Final Concept Proposal & Functional Specifications

Green Breeze

Professor Blinder
ECET 400
Due Date: 9/28/20
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Introduction

The Green Breeze is a revolutionary reimagining of the wind turbine. By capturing winds produced by automobiles and locomotives, the Green Breeze is able to convert this otherwise wasted energy into electricity and recycle it back into the power grid.
The majority of wind technology on the market today is designed around old ways of thinking about power generation. Most turbines are giants, designed to be free-standing in an open space, utilized by an industrial wind farmer, and far away from those that consume their power. While such strategies had made sense for coal and diesel power plants, alternative energy technologies allow for decentralization and variation in where and how electricity is produced. And in an age where microgrids are gaining favor with many cities and institutions alike, Green Breeze will become a local power source for the community in which it inhabits, turning it's waste back into food for the grid.

Project Organization

Jarrett Bond

- Studies electrical and computer engineering technology at NJIT.
- Accomplished electronic technician.
- Responsible for: Designing mechanical components, constructing converter, programming sensors

Shawn McHugh

- Pursuing a Bachelor's Degree in Electrical and Computer Engineering Technology
- IT Technician by trade and experienced fabricator.
- Responsible for: Constructing base, measuring power output/efficiency.

Kevin George

- Studying Electrical and Computer Engineering Technology at NJIT
- Interested in the Computing side
- Responsible for programming and gathering statistics of device

August Rosenberger

- Majoring in Electrical and Computer Engineering Technology at NJIT
- Interested in hardware development and integration
- Responsible for hardware

Concept

Efficient wind turbine to capture wasted kinetic energy from moving vehicles. Can be used on roadways or in subway systems and monitored effectively. These units will be easily installed and connected to either segmented or large scale power grids. Wind turbines are not a new concept by any means, however, there is no product ready for wide scale adoption like the Green Breeze. Our product will fit seamlessly into existing power systems with little professional expertise or training.

Problem Addressed

Vehicles push the air around them as they travel which reduces efficiency. If that same energy can be converted back into usable electricity then there would be less waste. Aerodynamic drag is one of the largest contributors to efficiency, so much so that for each percent of wind drag lost accounts for a half of a percent of fuel saved. The majority of said wind drag can be captured if our turbines are placed properly on a roadway or subway system.

Project Description and Functions

A horizontal-axis wind turbine. Three sets of turbine blades are staggered one foot apart on a single shaft. The second and third set of blades rotated 30 and 60 degrees clockwise (respectively) in relation to the first set of blades. Designed to be implemented within close proximity of moving automobiles and locomotives, the turbine utilizes the residual wind energy to produce electricity by means of an alternator. The electricity generated is then sent through a regulator to control power output fluctuations. Electricity is then converted to DC and sent to it’s battery. The battery powers all other electronics within the equipment. Additional electronics are used to control the device as well as monitor, store, transmit, and receive all pertinent data.

% Original Design Discussion

The Green Breeze’s originality comes from its design and implementation. There is no product on the market that is designed for installation within tunnels or under bridges. The only wind turbines designed for roadside installation are vertical axis turbines. Nor is there is not a horizontal axis wind turbine with several rows of blades on the market. This makes Green Breeze at least 50% original.

