Pulling the Plug on World Problems:

Creating an Inexpensive and Frictionless Wind Turbine to Power the World

Engineering Goal

And Rationale

Problem: To create a **cheap** and **frictionless** windmill which can **spin freely and with stability**. By placing it in a wind tunnel, the RPS can be measured and compared to the current conventional windmill. **Constraints** include a budget of $50 dollars and access to regular machine available in a common workshop.

Rationale/Need: Electricity has become an important and easily accessible resource lately. This, however, is not the case for many rural and developing parts of the world. The purpose of this windmill will be to provide the people living in these areas access to a cleaner and safer light source which utilizes electrical light, instead of burning unsafe kerosene. Obviously, this solution is far more cleaner, safer, and much more practical.

Solution

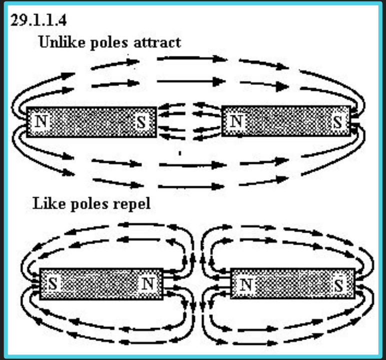
The proposed method is a wooden Vertical Axis Wind Turbine which utilizes magnetic suspension. The cost of this solution amounts to $45, which is distinctly cheap for the type of technology that it utilizes and the long term benefits of owning it. In addition to that, this windmill utilizes magnetic suspension, which applies the concept of similar poles repelling. Because they repel using the nature of the magnetic fields, there is no physical contact to produce friction, therefore increasing its efficiency in converting mechanical to electrical energy.

Research and Concept Review

Magnetic Principles

Law of Magnetism: Opposite poles attract each other and similar poles repel

- Basis of magnetic suspension: repulsive properties
  - Magnetic Repulsion will provide a contactless suspended turbine for better efficiency



http://www.lewpaxtonprice.us/magnet.htm

Research and Concept Review

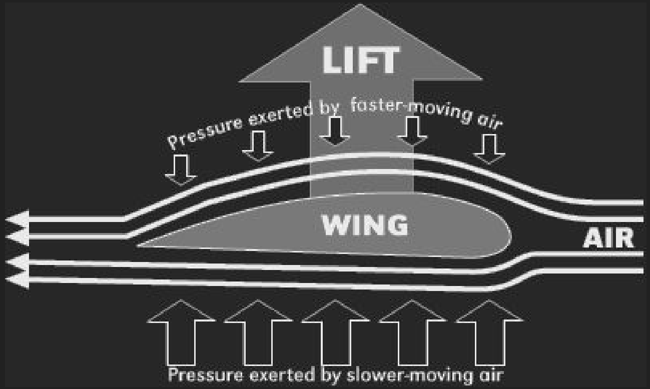
Lift and Airfoil Principles

Bernoulli's Principle: Within a horizontal flow of fluid, points of higher fluid speed will have less pressure than points of slower fluid speed.

- Basis for lift and airfoils

Lift: A mechanical force, generated by the interaction and contact of a solid body with a fluid.

- Basis for airfoils
    - This will provide the kinetic energy to drive the turbine and create rotational force



https://www.grc.nasa.gov/www/k-12/airplane/incline.html

Research and Concept Review

Current Technology

- HAWT: Horizontal Axis Wind Turbine
    - Good at spinning at high wind speeds
    - Poor efficiency
        - A lot of energy is wasted as heat energy due to the high amount of friction in the joints
        - Utilizes Ball-bearings to reduce friction
    - Can't spin with the common low wind speeds
    - Requires energy to move the blades against the wind
    - Very expensive to build and set up
    - High friction
        - Heat can build up to create fires
    - Require large amounts of land to set up

http://www.dailymail.co.uk/news/article-2695266/Wind-turbine-fire-risk-Number-catch-alight-year-ten-times-higher-industry-admits.html

https://www.siemens.com/global/en/home/markets/wind/turbines-and-services.html

Tools and Instruments

Provided by the school

- Protractor
- Compass
- 3.5 cm Hole Saw Drill Bit
- 2.8 cm Forstner Bit
- Chisel
- Autodesk Inventor Software (3D Modeling)
- Drill Press
- Hand Saw
- Bandsaw
- Hacksaw
- X-Acto Knife
- Sharpie
- .2 cm Drill Bit
- A Pencil

