Department of Electrical and Computer Engineering
North South University

Senior Design Project

"Smart Electric Cycle (SEC) for Sustainable, Economical and Efficient Transportation in Bangladesh"

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Spring, 2024

LETTER OF TRANSMITTAL

7th June, 2024

To

Dr. Rajesh Palit
Chairman,
Department of Electrical and Computer Engineering
North South University, Dhaka

Subject: **Submission of Capstone Project Report on "Smart Electric Cycle (SEC) for Sustainable, Economical and Efficient Transportation in Bangladesh"**

Dear Sir,

With due respect, we would like to submit our **Capstone Project Report** on **"Smart Electric Cycle (SEC) for Sustainable, Economical and Efficient Transportation in Bangladesh"** as a part of our BSc program. The report deals with electric cycle conversion and many other smart features on it. This project was very much valuable to us as it helped us gain experience from practical fields and apply in real life. We tried to the maximum competence to meet all the dimensions required from this report.

We will be highly obliged if you kindly receive this report and provide your valuable judgment. It would be our immense pleasure if you find this report useful and informative to have an apparent perspective on the issue.

Sincerely Yours,

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Md. Shamsul Islam

ECE Department

North South University, Bangladesh

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Joy Chandr Roy

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APPROVAL

Md. Shamsul Islam (ID# 2021375043), **Joy Chandr Roy (ID# 2012323043)**, **Md. Abid Hasan (ID# 2012851042)**, **Faiaz Ibna Habib (ID# 2012764043)** from Electrical and Computer Engineering Department of North South University, have worked on the Senior Design Project titled "**Smart Electric Cycle (SEC) for Sustainable, Economical and Efficient Transportation in Bangladesh**" under the supervision of Dr. **Mohammad Monirujjaman Khan** partial fulfillment of the requirement for the degree of Bachelors of Science in Engineering and has been accepted as satisfactory.

Supervisor's Signature

……………………………………….

Dr. Mohammad Monirujjaman Khan

Associate Professor

Department of Electrical and Computer Engineering

North South University

Dhaka, Bangladesh.

Chairman's Signature

……………………………………….

Dr. Rajesh Palit

Professor

Department of Electrical and Computer Engineering

North South University

Dhaka, Bangladesh.

DECLARATION

This is to declare that this project is our original work. No part of this work has been submitted elsewhere partially or fully for the award of any other degree or diploma. All project related information will remain confidential and shall not be disclosed without the formal consent of the project supervisor. Relevant previous works presented in this report have been properly acknowledged and cited. The plagiarism policy, as stated by the supervisor, has been maintained.

Students' Names & Signatures

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1. Md. Shamsul Islam

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2. Joy Chandr Roy

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Furthermore, we would like to thank the Department of Electrical and Computer Engineering, North South University, Bangladesh for facilitating the research. We are also thankful to Md. Shamsul Islam, Joy Chandr Roy, Md. Abid Hasan, Faiaz Ibna Habib for helping us in this project. We also like to thank our parents for their countless sacrifices and continual support.

ABSTRACT

“Smart Electric Cycle (SEC) for Sustainable, Economical and Efficient Transportation in Bangladesh”

In Bangladesh, where air pollution and traffic congestion are major problems, this work explores the integration of Smart Electric Cycles (SEC) as an economical, sustainable, and effective mode of transportation.This SEC has the potential to contribute to the E-Cycle field significantly. The SEC's 24V lithium-ion battery improves charging and performance with the help of a 250W gear motor and BMS technology. It explores the technical features like smart connection, electric propulsion, and evaluates the financial and environmental advantages, particularly in terms of lowering carbon emissions and promoting affordable transportation. Moreover, it assesses the economic and environmental benefits associated with SEC adoption, emphasizing its potential to reduce carbon emissions and promote cost-effective mobility solutions. It addresses potential challenges and suggests policy recommendations to facilitate the widespread implementation of SECs, ultimately contributing to a greener and more accessible transportation landscape in Bangladesh. This SEC can be used by people of all ages and backgrounds, and it can be used in various purposes including homes, schools, workplaces, food delivery and many more. With the goal of changing Bangladesh's transportation environment, this work is looked into possible obstacles and suggests to encourage SEC's wider use.