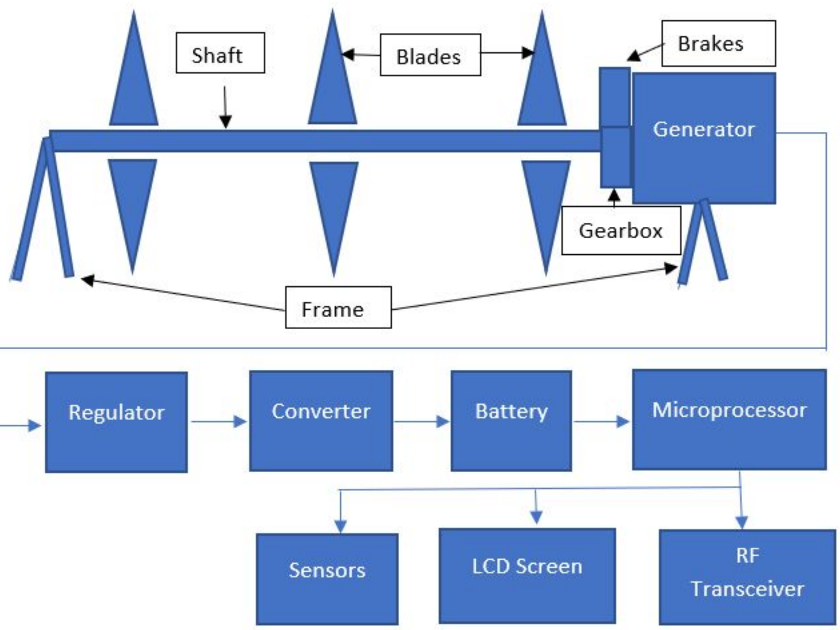
<u>Functional Specifications</u>

Green Breeze

The turbine produces electricity for the power grid by capturing kinetic energy produced by moving vehicles and converting it into electric energy. Can be used on roadways or in subway systems and monitored effectively.

Product Features: Horizontal-axis turbine with multiple sets of blades, LCD screen, microcontroller, monitoring software, voltage regulator, battery pack, power converter, brake system,

Physical Layout:



Power: Self powered with battery back-up

User Interfaces: Laptop

Max Cost Per Unit: $570

Peripherals for Visual Displays: LCD screen to display rea-ltime turbine speed and power output

Peripherals for User Input: Brake override to slow or stop turbine rotation

Interfacing with Other Equipment: Capable of interfacing with laptops and PCs either directly or remotely

Research

Topics

1. Patents
2. Turbine Design
3. Integration

Sources of Research

1.
    a. https://patents.google.com/patent/US7427173B2/en,
    b. https://patents.google.com/patent/US7902690B1/en,
    c. https://patents.google.com/patent/US20140196446#patentCitations

2.
    a. https://www-morganclaypool-com.libdb.njit.edu:8443/doi/pdf/10.2200/S00660ED1V01Y201508PEL009
    b. https://ieeexplore-ieee-org.libdb.njit.edu:8443/stamp/stamp.jsp?tp=&arnumber=5163894
    c. https://ieeexplore-ieee-org.libdb.njit.edu:8443/stamp/stamp.jsp?tp=&arnumber=7086062

3.
    a. https://www.irena.org/newsroom/articles/2018/Jan/Running-on-renewables-transforming-transportation-through-renewable-technologies
    b. https://www.energy.gov/funding-financing-energy-projects

Results of Research

1.

Several Patent applications relating to wind generation from automotives have been issued within the last two decades. The first source cited involves a vertical-axis turbine design to be implemented along roadways. The turbine itself is set within a housing shell and captures the kinetic energy found within the wind that automobiles produce. First filed by Taiming Chen in May of 2006, the patent is anticipated to expire in May of 2026.

The second source cited deals with a vertical-axis turbine designed to be installed on structures in order to capture vehicles' residual wind energy. Based on the images submitted, the device is made to be installed overhead, on the far side (relative to the direction of traffic) of underpasses. This patent application was filed by Arie and Gregory Van Meveren in February of 2010 and is set to expire in February 2030.

The third source is to a patent that is very similar to our design. A horizontal-axis turbine with multiple sets of rotary blades, this turbine was imagined to fit within subway tunnels and elevator shafts. This patent is of much larger design, consisting of upto sixteen rows of rotary blades in some images. This patent was first filed by Norman Holley in March of 2014, it has since expired.

