E-Bike Conversion Kit
Project Proposal

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Introduction

In the world currently, there is an ever-growing concern and issue with climate change and increasing carbon emissions. From our reliance on carbon emission vehicles, which is steadily growing to manufacturing and production needs, humanity is ever increasing its' ecological footprint in a time where we are trying to minimize it as much as possible. This increase in carbon emissions has led humanity to consider alternative options for reducing their ecological footprint which has led to developments in areas such as green transportation. Some of these green transportation alternatives include electric vehicles and electric bikes. However, as much as this technology has developed in electric bikes specifically, there is still not a low cost, consumer-friendly product available for conversion kits to transform a regular bicycle into an electric bike (e-bike). Current versions of the conversion kits are far too complicated for the average consumer with little to no technical knowledge to perform the installation. The market is lacking an easy to install and cost-effective alternative for everyday individuals to purchase and operate. Furthermore, for those who buy a brand-new electric bike, there is environmental waste associated with the disposal of their current bicycle, assuming they had a bicycle that they're replacing. The proposed solution to this problem is to create an affordable, user-friendly conversion kit to turn their regular bicycle into an electric bike.

Problem Identification

The engineering problem that our design group will address is in reducing the environmental waste created by the disposal of a bicycle when the consumer purchases a new e-bike along with reducing the difficulty in setup and installation of current electric bike conversion kits. The reduction of this environmental impact will be accomplished by utilizing the current bike that the consumer owns, rather than purchasing a brand-new electric bike that inevitably ends with the disposal of their current bicycle in some way. Furthermore, new electric bikes can cost more than $2000, which is not affordable for most families that are looking to use an electric bike as part of their everyday life. Although other options for e-bike conversion kits do exist, they are not very user-friendly. The existing kits in the market are essentially a bag of parts, with unclear instructions for installation or have descriptions that state "all the buyers should have experience to install it. If not, please do not buy it" [1].

For the semester project in design two, our design group has decided on designing a conversion kit to convert an ordinary pedal bike into an electric bike. This cost-effective and user-friendly solution could provide an opportunity for individuals that are looking to try an e-bike but have never had the chance due to technical knowledge or financial capabilities. If designed and implemented correctly, the use of an e-bike can be an alternative to an automobile due to its eco-friendly design, relatively low cost, and minimum maintenance.

Our group's goal for the conversion kit is to have it be to be installed by anyone, without prior technical knowledge or experience, and that it includes a clear installation instruction manual. The objective of the conversion kit is to be roughly half the cost of e-bikes currently on the market with comparable specifications to make it a desirable product. Currently there are a few major brands that sell e-bikes. Some of the big companies are as follows; Giant Manufacturing Co. Ltd., Specialized Bicycle Components, Inc. and Bosch e-Bike Systems who supply the electrical components to 84 smaller bike manufactures and many more. These companies offer an all in one solution with no option of converting an existing bicycle to an e-bike.

Figure 1- Specialized Turbo Levo Hardtail [2]

The bike pictured above is a Specialized Turbo Levo Hardtail, it is the cheapest option offered from Specialized Bicycle Components, Inc. with a price tag of $3699.00 CAD [2]. The bike comes with a 250w electric motor and a battery capacity of 460Wh, with an estimated range of 40 km - 89 km and a top speed of 32 kph [2]. The Specialized Turbo Levo Hardtail is going to be the benchmark for our project, and we will be designing a product that will be more cost-effective while just as capable as the Turbo Levo Hardtail.

Detailed Solution Proposal

This problem requires an engineering solution because it is engineers that can look at a problem and consider all aspects that are involved in a solution. The elements that will be included in the potential solution for this conversion kit are; structural analysis of the component enclosure and how it will be mounted, the configuration of parts, and testing of the product. Furthermore, the economic viability of the conversion kit should be considered as the main design goal, making it available to a variety of consumers of many technological backgrounds and financial situations. The main target demographic is consumers that frequently use a bike as a method of transportation or users who live in areas where there is a large quantity of carbon emission vehicles and traffic. This will allow prospective buyers to be more inclined to consider this conversion kit to put on a bike that they already own, rather than purchasing a new e-bike, or even convince someone to change their daily mode of transportation as it would be faster than convention motor vehicle transportation.