Materials

Along with professional supervision

- 18, 3.1 cm Ferrite Ring Magnets
- 1, 0.63 cm x 61 cm x 61 cm Lauan Plywood
- 1, 0.95 cm x 0.63 cm x 213 cm Pine Wall Trim
- 5, 1.3 cm x 91.4 cm Oak Wooden Dowels
- 1, 1.3 cm x 121.9 cm Poplar Wooden Dowel
- 1, 4.4 cm x 25.4 cm x 14 cm Poplar Wood Block
- Hot Glue
- 1, 0.3 cm x 25 cm x 25 cm Cardboard Sheet
- Industrial Strength Super Glue
- Safety Goggles
- Duck Tape
- Duco Cement/Super Glue
- 90 cm of 16 Gauge Copper Wire
- Wood Glue
- Permaplast (Plastic Clay)

Cost: $45

Designing and Concept Sketches

- Ideology
- After playing with the magnets for an extended period of time, it was noticed that…
  - The magnets seem to repel each other on their top, bottom, and side face.
  - Repeled at a height of 3.5 cm (without weight)
  - Repeled at a height of 1.2 cm (with force)
    - Total time taken: 2 weeks
- Initially, the top and bottom faces were utilized to repel
  - Various designs were made involving this (See Figure _)
  - Conceptual Issues were unstability, unfeasible, and difficult
  - The thought of 3D Printing occurred as well but the process was too tedious and weak for this purpose
    - Total time taken: 3 ½ months

Designing and Concept Sketches *cont.*

- Novel approaches were taken to utilized the odd repelling nature of the sides of the magnets.
    - Involved drilling holes and using the sides to surround and restrict the rotating magnet in the x and z planes.
        - Total time taken: 1 month
- Plan for construction
    - Utilize the engineering lab to create a small working prototype out of wood.
    - The magnetic hub would be made with recessed holes, instead of dowels which were proposed earlier, but were discluded due to their complexity.
    - The airfoils could be made out of wall trim because it's already in the rough shape of an airfoil.

Designing and Concept Sketches *cont.*

- Dowels could be used for the structural frame thanks to their vertical strength and they can also allow air to flow through with ease
- Plywood will be able to support the weight of the magnets and the force exerted by them.
  - Total time planned: 4 weeks

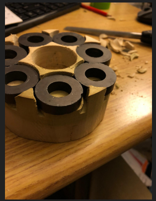
Prototype X Construction Procedures

Magnetic Hub

1. Draw a circle (x) with a diameter of 10.1 cm on the block using the compass.
2. Cut (x) out using the bandsaw.
3. Draw a circle (y) with a radius of 4 cm.
4. Divide the circle (y) into 7 parts and label the intersections between the lines and circle (y).
5. Drill holes on those 7 points drawn in step 4, using a 3.5 cm hole saw drill bit, 1 cm deep.
6. Drill holes on the points drilled in step 5 with a 2.8 cm forstner bit 1 cm deep.
7. Chisel the small piece remaining between the remnants of the hole saw bit and the forstner bit.
8. Drill a hole in the center the entire way through using the hole saw drill bit.
9. Super glue 7 magnets into each of the recessed circles.
10. Repeat steps 1-8.








Prototype X Construction Procedures *cont.*

Airfoils

1. Cut 10, 17 cm pieces from the 0.95 cm x 0.63 cm x 213 cm Pine Wall Trim.

Structural Dowels

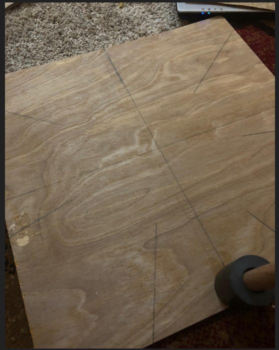
1. Cut 2, 30 cm pieces from the 1.3 cm x 91.4 cm Oak Wooden Dowel.
2. Repeat step 1 4 times

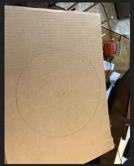
Plywood Top and Base

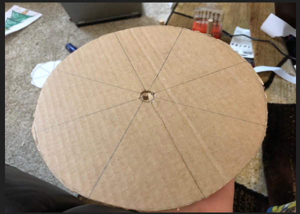
1. Cut the 0.63 cm x 61 cm x 61 cm Lauan Plywood into 4 equal pieces.