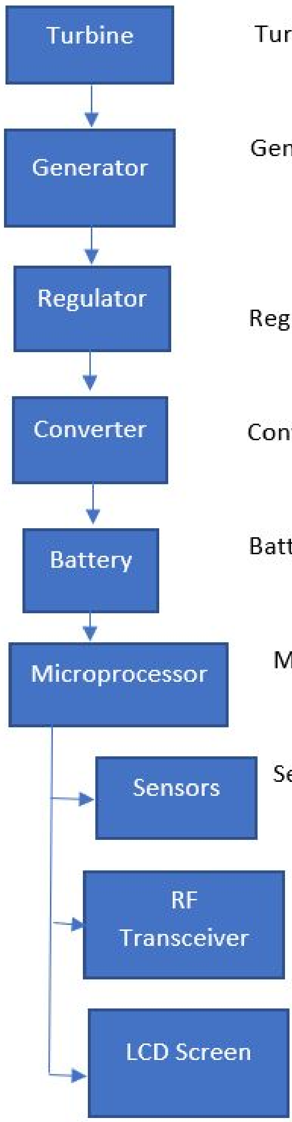
2.
There is a fair amount of information regarding power generation and wind turbines, this works in our favor, providing us with a wealth of technical data, and procedure to follow and improve upon. Source 2a provides a necessary distinction between inductive and synchronous generators. The key difference between the two is that induction generators can be used for fixed-speed and variable-speed systems, while synchronous generators are normally used in only variable-speed systems. Fixed-speed systems require a lot of maintenance and monitoring because they are directly tied into the grid, where variable-speed generation is typically tied into a power electronic system.This is important for us to know, so that moving forward we can continue to research information on different kinds of variable-speed systems.
Source 2b has details on a wind generation that is fairly similar to our basic design concept, both designs use rotational force to produce an AC power current, that is ultimately converted to DC and stored within a battery. This document also provides useful data regarding the transformation from AC to DC current as well as a detailed diagram and description on the use of a PM (permanent magnet) synchronous generator.
As far as source 2c goes, this document on the relationship between rotational speed (in rpm) and power output (in kW). This is also very important data for us in regards to our overall turbine design. Since we want to maximize our overall power output and efficiency we may need to implement some form of gear box in order to increase/decrease the speed of our generator's axis.

3.
The switch to renewables and electric vehicles is only becoming more apparent. According to IRENA (International Renewable Energy Agency), international electric vehicle sales doubled from 2015 to 2016. Some nations are more progressive like Norway, averaging a one to five electric vehicle to petroleum vehicle ratio. The efficiency of our transportation system will undoubtedly be reliant on renewable energy. Without it, our electric cars will still gain charge from coal, natural gas, and/or nuclear energy.
In regards to funding large scale adoption, there are grants and financing options to make it happen. The US Department of Energy offers financial and technical support for energy based projects and they are only one example. Through state, local, and private funding our project could be accelerated once ready for adoption.

Hardware

- *Base/Mount*
  The Green Breeze will experience drafts that make proper mounting a requirement. For roadways, a simple circular base with a wider diameter than the turbine can be secured to the sides of the road in a parallel fashion.
  In tighter situations like subways, the unit may have to be mounted to a wall due to limited ground space. This requires a horizontal mount that would secure both the top and bottom of the turbine against a wall.
- *Turbine/Shaft*
  A horizontal axis turbine with diagonally facing blades will create an efficient and space saving design. Once the design has passed the prototyping phase, it can be produced using recycled plastics to further reduce environmental impact.
- *Gearing*
  The gearing ratio must coincide with the desired placement. Air density and speed must be taken into consideration for either a high or low gear ratio. Prototypes will only include a single gear ratio.
- *Generator*
  Power generation will be accomplished with a direct current generator for ease of measurement and adoption. The output current will be ideal for small grid systems like subways. A transducer will be required for large scale alternating current grids, resulting in a minor efficiency loss.
- *Sensors*
  Proper instrumentation will require a mass airflow sensor, mass air density sensor, turbine crank sensor, and an output current sensor. Additional sensors can be incorporated for more accurate measurements.
- *Electrical*
  A central processing and control unit will collect all of the information from the sensors and determine system health and efficiency. Power will only need to be provided to said unit while it is processing or storing information, meaning that it is possible to power the electrical components with power generated exclusively onboard. A low capacity/high endurance battery can be used to ensure guaranteed data collection and storage.

