1/9/2017

LITERATURE REVIEW

Environmental Science

Chava, Manjusha

MASSACHUSETTS ACADEMY OF MATH AND SCIENCE

TABLE OF CONTENTS

INTRODUCTION

Global warming is the biggest problem facing the Earth. In the U.S alone, 1,545 million metric tons of CO_2 are produced yearly (EIA, 2016). CO_2 is a threat to our world because it impacts not only wildlife, but humans as well. Many diseases and deaths spawn from excess amounts of CO_2 (Jones, 2000). Motor vehicles such as cars, trucks, planes, etc. are the biggest contributors to CO_2 pollution (Scheer, 2016). However, there is technology available to reduce the carbon footprint generated by these modes of transportation. Electric vehicles are considered to be one of the most eco-friendly methods of transportation in the realm of automobiles. One reason why reason electric cars are superior to gasoline cars environmentally is because electric vehicles convert 80% of the energy from the battery into power used by the car, whereas standard gasoline vehicles convert only 14-26% of the energy from the battery. (Matulka, 2012). The efficiency of a car significantly impacts the amount of CO_2 being produced every year. Another reason electric cars are better is because they do not produce any tailpipe products, including gases such as CO_2, and therefore reduces the overall emission of pollutants (Matulka, 2012). As the demand for electric cars grows rapidly, the need for associated technology also rises. One aspect of electric cars that is frequently ignored when calculating CO_2 emission is the amount of CO_2 produced to charge the car battery . The production of electricity requires power stations to extract and use non-renewable resources. The burning of these fossil fuels are detrimental to the sustainability of life on Earth (McLaren, 2016).

PURPOSE

Electric vehicles are being modernized and sold quickly. Electric vehicle chargers must also be developed to produce the necessary amount of electricity needed for electric vehicles. Chargers also need to provide accessible and fast charge for electric cars in urban areas. Many cities lack available space, so installing electric vehicle charging stations would require more space than available. By integrating a parking meter into these charging stations, cities can save space because of its slim and a dual purpose design. Parking meters are designed to take minimal amounts of space on sidewalks. The combination of charging stations and parking meters will ensure that the least amount of space will be taken up. Electric vehicle users in urban areas would have easy access to these charging stations if they were placed in parking areas. The combination of an electric vehicle charger and parking meter is not an idea that is new to the market. There are no major faults with these types of electric chargers because of their ingenuity in combining two things to minimize the usage of space. However, these unique parking meters are hard to implement everywhere due to both the lack of electric vehicle users and the costs of charging.

RENEWABLE RESOURCES

SOLAR ENERGY

Solar energy is the largest source of renewable energy in the United States (Reece, 2016). This form of energy is created by using photovoltaic, commonly known as solar cells to convert photons produced from the rays of the sun to electricity (Knier, 2008). These cells use the photons to knock electrons in atoms out of their place, thereby aiding in the flow of electricity (Dhar, 2013). Interest in solar energy began in the 1870's, when professor William Grylls Adams and his student Richard Day discovered that the element selenium could convert light into electricity. This finding was the stepping stone for the future innovations of solar cells. Years later, photovoltaic cells, such as the one depicted in Figure 1, were manufactured using the element silicon because of its high efficiency in converting photons to electricity compared to selenium. Silicon was able to produce enough electricity to support low electrical input devices. Solar panels now also consist of silicon solar cells. However, the efficiency rating has skyrocketed since the preliminary creation of silicon solar cells (Reece, 2016).