Airfoil Hub

1. Draw a circle (b) with a diameter of 23 cm and cut it out using the hand saw.
2. Divide it into 10 parts.
3. Drill a 1.3 cm hole of it.
4. Draw a 45* angle 2 cm away from the edge
5. Repeat steps 1-4 for the 9 other lines.







Prototype X Construction Procedures *cont.*

Rotational Shaft

1. Cut a 20.5 long dowel from the 1.3 cm x 121.9 cm Poplar Wooden Dowel
2. Drill a hole .2 cm thick into both sides of the dowel
3. Super Glue a cardboard circle with a diameter of 2.5 cm on a magnet with a pole that repels its corresponding face on the magnetic hub.
4. Glue the dowel cut in step 1 onto the center of the cardboard circle.
5. Repeat steps 1-4 on the other side of the dowel.

Prototype X Construction Procedures *cont.*

Windmill

1. Draw a circle (a) with a diameter of 30. 5 cm on the plywood piece.
2. Divide it into 7 parts and label the intersections between the circle (a) and the 7 parts.
3. Use super glue to glue a structural dowel straight up at a 90* angle with regards to the flat plywood board.
4. Repeat step 3 with the other 6 points and 6 dowels (1 is left out for accessibility to the center for the future).
5. Super glue the Magnetic Hub directly inline with the center of circle (a).
6. Repeat step 5.
7. Glue the airfoils with the thicker part facing outwards at 40* (See Figure 2).
8. Repeat step 7 10 times.
9. Slide the airfoil hub onto the rotational shaft 2 cm from the edge.

Prototype X Construction Procedures *cont.*

Windmill

10. Insert the rotational shaft and keep it suspended over the magnetic hub. Place the plywood top and the magnetic hub above it.

Issues

With Prototype X

- The 7 magnets surrounding the central magnet made the rotational shaft unstable
  - The rotational shaft left the track and wanted to flip towards the attractive field.
    - Fix: Remove the 7 surrounding magnets and add a copper wire to provide minimal contact but a strong guide.
- The airfoils were a little too long
  - Fix: add clay to the structural dowels to increase the height of the structure.

*Changes from the previous procedure will be bolded in the next few slides

Prototype Y Construction Procedures

Magnetic Hub

1. Draw a circle (x) with a diameter of 10.1 cm on the block using the compass.
2. Cut (x) out using the bandsaw.
3. Draw a circle (y) with a radius of 4 cm.
4. Divide the circle (y) into 7 parts and label the intersections between the lines and circle (y).
5. Drill holes on those 7 points drawn in step 4, using a 3.5 cm hole saw drill bit, 1 cm deep.
6. Drill holes on the points drilled in step 5 with a 2.8 cm forstner bit 1 cm deep.
7. Chisel the small piece remaining between the remnants of the hole saw bit and the forstner bit.
8. Drill a hole in the center the entire way through using the hole saw drill bit.
9. **Super Glue a small and straight piece of copper wire 7.5 cm long in the middle.**
10. **Super Glue a magnet in the middle with the pole repelling the corresponding magnet on the rotational shaft.**
11. Repeat steps 1-8.








Prototype Y Construction Procedures *cont.*

Airfoils

1. Cut 10, **16** cm pieces from the 0.95 cm x 0.63 cm x 213 cm Pine Wall Trim.

Structural Dowels

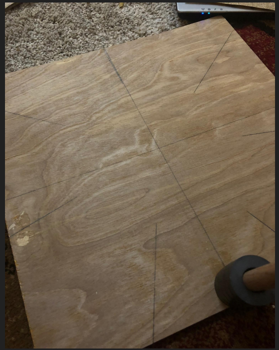
1. Cut 2, 30 cm pieces from the 1.3 cm x 91.4 cm Oak Wooden Dowel.
2. Repeat step 1 4 times

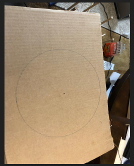
Plywood Top and Base

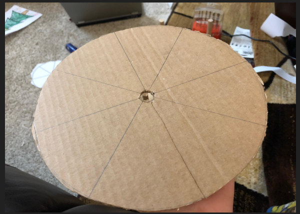
1. Cut the 0.63 cm x 61 cm x 61 cm Lauan Plywood into 4 equal pieces.