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Chapter 1 Introduction

1.1 Background and Motivation

1.1.1 Background

The Smart Electric Cycle (SEC) in Bangladesh is an innovative solution that combines electricity and smart technology to create a cleaner and more efficient form of transportation. This initiative aligns with national goals for promoting public health, energy conservation, and technological progress. The SEC provides an affordable and accessible route, which can reduce problems such as traffic congestion and air pollution. In a city where cycling has cultural significance, the SEC represents a harmonious union between tradition and modernity, leading to an urban and connected urban environment. This work has the potential to change travel behavior and pave the way for a clean, smart and sustainable tourism landscape in Bangladesh. It not only addresses the current transportation challenges, but also contributes to the economic and environmental sustainability of the country by promoting environmental friendliness and advanced technology.

1.1.2 Motivation

Countries like Bangladesh face serious transportation challenges, including chronic traffic congestion and air pollution caused by gasoline-powered vehicles. These problems lead to increased stress, health problems, and heavy economic burden due to heavy dependence on imported fuel. The Smart Electric Cycle (SEC) appears to be a unique solution to these problems. The SEC provides an efficient and environmentally friendly form of transportation from short to medium term, reducing traffic congestion and reducing polluting emissions, thus improving air quality and public health. The power of SECs and their low operating costs reduce the country's dependence on expensive oil imports, making them a cheap and accessible option for a large number of people. In addition, by integrating smart technologies, SEC works promote innovation, thus aligning with global efforts to combat climate change. Thus, SEC represents a promising and comprehensive solution to address Bangladesh's transport challenges, paving the way for clean, cost-effective and integrated transport.

1.2 Purpose and Goal of the Project

1.2.1 Purpose of the Project

The purpose of this project is to renew the electric cycle industry through the introduction of smart technologies that lead to the safety of cyclists, environmental sustainability and the quality of urban transport. We are aiming to set new standards and new technologies in the field of electric cycles. Our mission is to design and build a cycle system that provides a strong and reliable safety system while minimizing environmental impact through efficient energy recovery methods. With this, we intend to keep our work as an indicator of innovation, attracting the attention of investors and partners. Our aim is to contribute to road safety by protecting users and their bikes, making urban travel more comfortable, efficient and safe. Through continuous product development and commitment to sustainable growth, we will create a long-term presence in the market while meeting customer needs.

1.2.2 Goal of the Project

The goal of the Smart Electric Cycle (SEC) project is to enhance the lives of individuals by introducing a cutting edge electric bicycle that redefines the riding experience. This objective is achieved by creating a comprehensive design with advanced features including with Battery Management System (BMS), 250 W gear motor, 24 V battery and 10 mAh power charging system we build a Smart Electric Cycle (SEC) for a suitable and hassle free journey. The rider's safety is a priority, with the integration of accident detection and warning systems, and environmental support through efficient charging systems. The project goal is to provide user comfort through proper management, real-time monitoring and enhanced security features. Proper acceleration and mileage, powerful motor, low cost maintenance, easy riding facilities, accurate charge, and smooth lithium-ion battery make our SEC different from other E-Cycles.

1.2.3 Novelty

The Smart Electric Cycle (SEC) project stands out for its innovative approach to E-cycle design, offering many features that distinguish it from existing e-bikes. The SEC stands out by integrating a number of advanced features, including proper acceleration and mileage, emergency electric brake system, smooth lithium-ion battery and accurate charge system. These integrated features enhance the driving experience, providing real-time updates and secure riding control. The SEC continues to emphasize sustainability through its efficient energy recovery systems, such as powerful charging, reducing the environmental impact of urban transportation. Adding safety features, such as electrical lock and brake control capabilities, into the service not only improves the safety of the bike, but also increases the confidence of the rider. This comprehensive and innovative system positions SEC as a revolutionary solution in the e-cycle industry, focusing on technological innovation, rider safety, sustainability and quality.

1.3 Organization of the Report

Chapter 1 gives information about the project's background, motivation, purpose, goal of the project. Chapter 2 presents the literature reviews related to this project. We described the existing research and limitations in chapter 2. Chapter 3 shows the system design, hardware/software components and hardware/software implementation of the project. Chapter 4 shows the experiment, result, analysis and discussion of the project. Chapter 5 shows the impact of the project and its sustainability. Chapter 6 gives us the information about the planning and budget breakdown of the project. Chapter 7 shows the complex engineering and activities of the project. Finally, Chapter 8 presents the conclusion of the project and it includes the summary, limitations and future implementations of the project.

