1. PROBLEM STATEMENT

Transportation plays a vital role in the day-to-day life of any person who does not live within walking distance of the places they must go. This is a major dilemma for those people who are constrained by funds or are limited by the type of transportation they can use.

1.1. Need Statement

Electric bikes are a convenient mode of transportation. They allow the user to have a quick vehicle that can maneuver in various environments. E-bikes are also a more environmentally friendly alternative to vehicles like cars and motorcycles. With all of the positive aspects of owning and using an e-bike, there are two major downsides to owning one. The first major problem with modern e-bikes is the cost of them. With pre-assembled bikes averaging around $2,000 - $3000 in price, not every person who would benefit from using an e-bike could afford to get a reliable one [1]. While one could get an electric bike for cheaper, the quality of the product is not guaranteed. Another problem is the complexity of these e-bikes and conversion kits. With the main alternative to buying an electric bike being to convert a manual one, conversion kits are usually cheaper at the cost of simplicity. E-bike conversion kits can have a lot of parts to assemble and require a majority if not complete disassembly of the original bike.

1.2. Objective

The solution proposed is for a more cost-effective and easy-to-assemble e-bike conversion kit. This kit contains minimal parts and only requires the removal of the handlebars and back wheel bolt of almost any bicycle. The kit is a near-universal fit on standard bikes and has the ability to be driven manually and electronically.

1.3. Background and Related Work

The length and content of this section varies, depending upon the project. This section is a summary of the research survey on the relevant technologies and systems. The objective is to provide an introductory answer to the questions.

1.3.1. Overview

In most modern e-bike conversion kits, the conversion is permanent and requires the removal of the pedal system or the rear wheel assembly. In some cases, both of those conditions must be met before attaching the conversion kit. The kit proposed requires less disassembly; thus, the kit is easier to install and maintain. Other conversion kits on the market do not offer hybrid operation. Those kits convert the bicycle to a fully electric bike and do not offer the ability to use the bike once the battery has died. The proposed design allows for there to be manual operation as well as electric operation.

1.3.2. Relevant Technologies

E-bike conversion kits that are hybrid in operation do exist on the market. Problems with these kits can be found in the prices of these kits and their propriety. Some of these hybrid kits are custom-made to fit a very specific type of bicycle. Others are more universal but are often very expensive for their universal design.

2. Design requirement Specifications

The E-Zoom kit presents an affordable and user-friendly solution for those seeking an alternative to e-bikes. The kit seamlessly transforms a regular bicycle into a versatile hybrid bike with minimal effort. Its primary

goal is to cater to budget-conscious customers who desire the quality-of-life improvement that an e-bike offers, without the hefty price tag. E-Zoom ensures a smooth transition to eco-friendly transportation, providing an economical and eco-conscious choice for riders of all levels.

2.1. Requirements

The marketing requirements for E-Zoom are fundamental to its success in the e-bike kit market. These requirements serve as the cornerstone of E-Zoom's development and marketing strategies, ensuring that E-Zoom aligns with the expectations and preferences of its target audience while gaining a competitive edge. They encompass hassle-free assembly, dual operation modes, real-time data access, affordability, a dependable battery, convenient transportation, water-resistant design, and secure attachment.

2.1.1. Marketing Requirements

The marketing requirements for E-Zoom are as follows:

1. E-Zoom has hassle-free assembly, with straightforward instructions.
2. E-Zoom can use both manual and electric modes of operation.
3. E-Zoom provides users with real-time, easily accessible data, including speed and battery life.
4. E-Zoom is a practical and budget-friendly alternative to traditional e-bikes.
5. E-Zoom has a dependable and long-lasting battery.
6. E-Zoom allows quick and convenient transportation.
7. E-Zoom has a waterproof design to shield it against environmental elements.
8. E-Zoom is firmly and securely affixed to the bike.

Figure 2-1 displays E-Zoom's objective tree from the marketing requirements.