Airfoil Hub

1. Draw a circle (b) with a diameter of 23 cm and cut it out using the hand saw.
2. Divide it into 10 parts.
3. Drill a 1.3 cm hole of it.







Prototype Y Construction Procedures *cont.*

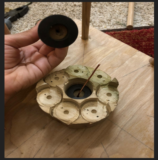
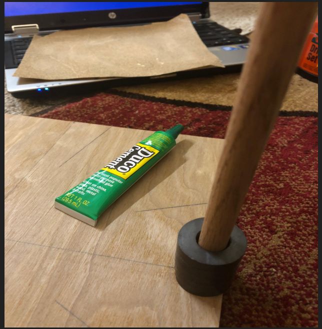
Rotational Shaft

1. Cut a 20.5 long dowel from the 1.3 cm x 121.9 cm Poplar Wooden Dowel
2. Drill a hole .2 cm thick into both sides of the dowel
3. Super Glue a cardboard circle with a diameter of 2.5 cm on a magnet with a pole that repels its corresponding face on the magnetic hub.
4. Glue the dowel cut in step 1 onto the center of the cardboard circle.
5. Repeat steps 1-3 on the other side of the dowel.

Prototype Y Construction Procedures *cont.*

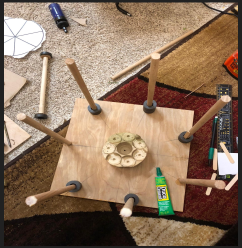
Windmill

1. Draw a circle (a) with a diameter of 30. 5 cm on the plywood piece.
2. Divide it into 7 parts and label the intersections between the circle (a) and the 7 parts.
3. Use super glue to glue a structural dowel straight up at a 90* angle with regards to the flat plywood board.
4. **Add clay with a height of 2.5 cm on top of the dowel.**
5. Repeat step 3 with the other 7 points and 7 dowels.
6. Super glue the Magnetic Hub directly inline with the center of circle (a).
7. Repeat step 5.
8. Glue the airfoils with the thicker part facing outwards at 40* (See Figure 2).
9. Repeat step 7 10 times.
10. Slide the airfoil hub onto the rotational shaft 2 cm from the edge.







Prototype Y Construction Procedures *cont.*

Windmill

10. Insert the rotational shaft and **make sure to have the copper wire insert into the hole in the rotational shaft.**
11. Place the plywood top and the magnetic hub above it the structure.