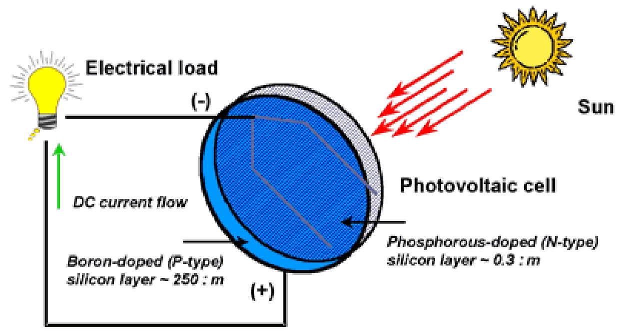


Figure 1. This is a diagram depicting the process of production of electricity through the sun in a photovoltaic cell. The photons from the sun knock electrons out of their place. Electricity is then produced by the moving of electrons to fill the space the photons create. (Wifi Notes, 2015)

The types of solar panels vary based on the use of silicon. Monocrystalline, polycrystalline, and thin film are the three different types of solar panels. Monocrystalline solar panels, seen in Figure 2, are formed by using a single silicon crystalline structures. These structures are formed by placing a seed crystal into molten silicon and slowly extracting the crystal to form a large tube, as shown in Figure 3. This tube is cut into small wafers around the seed crystal. Because the wafers have to be circular, a lot of silicon wasted to perfect the shape (Sendy, 2016).

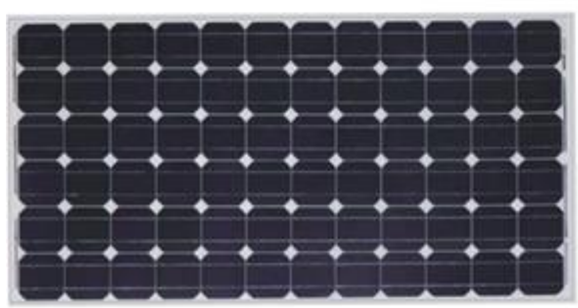


Figure 2. This is an image of a monocrystalline panel. These types of panels have rounded wafers. (Global Supplier, 2011)

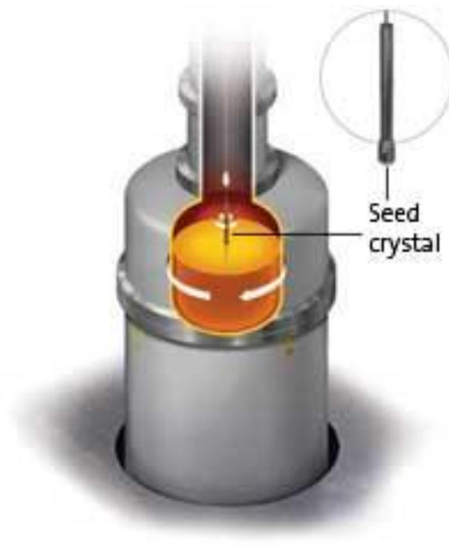


Figure 3. This image depicts the process by which the solar panels are formed, starting with the preliminary steps. A seed crystal is slowly lowered into molten silicon. Once it is dipped, the extraction process begins. (Solar World, 2016)

Polycrystalline panels, seen in Figure 4, are produced using the same method as monocrystalline panels. However, instead of extracting the tube from the molten silicon, the silicon rocks are placed in a mold to be melted and cooled because there is no need to alter the shapes of the wafers in the manufacturing of polycrystalline panels, which significantly reduces silicon waste. (Sendy, 2016)

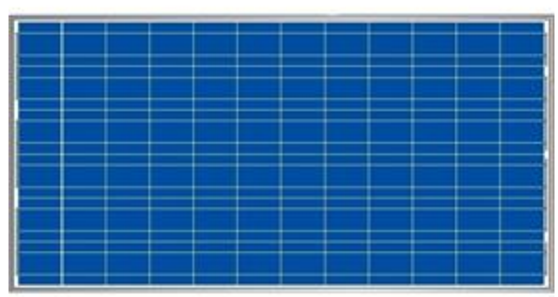


Figure 4. This is a picture of a polycrystalline panel. Unlike the structure of monocrystalline panels, the wafers in polycrystalline models are not rounded.(Savana Solar, 2013)

Thin film solar panels, seen in Figure 5, are manufactured by placing any material that can produce electricity using the rays of the sun onto a sheet of glass. The materials used in thin film solar panels include silicon, cadmium telluride (CdTe), and copper indium gallium selenide (CGIS). There are advantages and disadvantages to each type of solar panel. (Sendy, 2016)