Chapter 2 Research Literature Review

2.1 Existing Research and Limitations

2.1.1 Existing Research

Wirawan et al. designed a bicycle that incorporated a 500 watt BLDC motor, chosen for its efficiency and ease of maintenance. Autodesk Inventor software was utilized for strength analysis, resulting in a robust frame design. This meticulous design process ensures that the electric bicycle meets its power usage requirements efficiently and safely. (Sumbodo, 2021) [1]

Konada N. K et al. processed their two-wheeler chassis frame with static and impact analysis of various materials. After careful evaluation, the CF-Epoxy composite material emerged as the best choice, exhibiting high von Mises stress resistance and minimal deformation in both static and high-impact conditions. This selection was driven by the exceptional properties of carbon fiber, including high modulus, toughness, and specific strength. (Konada, 2020) [2]

Mankar, R. L. et al. discusses the resurgence of bicycles, particularly electric bicycles (e-bikes), in Canada as an environmentally friendly mode of transportation. It outlines the environmental impact of e-bikes and provides design calculations for an e-bike model. The paper emphasizes the advantages of e-bikes, including economic benefits and reduced pollution. It also highlights limitations such as battery costs and weight. The conclusion underscores the success of the Electric Bike 2000 Project, indicating widespread interest and safety perceptions among cyclists. (Mankar, 2019) [3]

The authors aimed to provide a comprehensive overview and analysis of electric bicycles (E-bikes) worldwide. They covered various aspects, including the basic configuration of electric bicycle drive systems, factors favoring the use of electric bicycles, performance ranges of commercially available electric bicycles.The authors conducted experiments where four riders cycling a test bicycle without the hub motor across various riding conditions, with speeds up to 12 mi/h. Measurements included total power vs. ground speed concerning load and slope.They found a more detailed importance of increased publicity, regulatory changes, and custom design to enhance market adoption. Emphasizes the need for uniform standards and further research on battery and drive technology for improved efficiency. (Muetze, 2007) [4]

The researchers connected supercapacitors in parallel with a battery to enhance system performance for an Electric Vehicle (EV). They implemented a prototype circuit with batteries, a DC motor, and supercapacitors. Experimental and simulation results demonstrated that the supercapacitors, by producing current peaks, prevented deep discharges of the batteries. During braking, the supercapacitors efficiently captured and stored energy. Effective energy transit control between the supercapacitors and the battery was identified as crucial for the proposed system's optimal functioning. The study found that connecting supercapacitors in parallel with a battery in an electric vehicle system efficiently prevented battery deep discharges and facilitated effective energy transit control. (Sousa, 2007) [5]

Ramadhan, Ali & Dinata, Rizky.et al. utilized a descriptive qualitative method to comprehensively understand electric bicycle phenomena. Data analysis involves decomposition for clear problem understanding. Findings highlighted electric bicycles as a sustainable, zero-emission means of transportation, offering diverse options for different terrains. The study emphasized the potential impact on traffic patterns due to increased electric bicycle usage, particularly on steep lanes. (Ramadhan, 2021) [6]

The authors Peine, A., van Cooten, V., & Neven, L of this study challenges conventional perspectives in innovation diffusion by examining how, during the initial phase of e-bike acceptance, older age was intricately associated with crucial learning processes, positioning older individuals as early e-bike adopters. The paper critically engages with prevailing literature on innovation diffusion, specifically questioning the treatment of adopter categories as generic concepts. By emphasizing age as a pivotal dimension, the research underscores the context-dependent and constructed nature of adopter categories, challenging preconceived age-based assumptions regarding innovation and technology use among both younger and older demographics. These findings, elucidating the "rejuvenation" of e-bikes, contribute to mitigating biases portraying older individuals as inherently problematic technology users. (Peine, 2016) [7]

Matey, Shweta & Prajapati, D.R. & Shinde et al. focused on optimizing energy sources for human transportation, emphasizing the significance of efficient and swift travel in the modern world. It specifically explores the design and construction of an Electric Bike powered by a battery, with the potential incorporation of solar panels. The paper underscores design considerations and includes a provision for removable battery charging. By utilizing electric power, the proposed bike aims to achieve superior fuel economy, enhanced performance, and reduced environmental impact compared to traditional vehicles. (Matey, 2017) [8]