Testing

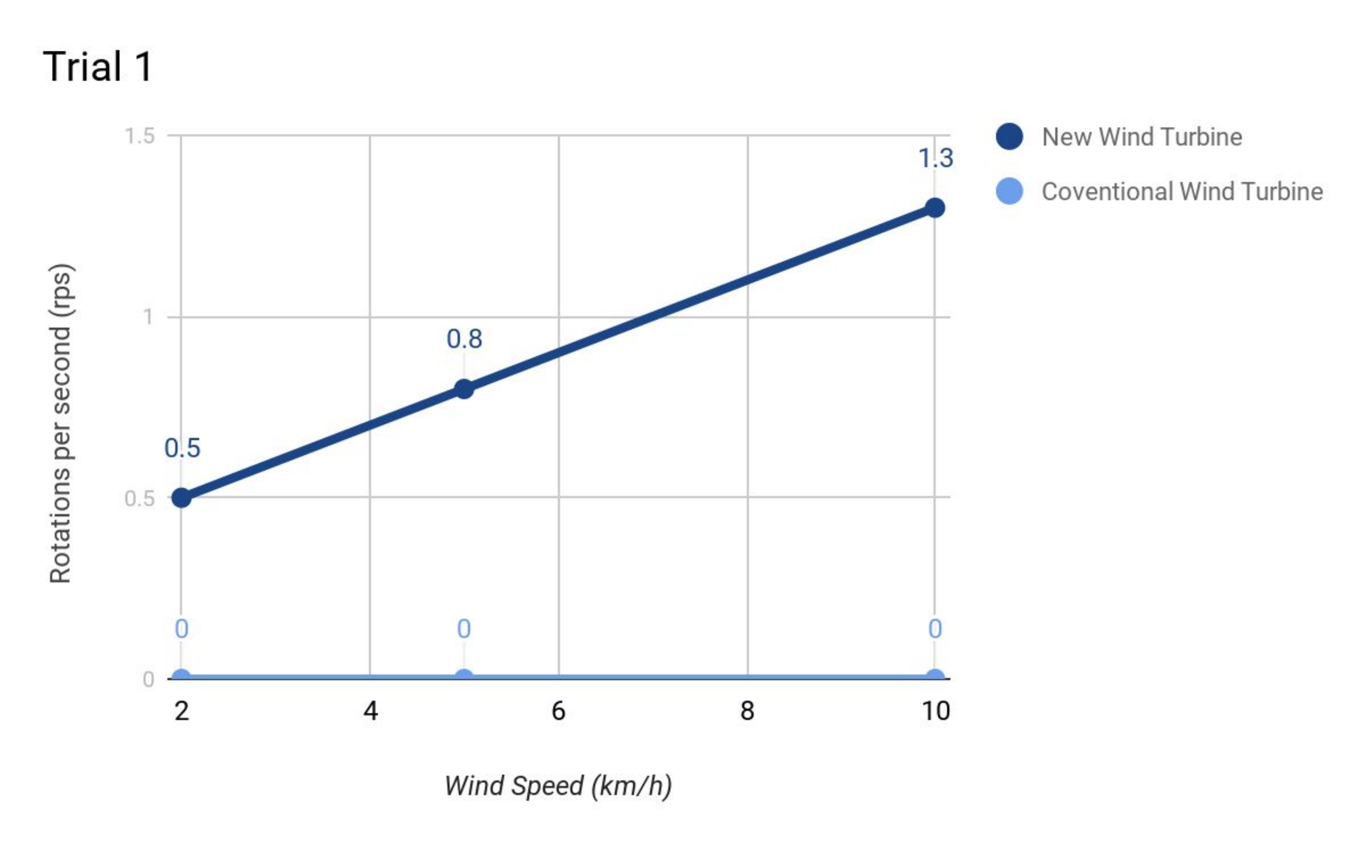
1. The windmill was put in front of a fan and a mark was made on one of the airfoils. The phone was set up behind the windmill, along with a timer
2. The fan was turned to Level I and the phone recorded the timer and windmill in slow motion.
3. Steps 1-2 were repeated for Level II and III
4. The footage was reviewed and the number of rotations per second was estimated.