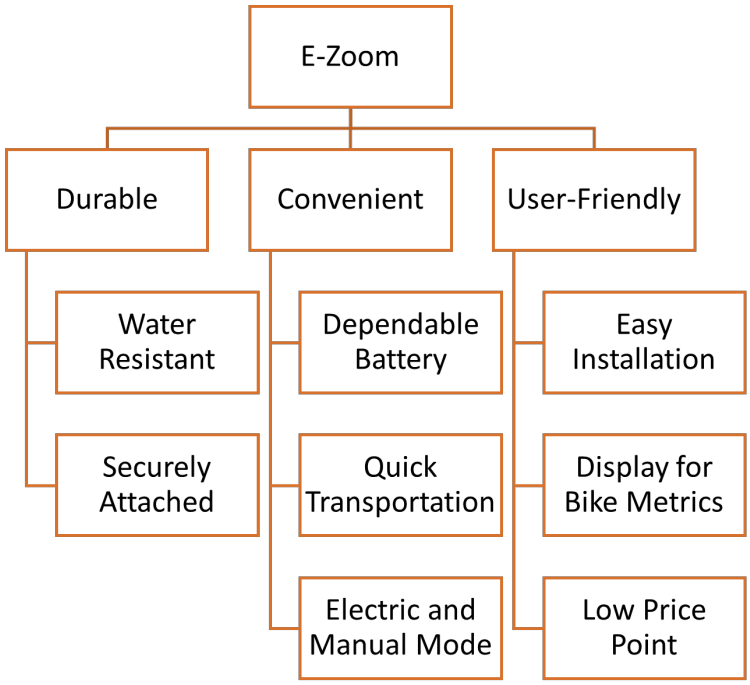

Figure 2-1. Objective Tree for E-Zoom: Hybrid Conversion Kit

By adhering to the marketing requirements outlined in this section, E-Zoom delivers a user-friendly, durable, and budget-friendly conversion kit that gives riders the ability to experience a better commute.

2.1.2. Engineering Requirements

In this section, the engineering requirements for E-Zoom are outlined, and they directly align with the marketing requirements stated previously. These engineering specifications are crucial for translating E-Zoom's vision into a practical and efficient solution. In Table 2-1, a detailed breakdown of the engineering design requirements and their justifications is presented.

Table 2-1: Engineering Design Requirements

Marketing Requirements	Engineering Requirements	Description
3	The kit shows data via the affixed display.	The display allows users to monitor speed and battery life at a glance.
1	The kit has fewer than 6 parts for assembly.	Having fewer parts reduces installation time.
2	The motor turns off, allowing for manual operation due to user input.	With the two separate systems, turning off the motor allows the manual pedals to work freely as usual.
5	The battery lasts 10 – 25 mi.	Competitors' mileage ranges from 20 to 70 miles. A typical bike commute lasts approximately 21.2 minutes [2], at a speed ranging from 11 to 18 mph [3]. So, the average mileage per commute is 3.9 to 6.4 miles. E-Zoom can surpass the average mileage and stay competitive.
6	The kit allows e-bikes to reach speeds of 15 to 20 mph.	Competitors' speeds range from 16 to 36.6 mph, but college campuses often enforce low speed limits. Given that students are a large portion of E-Zoom's target audience and the CPSC's 20 mph speed limit for motor-powered bikes [4], E-Zoom remains competitive and compliant with regulations.
7, 8	The kit has all electronics tightly sealed to prevent exposure in accordance with IPX4-level water resistance.	This requirement is to ensure durability under rainy conditions. IPX4 certification ensures that the enclosure can withstand splashing water without incurring water damage [5].

In summary, the engineering requirements outlined in this section have been chosen to ensure E-Zoom meets its marketing requirements. Adherence to these requirements enables E-Zoom to give its customers a better user experience, easier assembly, multiple modes of operation, a reliable battery, competitive speeds, and ensured durability from the elements.

2.2. Constraints

Certain constraints are put in place to ensure that this product meets the needs of the customer. The constraints of the conversion kit are the cost, reliability, size, safety, and accessibility.