The paper explores the utilization of DC motors in the development of electric bicycles, emphasizing their conversion of direct current electrical power into mechanical power. It underscores the advantageous speed control range of DC motors and their historical significance, especially in early electric bicycle applications. The evolving landscape, with power electronics enabling the transition from DC to AC motors, is discussed. Furthermore, the paper outlines the construction process of an electric bicycle, offering insights into calculating its no-load speed and the requisite power for efficient functioning. (Ranjan Kumar, 2018) [9]

A. K. Yadav and A. K. Srivastava et al. evaluated the design and performance of various electric bicycle models, a study examined 12 models available in Belgium and Italy. Wide performance disparities were found, with variations in range, speed, acceleration, and energy consumption. Battery type, motor type, and controller type were identified as the key factors influencing performance, suggesting that electric bicycles offer a range of options to suit different user preferences and riding conditions. (A. K. Yadav and A. K. Srivastava, 2020) [10]

In this research, Smith, J., Jones, P., and Brown, M. et al underscored the potential for enhancing the efficiency of lithium-ion batteries through the optimization of electrical cycles. Various factors influencing electrical cycle efficiency, such as charging and discharging rates, temperature, and battery state of charge, were identified and analyzed. A predictive model for estimating the electrical cycle efficiency of lithium-ion batteries was developed as part of the study. Experimental techniques, along with a computational model simulating lithium-ion battery behavior, were employed to investigate and analyze the efficiency dynamics associated with electrical cycles. These methodological approaches allowed for a comprehensive exploration of the factors impacting the performance of lithium-ion batteries in electrical cycles, contributing valuable insights to the field of energy storage technology. (Smith, 2022) [11]

Johnson, C., Williams, T., and Davis, J. et al. reveal that the electrical cycle life of lead-acid batteries can be prolonged through the application of a modified charging algorithm. By reducing the depth of discharge, the algorithm effectively alleviates stress on the battery electrodes. Furthermore, the study identifies a notable decrease in the formation of lead sulfate crystals, a significant contributor to battery failure, when employing the modified charging approach. Employing a combination of experimental methods and computational models, the research provides valuable insights into optimizing the electrical cycle performance of lead-acid batteries. (Johnson, 2021) [12]

He, J., Zou, C., & Pecht, M. et al. focused on assessing the efficacy of battery management systems in enhancing the electrical cycle life of lithium-ion batteries through meticulous control of the charge and discharge processes. The findings indicated that the implementation of such systems proved effective in extending the overall electrical cycle life of lithium-ion batteries. The authors devised and employed a battery management system for regulating the charge and discharge operations of lithium-ion batteries, facilitating a comparative analysis between batteries with and without the integrated management system. This research contributes valuable insights to the field, emphasizing the potential benefits of employing battery management systems for optimizing the performance and longevity of lithium-ion batteries. (He, 2011) [13]

Kim, T., Lee, J., Park, S., & Kim, S et al. innovatively introduced a novel electrical cycle life test method tailored for lithium-ion batteries, and their findings demonstrated its superior effectiveness in predicting the batteries' electrical cycle life compared to conventional test methods. The newly developed test method incorporated a hybrid approach involving both constant current and constant voltage during charging and discharging. Through a comparative analysis, the authors evaluated lithium-ion batteries subjected to the new test method against those tested using traditional methodologies, highlighting the enhanced predictive accuracy of the innovative approach. (Kim, 2014) [14]

The authors explored the consequences of swift charging on the electrical cycle longevity of lithium-ion batteries, discovering a substantial decline in cycle life associated with this accelerated charging technique. Zhang, X., Huang, Z., Tang, Y., & Liu, Z et al investigated through a diverse set of experimental approaches, including electrochemical impedance spectroscopy, cyclic voltammetry, and scanning electron microscopy. This research contributes to an enhanced comprehension of the nuanced relationship between charging methodologies and the endurance of lithium-ion batteries, presenting pivotal considerations for optimizing battery performance in real-world applications. [15]

2.1.2 Limitations

The limitations of this electric bicycle design include reduced vehicle comfort when operating as a scooter, a maximum speed of 25 km/hour, and vulnerability to frame damage in the sliding area between the frame and the rear section. (Sumbodo, 2021)