Results

Raw data table for the new wind turbine

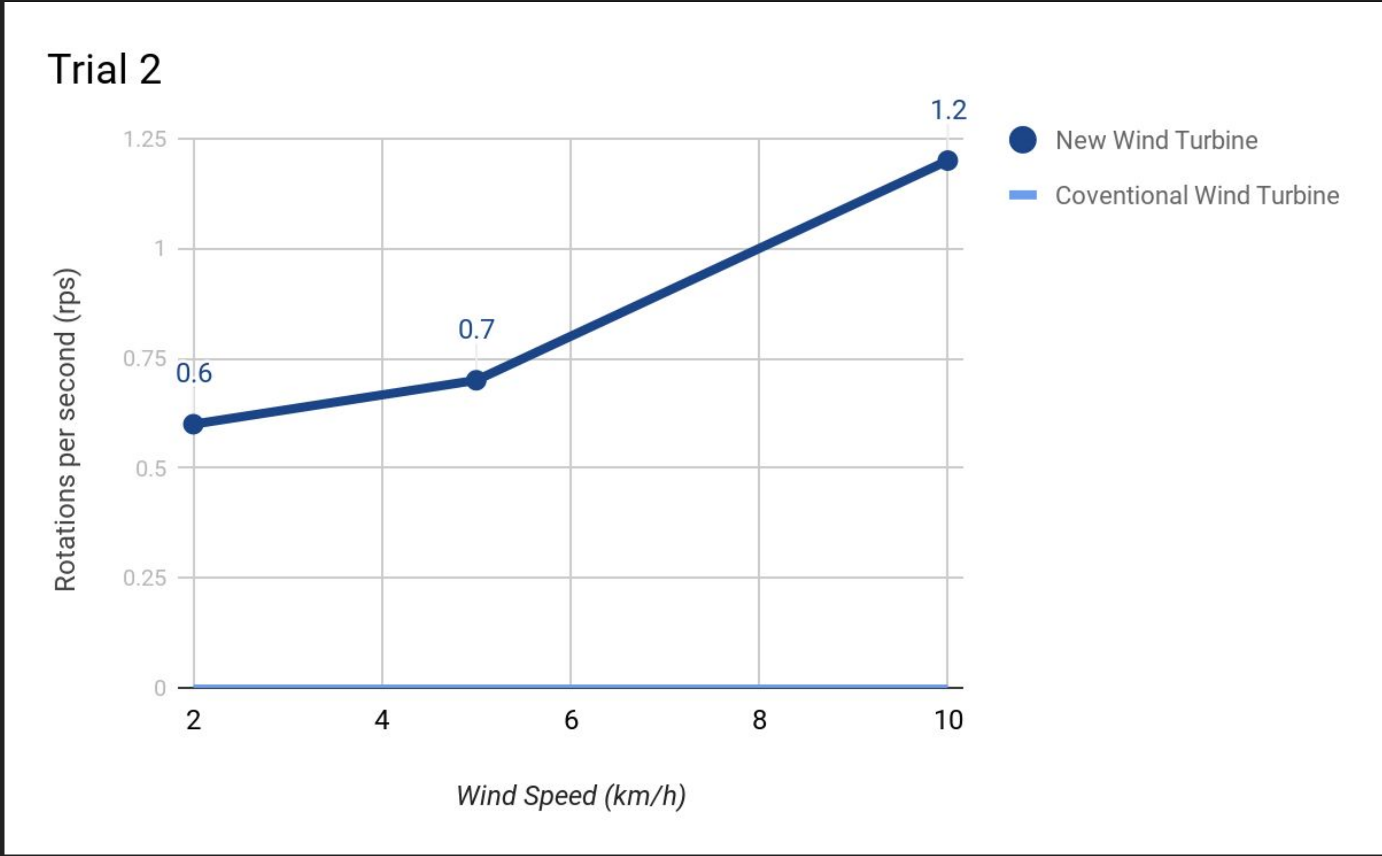
	Level I	Level II	Level III
Trial 1	.5 rot	.8 rot	1.3 rot
Trial 2	.6 rot	.7 rot	1.2 rot
Trial 3	.5 rot	.7 rot	1.0 rot