Table 2-2: Constraints

Type	Name	Description
Economic	Cost	The expected retail for this price is $250 based on a parts cost of $200.
Sustainability	Reliability	The system is designed to function well with regular maintenance as a standard bicycle. The battery's high capacity paired with an optimal speed controller setup provides the advertised mileage while maintaining battery health.
Manufacturability	Size	17.7" x 20.1" x 26.8" triangle of space in which the kit will rest.
Health and Safety	Safety	The e-bike is only allowed to operate at 20 mph due to safety restrictions and guidelines.
Social	Accessibility	The kit does not exceed 5 parts for assembly.

The cost constraint ensures that the price of the kit stays competitive. Reliability constraints are to make sure that the product works as intended with no malfunctions. The size constraint is to ensure that the kit can work on some of the smallest standard-sized bikes being manufactured. Safety constraints are to not only abide by federal regulations but also to ensure that transportation at safe speeds is attained. The accessibility constraint is to ensure ease of installation.

2.2.1. Economic Constraints

Economic constraints are essential for the viability of the project in terms of mass production and sales. Components were selected because of both readily available and cost-effectiveness to meet the target retail price of $250. Straying from this price range would render the product uncompetitive in the market.

2.2.2. Environmental

The system's design focuses on reliability and sustainability. The long battery life minimizes waste, and the recyclable materials used in the casing align with environmental best practices.

2.2.3. Manufacturability

The sizing given is the dimensions of the triangular area between the head tube and seat tube of an XS-sized bicycle.

2.2.4. Health and Safety

To ensure the safety of the rider, pedestrians, and other motorists' safety; the kit must only operate at the speed limit of 20 mph.

2.2.5. Social

By limiting the number of parts necessary for the assembly of the conversion kit, the amount of time spent installing the product can be reduced. This also allows for there to be more simplicity in the installation process and less disassembly to install the conversion kit.

2.3. Standards

The standards and practices of this project listed below are for the insurance of the safe operation of the kit.

Table 2-3: Engineering Standards

Specific Standard	Standard Document	Specification / Application
IPX4	IEC standard 60529	Protected against splashing water
ECFR 1512.2	Code of Federal Regulations Title 16	Definition of a bicycle/20 mph speed limit
UL 2722	UL Solutions	Electrical safety of e-mobility devices

These standards are used to ensure that external factors such as water do not hinder the use of the product. There are also standards used to define the product's use and the limitations that must be put on it to ensure safe operation.

2.3.1. Testing Standards

The IPX4 standard is to ensure the use of the kit when water is splashed on it. This includes but is not limited to rain, puddles, sweat, and water bottle splashes. As the kit is not designed to be submerged in water, no further ratings are required.

2.3.2. Safety Standards

The Code of Federal Regulations defines an electric bike as one being powered by a 750 watt or less motor being driven by an operator of 170 pounds up to 20 mph on a level paved surface. Given these regulations, the kit must meet these specific standards to be operated safely and driven legally. UL 2722 is another safety regulation on lithium-ion batteries in personal e-mobility devices. This standard ensures that the battery and electronic components of e-mobility devices are safe and pose no present fire and safety hazards.

2.4. References

[1] "How much does and electric bike cost?," Ride1UP, [Online]. Available: https://ride1up.com/how-much-does-an-electric-bike-cost/, [Accessed: Sep. 26, 2023].

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https://www.census.gov/content/dam/Census/library/publications/2021/acs/acs-48.pdf. [Accessed: Sep. 26, 2023].
[3] Danna, "Quick answer: How fast do average people ride bikes," BikeHike, [Online]. Available: https://bikehike.org/how-fast-do-average-people-ride-bikes/ [Accessed: Sep. 26, 2023].
[4] "Bicycle Requirements Business Guidance," U.S. Consumer Product Safety Commission, [Online]. Available: https://www.cpsc.gov/content/bicycle-requirements-business-guidance. [Accessed: Sep. 29, 2023].
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