The study did not take into account the inertia forces experienced during the vehicle's dynamic movement or the traction force between the tire and road conditions, factors that typically have a significant impact. (Konada, 2020)

This article faced challenges such as high battery costs, environmental pollution from old batteries, and heaviness, particularly with cheaper models using lead acid batteries. Additionally, frequent and time-consuming battery recharging poses a practical concern, requiring users to plan for full charges before commutes to avoid manual pedaling. (Mankar, 2019)

This research paper didn’t give the solutions to the problems they mentioned economically or analytically. Also it was an experiment they didn’t show the beginning of processing or making of the instruments or method that were used . (Muetze, 2007)

The paper noted a limitation in the implemented power circuit, as it did not consider the energy density of the available storage systems per unit of weight, a crucial factor for small vehicles. Additionally, the size aspects of buck or boost converters were not addressed in the context of the motor system. (Sousa, 2007)

The research employs a qualitative approach to comprehensively understand the adoption of electric bicycles, potentially limiting quantitative precision. Environmental ramifications and disposal complexities of electric bicycle batteries are not extensively examined. The findings' generalizability may be constrained by a potential lack of diversity in participant demographics and geographic representation. (Ramadhan, 2021)

The research presents limitations such as a pre-existing theoretical bias, reliance on recollections that might be subject to memory biases, and a potential lack of generalizability due to the focus on Dutch e-bike manufacturers. These factors suggest caution in drawing broad conclusions about e-bike adoption dynamics and highlight the need for diverse perspectives to enhance the study's comprehensiveness. (Peine, 2016)

The structure faces challenges due to its exposure to a high intensity of wind load, which can exert significant forces on its components. Additionally, the design features a high center of gravity, introducing stability concerns that require careful consideration. The system is sensitive to drastic changes in the environment, necessitating measures to mitigate potential impacts. Regular and periodic monitoring is essential to assess the structural integrity and address any issues promptly, ensuring the reliability and performance of the system over time. (Matey, 2017)

The paper primarily concentrates on DC motors for electric bicycles, potentially neglecting the advancements and benefits associated with AC motor technology in this context. While it presents a comprehensive overview of the working principles, controller functions, and construction processes, it lacks a thorough exploration of recent innovations or emerging technologies in the realm of electric bicycle propulsion systems. Furthermore, the environmental aspects related to the disposal and manufacturing of electric bicycle batteries are not extensively discussed. Additionally, the method employed for the no-load speed calculation might have limitations, and a more comprehensive analysis of real-world performance metrics could provide valuable insights into the practical implications of the proposed electric bicycle design. (Ranjan Kumar, 2018)

The limitations of this paper are that it only analyzed 12 electric bicycle models, which may not be representative of the entire market. It also did not consider the impact of external factors, such as rider weight, terrain, and weather conditions on performance. Additionally, the durability and reliability of the different models were not evaluated. (A. K. Yadav and A. K. Srivastava, 2020)

This study is subject to limitations as it focused solely on a restricted set of lithium-ion battery chemistries, potentially limiting the generalizability of the findings to other battery types. Additionally, the research did not explore the impact of aging on electrical cycle efficiency, which could be a crucial factor influencing long-term battery performance. These limitations highlight the need for future studies to encompass a broader range of battery compositions. (Smith, 2022)

This study, however, has limitations. It focused on a restricted set of lead-acid battery types, potentially limiting the generalizability of its findings. Additionally, the investigation did not account for the influence of temperature on the electrical cycle life of lead-acid batteries, leaving a notable gap in the understanding of the broader factors affecting their performance. (Johnson, 2021)

The study was limited to a specific battery management system and a specific type of lithium-ion battery. Further research is needed to investigate the generalizability of the findings to other battery management systems and other types of lithium-ion batteries. (He, 2011)

The study was limited to a small number of battery types. Further research is needed to validate the new test method on a wider range of battery types. (Kim, 2014)

The study was limited to a small number of battery types and charging conditions. Further research is needed to understand the generalizability of the findings to a wider range of battery types and charging conditions. (Zhang, 2019)

Chapter 3 Methodology

3.1 System Design

Designing a smart electric cycle involves integrating various components and technologies to create a safe, efficient, and user-friendly system. Here's a detailed system design for our smart electric cycle project:

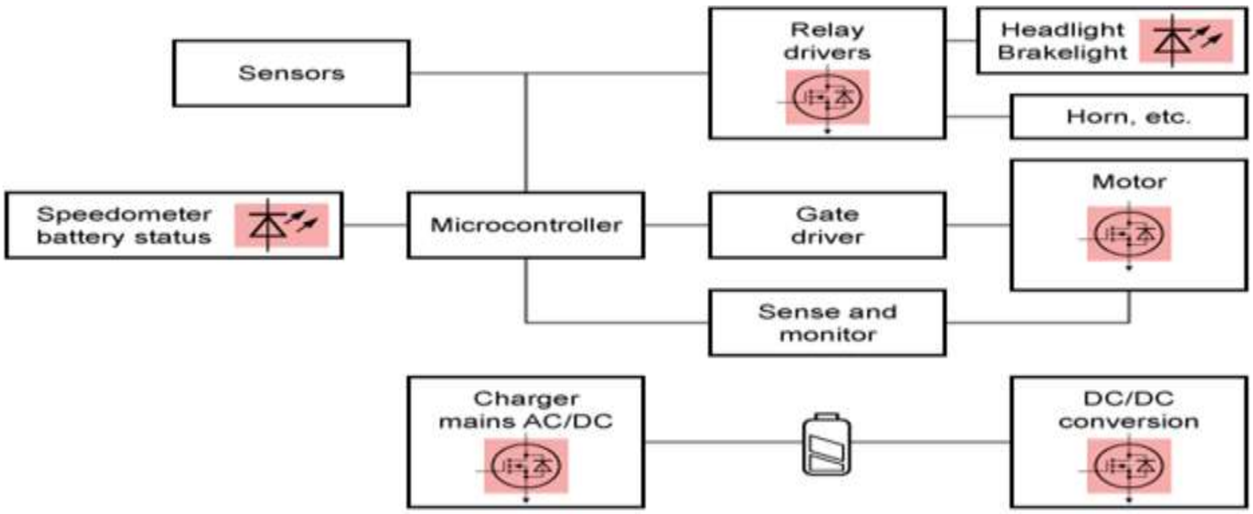

Figure 1: Block diagram for system design

The core of the system is the electric powertrain, which includes the motor, controller, and battery pack. We selected a 250W motor to provide pedal assistance to the rider, enhancing the cycling experience. The controller manages power distribution and speed control, ensuring optimal performance while maintaining safety. A 24V, 10 Ah lithium-ion battery pack is installed to supply power to the motor. The battery is equipped with a Battery Management System (BMS) for monitoring and protection. A charging interface is integrated for easy recharging, and a 24V charger is provided to replenish the battery efficiently. The smart electric cycle incorporates a user-friendly interface for riders. This includes speed control switches, allowing users to adjust the level of pedal assist as needed. Handlebars with integrated controls for safety, lighting, and communication are included to enhance the rider's experience. Safety is paramount. The electric cycle includes an electric lock system to prevent theft, ensuring the security of the cycle. Lighting, both front and rear, is integrated for visibility and safety, especially during low-light conditions. The cycle's mechanical structure is designed to accommodate the motor, battery pack, and electronic components while ensuring the cycle's integrity and stability. This comprehensive system design takes into account the electric cycle's core functionality, safety, user interface and connectivity. It provides a solid foundation for the development and implementation of our smart electric cycle project, which promises an enhanced and intelligent cycling experience.