Top-Level Block Diagram



Turbine: Transfers mechanical energy from wind to the shaft

Generator: Converts mechanical energy from shaft into electricity

Regulator: Stabilizes the voltage of generated electricity

Converter: Converts AC voltage into DC voltage

Battery: Stores power generated and powers electric components

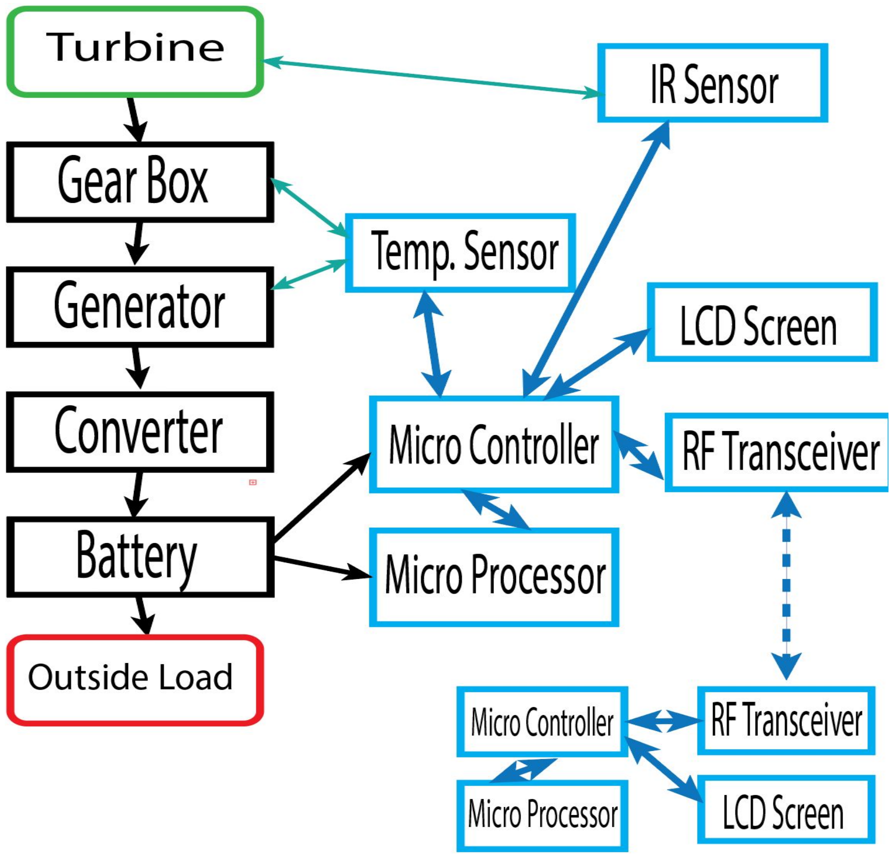
Microprocessor: Collects sensor and transceiver information, turns info into usable data