Figure 5. This is an image of a thin film solar panel. The materials are cooled and placed onto a sheet of glass, which makes the panel flexible and easily mass producible. (Conrad, 2016)

The strengths of monocrystalline panels include having the highest efficiency ratings in converting sun rays to electricity, high space efficiency, a long duration of functionality, and high performance in lower temperatures compared to other types of panels. The only disadvantage to monocrystalline solar panels is that they are the most expensive to produce. The advantages to polycrystalline panels are that they are not very expensive, produce less heat, and have a lower wastage of silicon when compared to the other models of solar panels. The disadvantages of polycrystalline panels include having a lower space efficiency and having a lower efficiency of electricity production rates compared to monocrystalline panels. Thin film solar panels are widely used for producing small amounts of electricity. This type of solar panel is flexible, can be mass produced, and produces the same amounts of electricity consistently without being affected by temperature or shade. The drawbacks to thin film panels include low space efficiency, which means they take more space than electricity given out. Thin film panels also have a low efficiency of electricity, therefore these panels are not used for large scale electricity production. They also have a much shorter lifetime compared to other types of solar panels. Overall, monocrystalline solar panels are more efficient and produce more electricity than polycrystalline or thin film solar panels. (Sendy, 2016)

Solar energy is important in the fight against climate change primarily because it produces clean electricity. The production of solar energy suggests that the electricity created does not produce greenhouse gasses such as CO_2 compared to non-renewable resources. The increased usage of renewable resources such as solar energy will decrease American dependency of non-renewable resources such as fossil fuels. (Energy, 2016)

WIND ENERGY

Wind energy is another type of renewable resource that is expanding in popularity throughout the United States (WEF, 2016). The energy from wind is converted into mechanical energy, which is then converted into electricity. The use of wind power dates as far back as 5,000 B.C. People used the wind to propel their ships along the Nile River (WEF, 2016). Later on, many more civilizations began creating different wind catching mechanisms to power many of their necessities (WEF, 2016). These wind catching mechanisms were later called wind turbines. The primary function of wind turbines is to be able to rotate by catching the wind. The kinetic energy from the wind causes the blades of the turbine to turn. These blades connect to a gear box, which directly spins the generator. The gear box converts the mechanical energy into electrical energy (Ecosources, 2016). Figure 6 clearly shows each part of the wind turbine for reference.