Trial 1

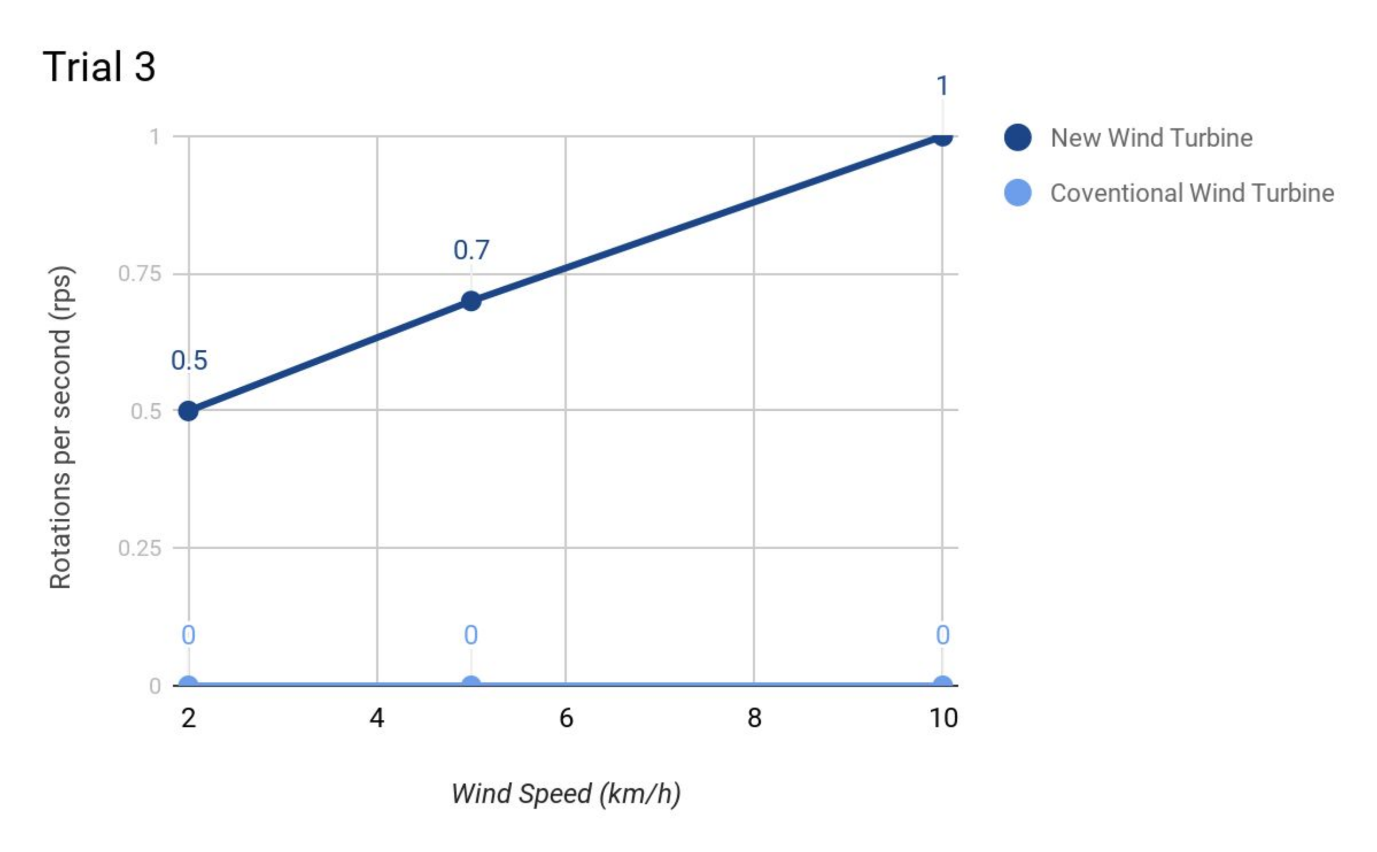


Trial 1
New Wind Turbine
Coventional Wind Turbine
1.5
1
0.5
0
Rotations per second (rps)
0.5
0.8
1.3
0
0
0
2
4
6
8
10
Wind Speed (km/h)

