wood, plants, cotton string, etc) with the exception of the joint materials.
- The maximum cross sectional area of a member of the tower is 0.15 in². However, where each leg touches the horizontal surface it is resting on (the table) a small wooden pad that has a maximum surface area of 0.25 in² and maximum thickness of 0.125 inches may be attached at the end of each leg.
- The maximum weight of the tower/windmill/generator/light is 2 pounds
- The windmill section may be constructed out of any material, however pre-manufactured parts that were originally designed to be a windmill, propeller, fan blade, turbine, etc, may not be used.
- Terminals for voltage measurement must be provided and rigidly attached to an easily accessible location on the tower.
• One component of the design must be drawn in a 3-D modeling software package by a team member and 3-D printed on the printers in Perkins Hall.
• The generator/light/electrical wiring that is provided must be used

Items provided:
• Generator
• Light bulb
• Electrical Wiring
• Hook for weight
• Standard supplies such as wood glue, string, etc

Testing Day Procedures
• Device will be inspected for adherence to guidelines
• The tower will be placed on the testing surface, which is located in Perkins Hall S10.
• The initial test will determine if the structure will either tip or slip in the horizontal direction. On high speed, the lab instructor will place the fan 16 inches from the center of the tower and allow it to run for thirty seconds. This will be done in four directions (0, 90, 180 and 270 degrees)
• The second test will determine the power generated by the windmill. This will only be done in one direction.
• Teams will have three minutes to position the fan. The fan must be a minimum of 16 inches away from the blades of the device. Once the team has positioned the tower, no adjustments may be made until the testing is complete
• The fan will be set on medium and allowed to run for thirty seconds. The voltage will be recorded every 5 seconds.
• A pasco wind sensor will be used to measure wind speed on testing day.
• The previous three steps will be repeated on the high fan speed.
• Once all the wind testing has been completed the tower will be tested for a static vertical load of 25 pounds. Additional weights may be added for extra credit.

Performance grading
**Voltage:** The average voltage at each speed will be calculated and then added together

5 points- highest sum of the average voltage readings in the class
4 points-sum of the average voltages within the 75-99th percentile
3 points-sum of the average voltages within the 50-74th percentile
2 points-sum of the average voltages within the 25-49th percentile
1 point- sum of the average voltages within the 0-25th percentile
**Stability and safety:** The device stability is determined by its resistance to slipping, tipping and collapsing. The safety is determined by whether parts of the windmill, such as the blades, come off.

5 points- Device does not (1) tip, (2) slip or (3) collapse and (4) device remains intact during dynamic testing

4 points- fails in one of the four stability/safety criteria

3 points-fails in two of the four stability/safety criteria

2 points-fails in three of the four stability/safety criteria

1 point-fails all four of the stability/safety criteria

When testing for the static load, the team has the option to add weights in 10 pound increments in order to earn extra credit points. One point will be added to the performance score for each additional 10 pounds that the tower can hold.

**Cost effectiveness:** as in most applications, the cost of the device is a major factor in design selection. The cost of the tower will be determined by: $200 \times (weight \ of \ device \ in \ pounds) + \$3 \times (number \ of \ joints) + \$10 \ for \ each \ gear, \ pulley, \ and/or \ bearing \ used.

5 points- the least expensive device

4 points-cost is within the 1-25\textsuperscript{th} percentile of the maximum cost

3 points- cost is within the 26-50\textsuperscript{th} percentile of the maximum cost

2 points-cost is within the 51-75\textsuperscript{th} percentile of the maximum cost

1 point- cost is within the 76-100\textsuperscript{th} percentile of the maximum cost

Calculations/Measurements

1. Coefficient of static friction between the legs of the tower and the table
2. Force required to cause the tower to slip (assume force acts at center of windmill)
3. Force required to tip the tower (assume force acts at center of windmill)
4. Power from the wind
5. Power provided by the windmill
6. Betz limit, and comparison of your device’s efficiency to Betz limit

Safety

- Always wear safety glasses when testing. Failure to do this will result in a severe point deduction
- Make sure the blades are securely attached to the device. Do not stand to the side of the device during the testing in case the blades do come off.

Frequently Asked Questions”

1. **Can we use small nails or brads (18 gauge max diameter) to connect members of the tower together?** Yes. Non-naturally occurring materials can be used for the connections
2. **Can we use small pieces of wood at the joints that result in a larger cross-section?** Yes, but the maximum length the piece of wood used to reinforce a joint can overlap a main member is the minimum of either (1) \(\frac{1}{4}\) inch or (2) one-tenth the distance to the next joint. For example, if the distance between joints is 3 inches, the overlap is limited to 0.25 inches (instead of \(\frac{3}{10} = 0.3\) inches). However if the distance to the next joint was only two inches, the overlap is limited to 0.2 inches (instead of the 0.25 inches).

3. **Can we laminate the members of the tower?** No. Each member must be a solid piece of wood.