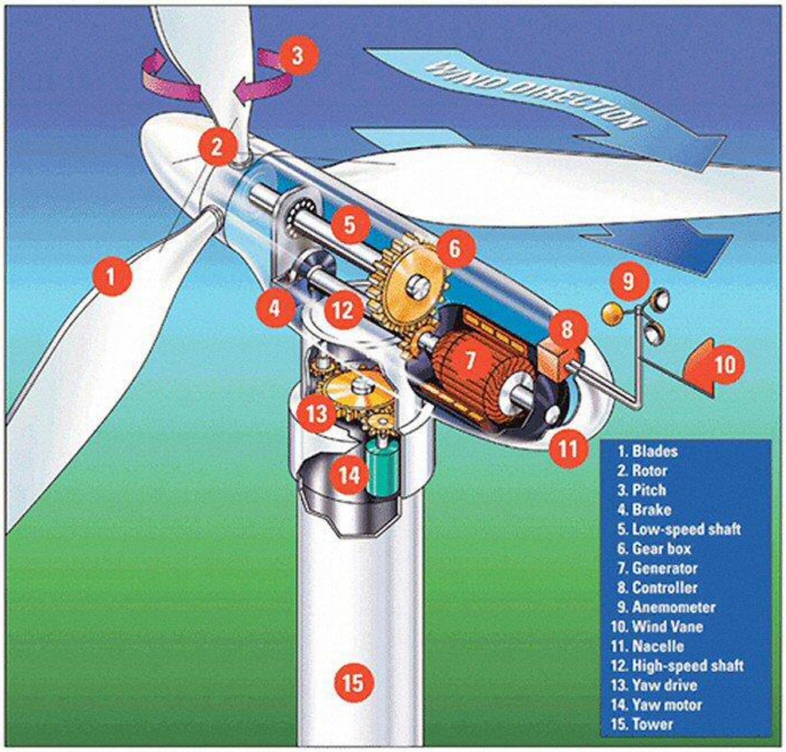
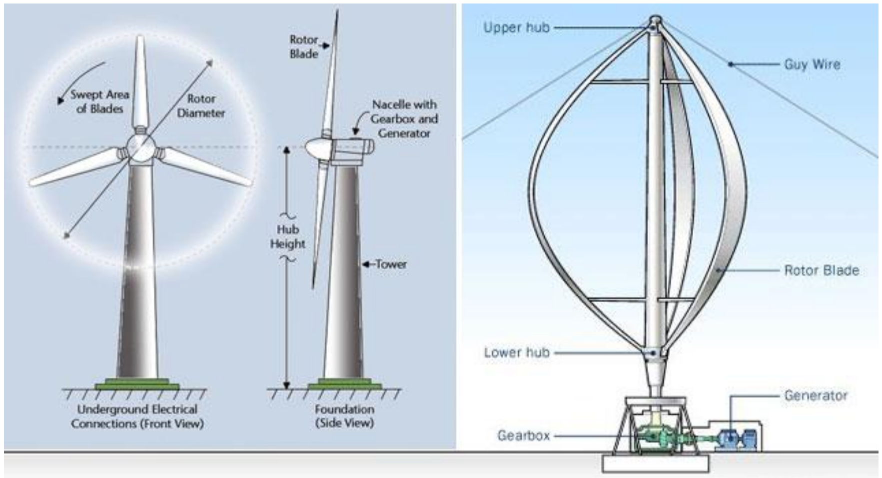


Figure 6. This image labels the key components of a wind turbine, specifically horizontal axis wind turbines. (Wind EA, n.d.)

There are two different classes of wind turbines that are grouped based on the blades of the turbine: vertical axis wind turbines (VAWT) and horizontal axis wind turbines (HAWT). Figure 7 shows how the blades in VAWTs rotate perpendicular to the ground whereas the blades in HAWT rotate parallel to the ground. VAWTs have the same function of HAWT but use a completely different design. Because the blades are vertically placed in VAWTs, they are omni-directional, which means that they able to produce electricity from winds coming in any angle. (Lewandoski, 2016)

A.



B.

Figure 7. This image compares (A.) horizontal axis wind turbines (HAWT) to (B.) vertical axis wind turbines (VAWT). (English Eco Energy, 2013)

VAWTs are used widely for small scale projects and can also perform well in turbulent wind speeds because they are lightweight and can evenly distribute the force of the winds throughout all blades. In contrast, the blades of the HAWTs are designed around a horizontal axis, which limits the amount of wind the blades are able to catch. An advantage of HAWTs is that they are able to produce more electricity because the blades can produce higher torque, or rotational movement than VAWTs. HAWTs are used significantly in supplying large amounts of electricity for residential or commercial uses. (Smith, 2007)

Though all wind turbines are characterized into two classes, there are many subclasses. Inside the VAWT class exists the subclasses Savonius and Darrieus wind turbines. Savonius wind turbines, as depicted in Figure 8, are high torque machines that rotate around a shaft. Because of the curved scoops, Savonius wind turbines do not experience much air resistance and instead move with the wind at high speeds. Savonius turbines are very useful because they can be used in low altitudes with low wind speeds and yet produce large quantities of electricity. (Smith, 2007)

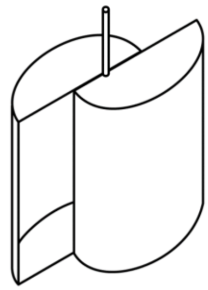


Figure 8. This image shows the structure of a Savonius wind turbine, which is a subclass of VAWTs. (Wikipedia, 2013)