Trial 2

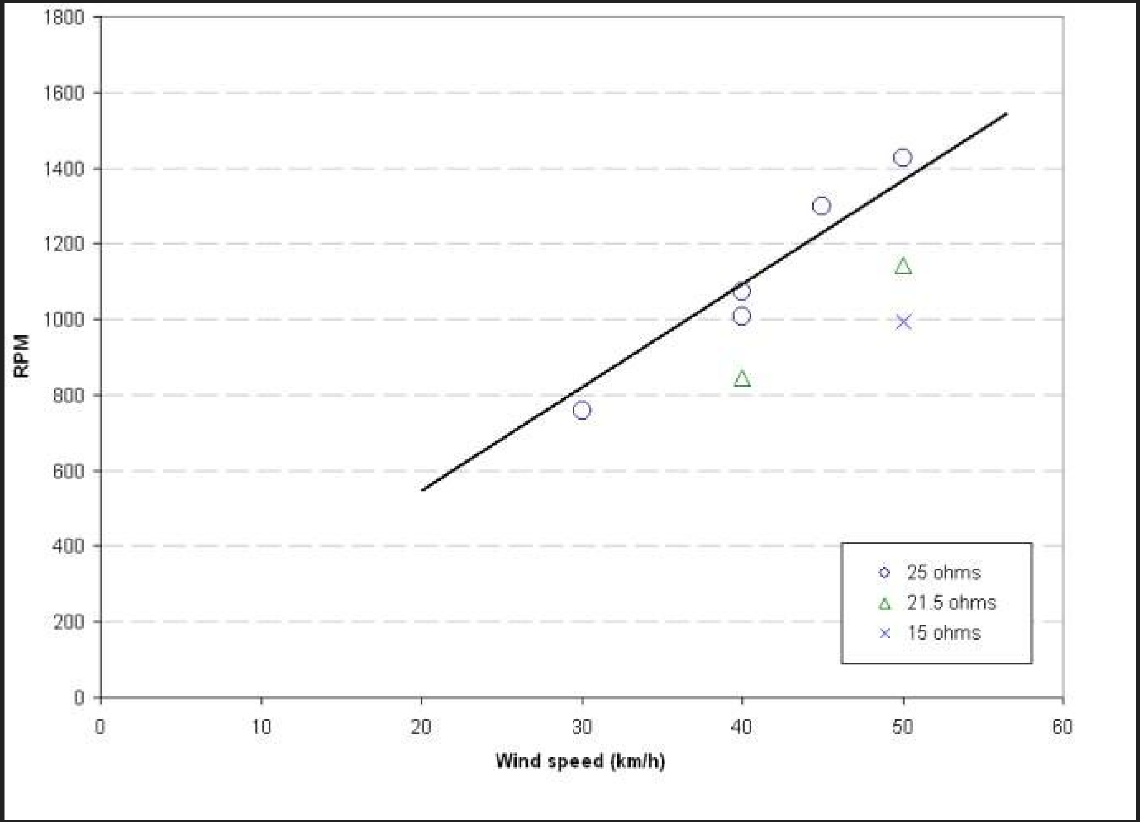

Trial 2
1.2
0.7
0.6
1.25
1
0.75
0.5
0.25
0
2
4
6
8
10
Rotations per second (rps)
Wind Speed (km/h)
New Wind Turbine
Coventional Wind Turbine

Trial 3


Trial 3
1
0.7
0.5
0
0
0
1
0.75
0.5
0.25
0
2
4
6
8
10
Rotations per second (rps)
Wind Speed (km/h)
New Wind Turbine
Coventional Wind Turbine

Note

The conventional Wind Turbine doesn't rotate at wind speeds below 20 km/h. However, once it reaches 20 km/h, the RPM is very high. Refer to the graph to the right for more details.



https://www.warlock.com.au/500wattblades.htm

Discussion

The wind turbine surpassed the conventional turbine in every low speed test. As the higher speeds came, the conventional turbine definitely surpassed the New Wind Turbine. Statistics are not needed to show the difference in performance, due to the major gap in data and the trendline for the conventional turbine remaining 0 throughout the tests. This data shows that this project was very close to a complete success, as it is cheap, almost frictionless, and can spin freely and with a significant amount of stability. It is very very practical mainly because i can harness low wind speeds, unlike the conventional turbine. In addition to that, it is small and relatively cheap and is surprisingly easy and simple to understand, despite the complex concepts. It is small and can be used by anyone which a wind source to produce power off the grid, whether it be someone in a small village or someone looking to use green and renewable power.

Future Ideas

Or Improvements

- Create better airfoils
  - The efficiency was directly impacted due to the shape of the airfoil. In the future, it would be easier to purchase a wall trim with a better shape.
- Use electromagnetic levitation
  - This is a guaranteed way of making the windmill completely frictionless and is far cheaper than using permanent magnets.
- Apply magnetic levitation to horizontal convention windmills
  - See if this would be better than making it vertical.

References

Airfoils and Lift. (n.d.). Retrieved December 17, 2017, from http://web.mit.edu/2.972/www/reports/airfoil/airfoil.html

How Maglev Works. (n.d.). Retrieved December 17, 2017, from https://www.energy.gov/articles/how-maglev-works

Magnetic Levitation. (n.d.). Retrieved December 17, 2017, from http://hyperphysics.phy-astr.gsu.edu/hbase/Solids/maglev.html

VAWT vs HAWT. (n.d.). Retrieved December 17, 2017, from http://www.windturbinestar.com/hawt-vs-vawt.html

What is a Windmill and How Does a Windmill Work? (2016, December 24). Retrieved December 17, 2017, from https://www.conserve-energy-future.com/how-windmills-work.php