Sensors: Monitor turbine speed and component temperature

RF Transceiver: Transmits and receives data

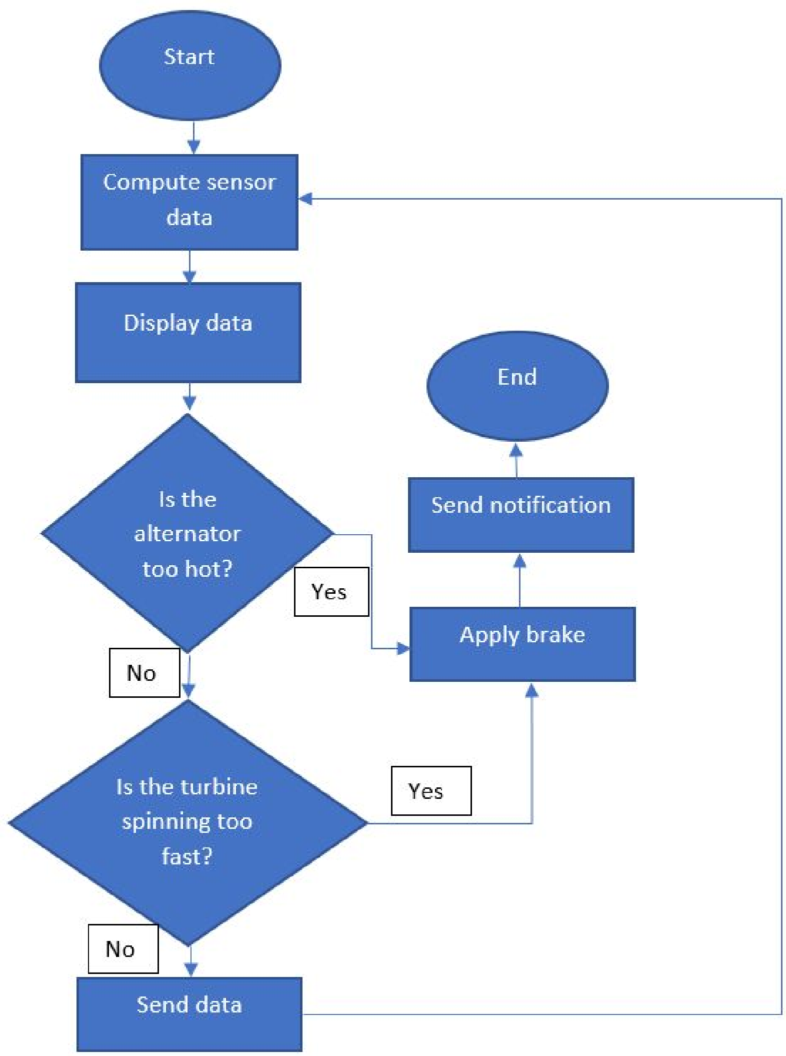
LCD Screen: Displays pertinent data

Second-Level Block Diagram



Software

Flowchart:

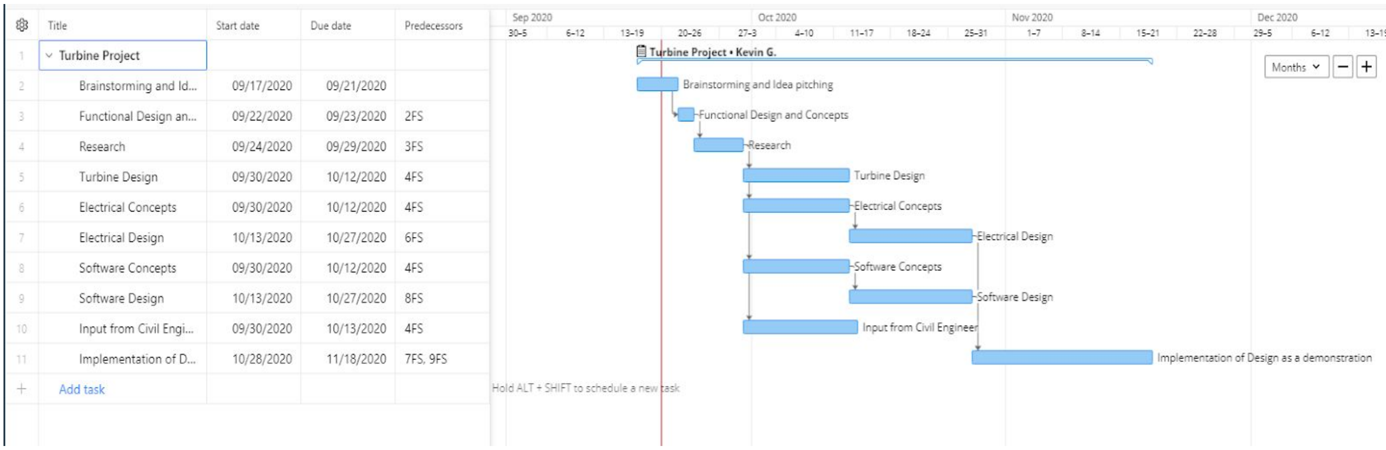


Language: Python

Platform: Raspberry Pi OS

Project Plan

Gantt Chart



	Title	Start date	Due date	Predecessors
1	Turbine Project			
2	Brainstorming and Id...	09/17/2020	09/21/2020	
3	Functional Design an...	09/22/2020	09/23/2020	2FS
4	Research	09/24/2020	09/29/2020	3FS
5	Turbine Design	09/30/2020	10/12/2020	4FS
6	Electrical Concepts	09/30/2020	10/12/2020	4FS
7	Electrical Design	10/13/2020	10/27/2020	6FS
8	Software Concepts	09/30/2020	10/12/2020	4FS
9	Software Design	10/13/2020	10/27/2020	8FS
10	Input from Civil Engi...	09/30/2020	10/13/2020	4FS
11	Implementation of D...	10/28/2020	11/18/2020	7FS, 9FS
+	Add task			

Work Breakdown Structure

Turbine Design, Electrical Design and Software Design will be done in parallel with each other taking the considerations of each of the member's strengths and weaknesses. Kevin will work on the software side, Shawn will work on the Electrical side, August will work on the Turbine Design and Jarrett will work on the Turbine Design

Four Hardware/Software Deliverables

Because this product has both hardware and software requirements, they need to be worked with the other discipline in mind

- Design of the Turbine and overall structure will need to be conceptualized and worked on with the guidance of a civil engineer
- Design of the electrical system will need to be created and tested to ensure that all components are functioning properly and to specifications
- Software Programming will be needed to determine if the product is continuing to function outside of the build parameters
- Model of the system will be used to demonstrate the overall effectiveness of the product

Possible Problems

Some of the challenges we will face are going to be in implementing our ideas into a compact and clean design. Some precautions and steps we can take to mediate these issues are to have a sense of hardware specs (size, power requirements, fragility, etc) and mechanical/ overall design. The design of our electrical system is also an area that can cause problems, we need to make sure that we can regulate the voltage generated, with a reliable and consistent output so that we do not burn out and destroy other components during use. We also would like to have the data collected from the turbine to be transmitted and displayed at another location.The main issue we see with accomplishing this is having a way to connect the data collected to an app or other remote end-device. Finally the last challenge we see moving forward is power consumption, while our design does allow for all components to be powered by internal battery, we need to make sure that our consumption is low enough that we will not lose power in between the peaks of our power generation. Assuming that rush hour traffic will provide us without peaks in power our consumption should be low enough to last us 12-16 hours approximately.

Expected and Worst-Case Costs

Expected:

Base/Mount: $20
Turbine/Shaft: $30
Gearing: $15
Generator: $50
Sensors: $50
Electrical: $35
Microprocessor: $50
Converter: $50

Total: $300

Worst-Case:

Base/Mount: $30
Turbine/Shaft: $50
Gearing: $35
Generator: $75
Sensors: $75
Electrical: $75
Microprocessor: $80
Converter: $150

Total: $570

Appendices

Definitions and Acronyms

Converter: A device that converts direct current into alternating current and vice-versa.
Gearbox: A train of gears used to change rotational speed or torque.
Generator: A device that converts mechanical energy into electrical potential.
Infrared Sensor: (IR sensor) A device that measures infrared light within its field of view.
Micocontroller: An integrated circuit that performs a specific function in an embedded system.
Microprocessor: An integrated circuit that performs all CPU functions.
Radio Frequency Transceiver: (RF Transceiver) a device that contains both a transmitter and receiver for communication using radio waves.
Rotor: A rotating assembly that drives the generator.
Turbine: A rotary engine that extracts energy from fluid flow.
Voltage Regulator: A device that takes a variable voltage and outputs a constant voltage.

Parts List

- Infrared sensor
- Temperature sensor
- RF transmitter/ receiver (2)
- LCD Display (2)
- Microprocessor (2)
- Generator
- Full - bridge rectifier
- Voltage regulator
- Gearbox
- Rotary Blades
- Rotor
- Brake Assembly
- Turbine Frame