To complete this project, our group will need to implement and analyze the following aspects of the e-bike conversion kit; an enclosure to hold the control electronics, the motor and batteries, custom mounting equipment to fasten the motor, the enclosure and user controls, and a mechanical drive system.

The general idea for the placement of the parts is to have the majority of them enclosed in a box that sits on a rack above the rear wheel. This will provide a secure enclosure for the parts, and keep them out of sight, giving the e-bike a less bulky and sleek look. The rack will be expected to withstand the weight of the motor and the torque that the motor will produce. The approximate weight of the enclosure and its containments will be around 30-40lbs.

The goal is to secure this rack to the bike in such a way that it does not require any drilling or other modifications to the original bicycle. It will be mounted to two locations on the bike frame, one horizontally just below the seat, and once vertically to the center of the rear axle. We plan to Use inventor/AutoCAD to analyze the different options for mounting, and to stress test the component using the weight of the enclosure and the parts within it. With this information, we can implement an ideal factor of safety into our designs. In the figures below, the proposed idea for the mounting of the rack can be seen.

Figure 3- Example of a rear-wheel rack [3]

Figure 4- Example of a double mounted rear-wheel rack [4]

For the mechanical drive system to be able to take mechanical power from the motor to the wheels, a chain is planned to run through the motor and down to the rear wheel, where an additional chainring will be placed. The mechanical output of the motor differs according to the desired amount of power the user wants the motor to produce. Assuming a flat surface for the pathway, a 250-500w motor is more than capable of accomplishing the job.

The figure below shows a general mockup of where the hardware will be mounted, according to our current ideas.

Figure 2- E-Bike Concept Drawing

Selecting the appropriate electrical components for an e-bike is crucial in designing a well-functioning and user-friendly e-bike. In Nova Scotia, legislation states that the largest capacity of an electric motor for an e-bike can be no more than 500 watts and is incapable of assisting at speeds above 30 km/h on the level ground [5]. Because of this, our design will be using no more than a 500-watt motor to comply with legislation.

When choosing an electric motor and electronic controller, it will be best to select equipment that is compatible with each other. This will minimize the number of issues within the system, which is essential in designing a low maintenance design. The best choice of motor is going to be a brushless DC motor. The brushless DC motor offers many advantages for an e-bike system. The first is that there is no maintenance or brush replacement after thousands of hours of service [6]. The second reason is that there are no fine metal particles and debris because there are no brushes [6]. Lastly, the brushless DC motors have very efficient rotor speed control over a conventional DC motor. They are the ideal solution for a bike that will have varying speeds. More research will need to be conducted to see if it is viable to use a brushless DC motor.

Since this is an electric bike, there will need to be a way to store energy locally on the bike to power the electrical equipment. The best solution for this is the use of batteries. Through some research, there are four common types of battery chemistries, lead-acid, nickel-cadmium (NiCd), nickel-metal hydride (NiMH) and Lithium-Ion Phosphate (Li-ion). When comparing battery technologies, there are numerous amounts of properties to consider, but for the e-bike application, the following properties of each battery chemistry are the most important to consider, energy density, toxicity, life cycle, and maintenance requirement. All this information is tabled below with the specifications coming from [7].

Specifications	Lead-Acid	NiCd	NiMH	Li-Ion
Energy Density (Wh/kg)	30-50	45-80	60-120	90-120
Life Cycle (80% Discharge)	200-300	1000	300-500	1000-2000
Maintenance Requirement	3-6 Months (Topping Charge)	30-60 Days (Discharge)	60-90 Days (Discharge)	Not Required
Toxicity	Very High	Very High	Low	Low

Table 1 - Battery Comparison

After looking at the data from the table above, it is clear to see that with the long-life cycle, high energy density, low maintenance, and low toxicity, the Li-Ion could be a viable choice for the project. Further in-depth research into the four types of batteries will be required before a final decision will be made.

Since this will be an electric bike, the user needs a way of controlling and operating the electrical components. The user controls for the e-bike will be accomplished by using switches/throttle on the handlebars. Please reference figure 2 for our proposed location. This seems like the most natural way for the user to control the e-bike. This will be accomplished by some resistive switch, display, or a combination of the two.