Darrieus wind turbines are characterized by their thin yet aerodynamic rotational blades. They can generate high rotational wind speeds and withstand wind speeds up to 220 km/h (136.71 mph). Darrieus turbines have generators and motors placed at the bottom of the turbine for stability. The disadvantage to placing large generators and motors near the ground is the heavy frictional movement, which makes it hard for the blades of the turbines to begin rotating. There are three different types of Darrieus wind turbines as shown in Figure 9: Darrieus, Darrieus H, and Hélicoïdale. These extensions of Darrieus wind turbines are characterized by the shape of their blades. Darrieus turbines have oval like blades that curve outward, whereas Darrieus H has “H” shaped blades and Hélicoïdale has a helix like arrangement. (Smith, 2007)

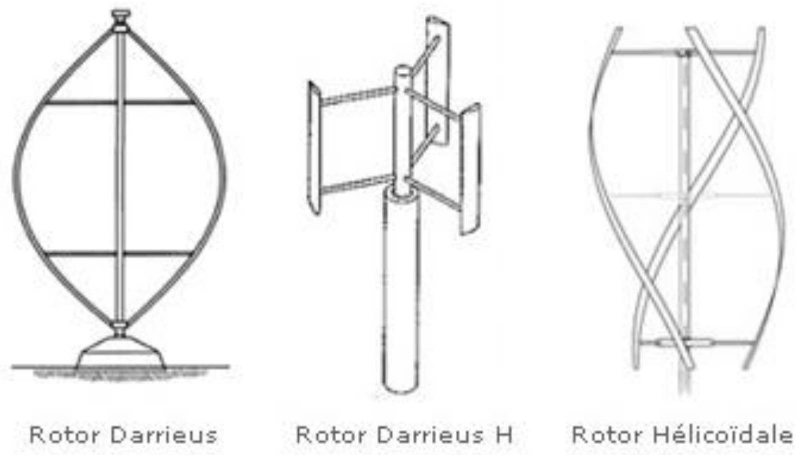


Figure 9. This image shows the different types of Darrieus wind turbines, all of which are types of VAWT. (Ecosources, n.d.)

Some disadvantages to the Darrieus wind turbines are that they have a low efficiency rating and it takes a longer time to rotate the blades compared to Savonius wind turbines. These drawbacks are primarily due to the heavy friction caused by placing the motor and generator at the base of the turbines. (Ecosources, 2016)

The most important advantage of wind energy is that it is sustainable and renewable as long as there is never a shortage of wind. Another benefit to wind energy is that it is "one of the lowest-priced renewable energy" resource, which means it can be applied all over the country. The most important advantage of wind energy is that it can be implemented onto farms and ranches by simply placing wind turbines on existing fields. There is no need to allocate separate land space specifically for wind farms. Although the benefits of wind energy are enticing, there are a few disadvantages to wind power, including damages to wildlife. For example, birds might fly into the blades of the turbines. Another downside to wind energy is that wind farms need large areas of land that are far from cities. This necessity poses to be a problem because this land can be used for other purposes. These shortcomings can be over looked according to wind energy companies and producers because of the various advantages compared to disadvantages. (Energy, 2016)

The importance of wind energy is crucial to replacing the use of fossil fuels or other non-renewable resources. Just like solar energy, wind energy is clean energy that produces large amounts of electricity with little to no emission of greenhouse gasses.

ELECTRIC VEHICLE CHARGER

Some electric vehicles can run about 40 miles before running out of charge. The batteries of electric vehicles can be charged in less than 12 hours depending on the type of electric vehicle charger. The different categories of electric vehicle chargers include Level 1, Level 2 and DC Quick Charger (DCQC). Level 1 chargers, as depicted in Figure 10, provide about 120 volts (V) of electricity or about 1.6 kW (kilo-Watts) and are used primarily in households. This type of charger is used over long periods of time, from roughly eight to twelve hours. Level 1 chargers are a necessity to have for an electric vehicle to charge in a household, but is not convenient if the vehicle is being used for more than 40 miles every day. These chargers are predominantly used in residential settings due to its usage overnight. (EV Town, 2015)

Figure 10. This is a picture of a Level 1 charger. It has no battery and consumes electricity from an outlet. (Volusion, 2016)

Level 2 chargers, depicted in Figure 11, can supply 240 V or up to 19.6 kW (Saxton, 2011). It is ideal to use a Level 2 charger due to low costs of the charger itself and the reasonably short time it takes to charge an electric vehicle battery (Saxton, 2011). These chargers can refill a depleted battery in about four to six hours. The cost of Level 2 chargers starts at a price of $2,000 (EV Town, 2015). Another reason to use a Level 2 charger is because it can be installed and used in both households and in charging stations. These chargers are normally found in public parking areas, residences, and commercial settings (EV Town, 2015).