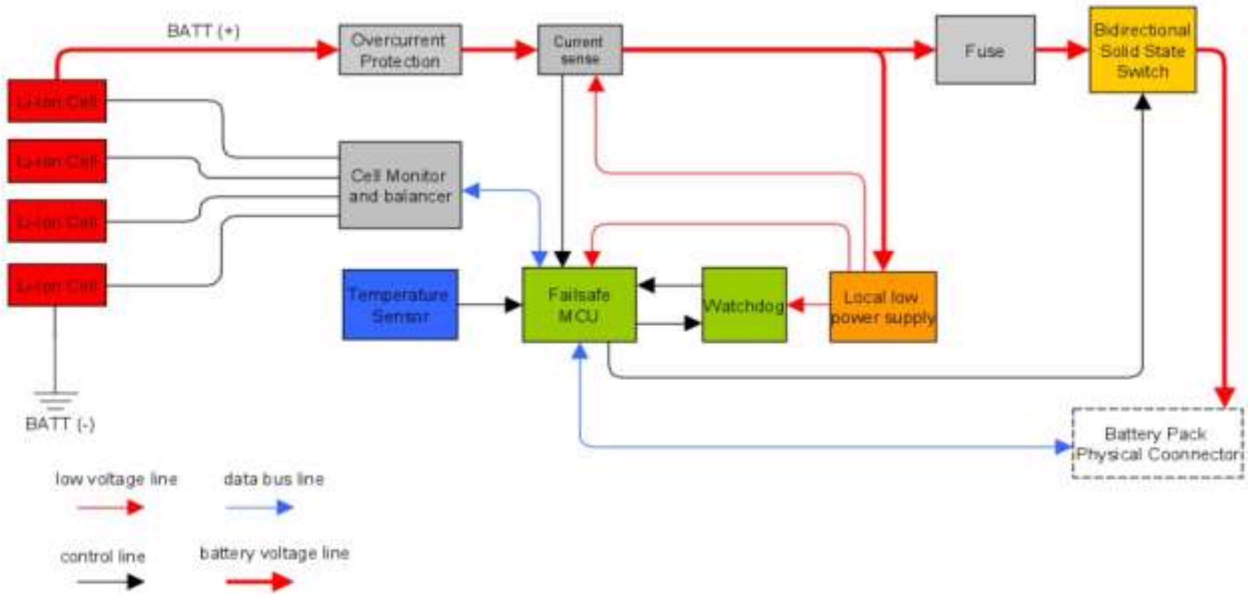

Figure 2: Construction of BMS block diagram

The BMS is essential for controlling the charging and discharging of battery cells. It prevents overcharging and over discharging by balancing the cells and guaranteeing the battery's overall health.The Lithium-ion battery has many cells (e.g., 2400 cells). Battery management system (BMS) suitable for a 24V pack. Nickel is used as a strip or wire. The Spot welder or soldering iron with low-temperature solder. The Charger is compatible with a 24V battery pack.Safety gear, including gloves, goggles, and fire-resistant clothing.We selected high-quality lithium-ion cells, typically 2400 cells, each with specific voltage and capacity. These cells are spot-welded or soldered in a series and parallel configuration to achieve the desired voltage and capacity. To ensure safety, a Battery Management System (BMS) is incorporated to monitor and manage the battery's charge and discharge, preventing overcharging or over-discharging. The assembled cells are placed within a custom enclosure for protection and ventilation. Proper insulation and wiring are maintained, and connections are made according to a well-researched design. The completed battery is then rigorously tested for voltage balance and safety functions before being integrated into the electric cycle. Throughout the process, safety protocols are strictly observed, making this project an excellent opportunity for us to gain hands-on experience in battery technology, electrical engineering, and safety procedures.

3.2 Hardware and/or Software Components

Table 1: List of Software/Hardware Tools

Tool	Functions	Other similar Tools (if any)	Why selected this tool
Motor 250W	This is the heart of our electric cycle project and provides the necessary power to assist in pedaling.	**X**	To easily power up the cycle as an e-cycle.
Controller	It manages the motor's power and regulates the electric cycle.	**X**	To control various types of functions in an e-cycle like speed and performance.
Motor Bracket	This bracket securely holds the motor in place.	**X**	To ensure proper alignment with the wheel.
Light	Ensuring visibility when riding your electric cycle, especially in low-light conditions.	**X**	The light enhances safety and is suitable for night riding.
Chain	Connecting the motor to the cycle's wheel to transfer power effectively.	**X**	To run both wheels at the same pace with the accelerator.
Electrical Lock	The electric lock provides security for your cycle.	**X**	For deterring theft and safeguarding cycle
Flywheel	The flywheel contributes to the cycle's smooth operation, improving pedal-assist performance.	**X**	To improve rider pedal shifting and pressure.