Proving the Solution

After the final assembly of our solution, we plan to test the capability of our product against that of the Turbo Levo Hardtail. This will be done by performing real-world testing. Recording the range and charge times all while proving capability and functionality. Our location to test this will need to be a controlled environment where the ground surface is even to provide consistent results. That's why we plan on inquiring into using the running track around the St. Francis Xavier field, which would be ideal for performance testing.

Engineering Applications:

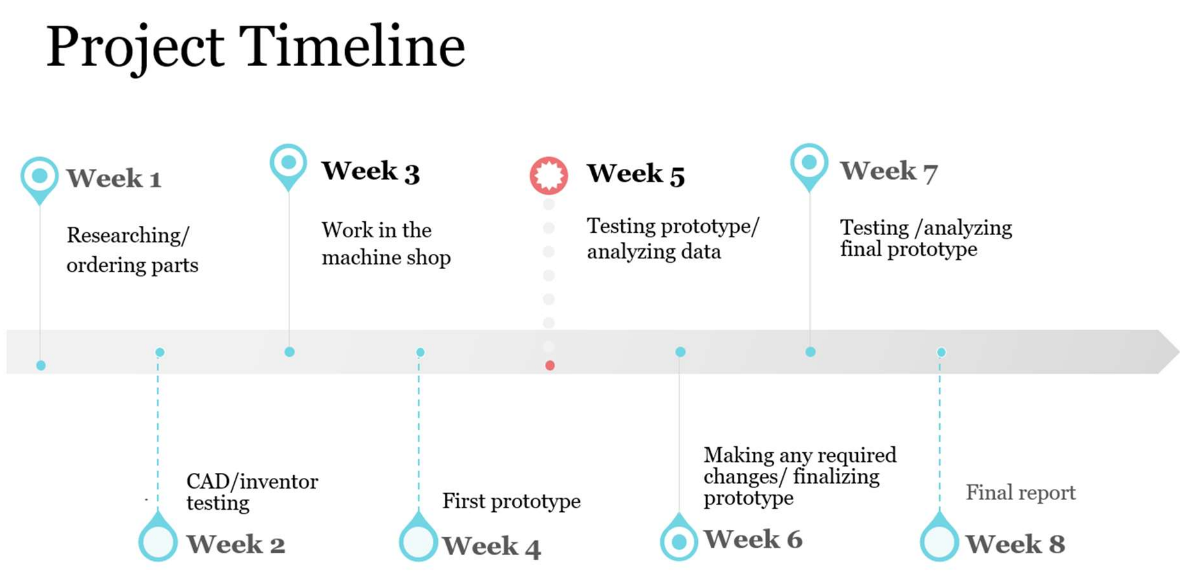
To bring our proposed solution to life, we will need to apply knowledge from many different courses. Statics and Strengths of Materials will aid with the calculations and computer analysis of the mounting system. Circuit analysis will help with the calculations required for battery capacity, charge time, range, and choosing the best option for a motor. Engineering Economics will aid with the budgeting we will have to do, along with deciding on a future price at which we would theoretically sell this product.

Limitations/Assumptions:

The main limitation of the project is the high cost of the parts required, specifically the batteries. That is why our physical prototype will be a scaled-down version of our theoretical design in terms of battery capacity. The assumptions we have while designing and testing our product are that is will be driven on dry, and smooth road conditions.

Timeline

Considering the proposal week of February 3rd, our first official week on the project, the general schedule is as follows. Week one will be dedicated to comparing the cost of parts from different manufacturers, and finally, ordering them. Week two will focus on producing engineering drawings and CAD/inventor testing of our mounting equipment. Week three will consist of work in the machine shop, to create the custom mounting system and the enclosure for the motor and batteries. Week four will be when our group starts to configure the parts onto our bike physically. Week five will consist of testing our prototype, analyzing the results, and comparing them to our benchmark of the Specialized Turbo-Levo Hardtail. Week six will be the time for implementing any necessary modifications to our kit. Finally, week seven and eight will consist of the final testing of our conversion kit, analyzing the data, and producing our final project report.



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