Figure 11. This is an image of a Level 2 charger. This charger differs from Level 1 charger because it has its own battery, which stores electricity and can output at a faster rate. (Clean Technica, 2013)

In contrast to Level 1 and Level 2 chargers, DCQCs boast the highest electricity output and can supply 50 – 120 kW. The amount of time it takes to completely charge for a battery is approximately 10 – 20 minutes. The major difference other than electrical output between the DCQC and the Level 1 and 2 chargers is cost because DCQCs can cost up to $100,000 and are economically inefficient in comparison to the other chargers. Due to the expense of a DCQC, these chargers are found only in commercial areas or public parking regions. (EV Town, 2015)

Figure 12. Pictured is a DC Quick Charger. These are mainly used commercially due to the amount of electricity required. (BMWi Charging, 2015)

PARKING METERS

Parking meters are devices used to collect money for the right to park a vehicle in a certain area for a limited time. Meters are installed by municipalities to regulate parking areas, enforce on-street parking policies, and generate revenue. Parking meters, such as the one shown in Figure 10, were first patented in 1928 by Roger W. Babson and revolutionized by Gerald A. Hale and Holger George Thuesen in 1935. Since then, the parking meter has become a widely used apparatus throughout the world. The original parking meters only collected coins and consisted of a mechanism which indicated the time before expiration (Hearst Magazines, 1935). Today, users can pay at many parking meters using credit cards or through a mobile device. Currently, most modern parking meters are multi-space meters, which controls multiple parking spaces. Multi-space meters are capable of including many advanced features, including a touch-screen interface and the ability to detect the presence of a car. The newest addition to parking meters include using solar power instead of electrically wiring the meter to the grid. Parking meters, however, are quite vulnerable to conditions such as burglary or vandalism. Meters that have not been modernized are more prone to burglary and vandalism than the meters that have been restructured. Due to the latest technology incorporated into these meters such as preliminary detection of vehicles, security of information, and access to mobile devices, parking meters are more safe and reliable than ever (Boston Gov, 2016).

Figure 10. Shown here is a parking meter similar to the ones used in the early 1900's. It is capable of time-keeping and coin collection. (Plains Humanities, 2011)

Figure 11. Meters such as the one depicted are now commonly used due to technological advancements and security. This particular meter uses an attached solar panel attached as its source of electricity. (Burdette, 2010)

ENGINEERING PLAN

ENGINEERING PROBLEM

Billions of tons of CO_2 are emitted by power plants every year due to the input of electricity into electric car charging stations, including ones placed at parking meters.

ENGINEERING GOAL

The goal of this project is to engineer a level 2 electric car charging station paired with a parking meter that runs completely on renewable energy so that it is both Eco-friendly and easy to install.

GENERAL PROCEDURE

The first steps for beginning this project include researching statistics and other necessary 23information about vertical wind turbines, their corresponding batteries, and electric vehicles (EV) chargers. Data regarding wind speeds will come from existing wind maps on cities in Massachusetts, specifically Boston. Vertical wind turbines require more than 9 m/s wind speed in order to function and produce copious amounts of electricity. The data obtained from wind maps will decide which wind turbine to utilize.

Once background information is gathered, a prototype will be constructed using materials such as a vertical wind turbine, a rechargeable battery which will store more than 3.6 V of electricity, and wiring to convert the electricity produced by the wind turbine into chemical energy and will be stored in the battery. Other materials include a voltmeter or a battery tester to test how much electricity is passing through. The prototype will be of a miniature car being charged by a small battery. This battery will be charged to near full capacity through the rotational movement of the wind turbine. Another component of this prototype is the parking meter. The wind turbine will not only have to provide enough electricity to charge the EV charger battery, but also has to keep a parking meter functioning constantly. The parking meter will be a small time-keeping device which will either be built or bought.

The prototype will be tested to determine the amount of time it takes to charge the battery used from 0 – 100% charge using only a wind turbine with both constant and inconsistent wind speeds. Once the data is collected, it will be analyzed by comparing it to EV batteries and scaling the data by a factor of how much larger the battery capacity is. Once the data is completely analyzed, a report will be produced summarizing the results.

RISK AND SAFETY

The potential risks of my project are any dangers caused by electricity. The use of electricity can cause many hazards and injuries. For example, skin could burn following contact with low voltage electricity. Ways to prevent contact between electricity and the body include the following: wearing gloves, wearing safety glasses, and making sure not to work with wet hands or wet materials. Hazards due to electricity include fires, chemical leaks, and sparks to name a few. Ways to reduce these risks include keeping a first aid kit at all times, working in a fully ventilated area, and having a fire extinguisher and chemical waste buckets available as well as never working without an adult, especially informed.

DATA ANALYSIS

The data collected will be analyzed by scaling and comparing them to standard electric vehicle chargers to determine whether the data accurately addresses my engineering statement.

DISCUSSION OF RESULTS AND CONCLUSIONS

The primary result that can be recorded from this project is whether a renewable energy powered EV charger can indeed function as a level 2 charger. This project will also measure the amount of electricity that will be produced by the charger and how much time it will take to do so. The amount of time will be limited first to test the electricity. The second test would limit the amount of electricity to measure the time.

REFERENCES

Advantages and challenges of wind energy | department of energy. (2016). Retrieved from http://energy.gov/eere/wind/advantages-and-challenges-wind-energy

Darrieus vertical axis wind turbine - ecosources. (2016). Retrieved from http://www.ecosources.info/en/topics/Darrieus_vertical_axis_wind_turbine

Environmental impact of solar energy. (2016). Retrieved from http://turbinegenerator.org/solar/environmental-impact-solar-power/

EV Town. (2015). Levels of charging. Retrieved from http://www.evtown.org/about-ev-town/ev-charging/charging-levels.html

How do parking meters' work? (2016). Retrieved from https://www.boston.gov/departments/parking-clerk/how-do-parking-meters-work

How much energy does A solar panel system produce? | SolarCity. (2016). Retrieved from http://www.solarcity.com/residential/solar-energy-faqs/solar-energy-production

Jane Lewandoski. (2016). Physics Retrieved from http://esearch.sc4.edu/physics

Jones, C. D., Totterdell, I. J., Betts, R. A., Cox, P. M., & Spall, S. A. (2000). Acceleration of global warming due to carbon-cycle feedbacks in a coupled climate model. Nature, 408(6809), 184-187. doi:10.1038/35041539

Knier, G. (2008). How do photovoltaics work? | science mission directorate. Retrieved from https://science.nasa.gov/science-news/science-at-nasa/2002/solarcells

22, Lyndsey Gilpin | October, & Pst, 4. A.The challenges of EV charging: 10 things to know. Retrieved from http://www.techrepublic.com/article/the-challenges-of-ev-charging-10-things-to-know/

Magazines, H. (1935). Popular mechanics Hearst Magazines.

Matulka, R. (2012). Top 10 things you didn't know about electric vehicles. Retrieved from http://www.energy.gov/articles/top-10-things-you-didn-t-know-about-electric-vehicles

McLaren, J., Miller, J., O'Shaughnessy, E., Wood, E., & Shapiro, E. (2016). CO2 emissions associated with electric vehicle charging: The impact of electricity generation mix, charging infrastructure availability and vehicle type. The Electricity Journal, 29(5), 72-88. doi:10.1016/j.tej.2016.06.005

NFPA - certified electrical safety compliance professional. (2016). Retrieved from http://www.nfpa.org/training-and-events/by-type/certifications/certified-electrical-safety-compliance-professional

Reese, W. (2016). The history of solar power. Retrieved from https://www.experience.com/alumnus/article?channel_id=energy_utilities&source_page=additional_articles&article_id=article_1130427780670

S.S Thipse. (2015). Compressed-air car

Saxton, T. (2011). Understanding electric vehicle charging. Retrieved from https://pluginamerica.org/understanding-electric-vehicle-charging/

Sayigh, A. A. M. (1979). Solar energy application in buildings. US: Academic Press. Retrieved from http://lib.myilibrary.com?ID=486748

Sendy, A. (2016). Pros and cons of monocrystalline v's polycrystalline solar panels. Retrieved from http://www.solarreviews.com/solar-energy/pros-and-cons-of-monocrystalline-vs-polycrystalline-solar-panels/

Smith, M. What are the most dangerous threats to air quality? Retrieved from https://www.scientificamerican.com/article/what-are-the-most-dangerous-threats-to-air-quality/

Wind Energy Foundation. (2016). Wind energy foundation | history of wind energy. Retrieved from http://windenergyfoundation.org/about-wind-energy/history/

SOURCES USED FOR IMAGES

[BMW charging station DC Fast Charger]. (2015). Retrieved December 4, 2016, from http://www.bmwi-charging.com/sites/default/files/Straight On Stand Mount_0.jpg

[Formation of Solar Panel Using Seed Crystal]. (2016). Retrieved December 4, 2016, from https://www.solarworld-usa.com/~/media/www/images/solar-101/melting.jpg?la=en

[Level 1 Charger]. (2016). Retrieved December 4, 2016, from http://cdn3.volusion.com/shnft.ndlpf/v/vspfiles/photos/dostarL1-2.jpg?1477045662

[Vertical vs. Horizontal Wind Turbine Diagram]. (2013). Retrieved December 4, 2016, from http://www.englishecoenergy.com/wind-power-horizontal_vertical.jpg

Burdette, D. (2010, May 20). Multi-space parking meter [Digital image]. Retrieved December 4, 2016, from https://upload.wikimedia.org/wikipedia/commons/0/0a/Multi-space_parking_meter.JPG

Different Darrieus rotor [Digital image]. (n.d.). Retrieved December 4, 2016, from http://www.ecosources.info/images/energie_batiment/eolien_vertical_darrieus.png

J. (2013, January 27). [Schematic drawing of a two-scoop Savonius turbine]. Retrieved December 4, 2016, from https://upload.wikimedia.org/wikipedia/commons/thumb/a/ac/Savonius_turbine.svg/2000px-Savonius_turbine.svg.png

Monocrystalline Solar Panel [Digital image]. (2011). Retrieved December 4, 2016, from http://hardware.global-supplier.com/attachment/view/6057.jpg

N., & D. (n.d.). Wind Turbine Diagram [Digital image]. Retrieved December 4, 2016, from http://www.wwindea.org/technology/ch01/imgs/1_2_img1.jpg

Photovoltaic Cell [Digital image]. (2015, March 25). Retrieved December 4, 2016, from http://wifinotes.com/energy1/images/how-pv-solar-cell-works.gif

Poly Solar Panel [Digital image]. (2013). Retrieved December 4, 2016, from http://www.savanasolar.com/media/catalog/product/cache/1/image/600x600/9df78eab33525d08d6e5fb8d27136e95/2/3/23_12.jpg

Power Max 16A / 12’ cord entry level model [Digital image]. (2013, May 9). Retrieved December 4, 2016, from https://cleantechnica.com/files/2013/05/level-2-electric-car-charger.png

Thin Film Solar Panels [Digital image]. (2016). Retrieved December 4, 2016, from http://www.conrad.com/medias/global/ce/1000_1999/1100/1100/1107/110719_RB_00_FB.EPS_1000.jpg

World's first installed parking meter [Digital image]. (2011). Retrieved December 4, 2016, from http://plainshumanities.unl.edu/encyclopedia/figures/800/egp.tra.023.jpg