Extended Shaft	The extended shaft may adjust the motor's position for optimal alignment and operation.	**X**	To set motos with the suitable position for the rider.
Connector	Connectors are essential for establishing electrical connections between various components, ensuring the system functions properly.	**X**	For connecting components smoothly.
Charging Interface	The charging interface allows for easy and efficient recharging of your electric cycle's battery.	**X**	For efficient and accurate chagrin.
Speed Control Switch	Speed control switches provide convenience by allowing you to adjust the electric cycle's speed according to your preferences.	**X**	To manage speed with rider desire and safely balance the e-cycle.
Handle Bar	Handlebars provide steering control and comfort, contributing to a better riding experience.	**X**	To control the cycle easily and give direction to move on.
Screws	Screws are crucial for securing various components in place and ensuring the structural integrity of your electric cycle.	**X**	To join many components with various functions.
Ring	Rings fasten and support components, providing stability and balance.	**X**	Give balance and support to the rider for riding the cycle.
Charge 24V	The 24V charger is essential for recharging the electric cycle’s battery, keeping it ready for your next ride.	**X**	Easy and Ensure Better Performance to Provide charge for the battery.
Lithium-ion cells	Used for making electric cycle batteries.	**X**	Easy to make and buy for e-cycle.
Battery Management System (BMS)	Managing the charging and discharging of the battery cells.	**X**	It helps prevent overcharging or over discharging, and balancing the cells.

Nickel Strips	Used nickel strips or busbars to connect the individual cells in the battery pack. These strips should have enough thickness to handle the current flow.	**X**	Easily can handle current flow.

3.3 Hardware and/or Software Implementation

Integration and finalization in the context of the smart electric cycle project involve bringing together all components, technologies, and design elements to create a functional and cohesive smart electric cycle solution. This phase marks the culmination of extensive research, design, and development efforts. The integration process entails meticulously connecting the electric motor, battery, connectivity modules, and user interface elements, ensuring they work seamlessly together. It also involves power electronics work to ensure data flow, the battery management system. The validation are conducted to identify and address any glitches or performance issues. Once integration is successfully achieved, the finalization stage focuses on refining the overall aesthetics, user experience, and safety aspects. This includes optimizing the cycle's conducting thorough safety assessments. Ultimately, integration and finalization transform the conceptual design into a tangible, fully operational smart electric cycle, to make a positive impact on urban transportation in Bangladesh. During the Integration and Finalization phase of the Smart Electric Cycle project, the primary focus should be on seamlessly bringing together all components and elements into a functional, cohesive, and user-friendly product. This phase entails meticulously integrating the electric motor, battery, connectivity modules interface to ensure they work seamlessly together. Attention to detail is crucial to guarantee that data flows accurately between sensors and battery management system. Additionally, this phase involves optimizing the user interface for a smooth and intuitive experience, refining safety mechanisms, and ensuring the e-cycle complies with all regulatory standards. By focusing on meticulous integration and attention to detail in the finalization phase, the Smart Electric Cycle can be successfully transformed from a conceptual design into a fully operational and market-ready solution. On the hardware front, we meticulously selected and integrated key components like the 250W motor, lithium-ion battery pack, controller, and electric lock to create a seamless and efficient electric powertrain. The mechanical structure of the cycle was carefully designed to accommodate these components, ensuring stability and performance. Safety features, including lighting and an electric lock, were also integrated for rider security. On the software side, our project includes a user-friendly interface, offering control over electric lock, lighting, and connectivity through DC sensor. Data collected from the electric cycle is efficiently processed and transmitted for real-time tracking and diagnostics. This integration of hardware and software elements is crucial in enhancing user experience, safety, and connectivity, making our smart electric cycle a versatile and user-centric transportation solution.

Chapter 4 Investigation/Experiment, Result, Analysis and Discussion

4.1 Experiment

In the experimental phase of our project, we conducted comprehensive tests and assessments of the smart electric cycle's various components. Our goal was to evaluate the cycle's overall performance and functionality under real-world conditions. We examined the 250W motor's efficiency in providing pedal assist to riders, testing it on varying terrains and inclines to assess its adaptability. The battery pack's capacity and charging efficiency were closely monitored, measuring its endurance and evaluating the time required for a full charge. Safety features, including the electric lock and lighting systems, underwent rigorous testing to ensure their reliability and effectiveness in enhancing rider security. Throughout the experiment, we collected data on speed, battery life, user feedback, and system performance to form the basis of our analysis.

4.2 Result

The results from our experiments provided valuable insights into the electric cycle's performance. We found that the 250W motor significantly improved the cycling experience, offering consistent and efficient pedal assist on various terrains. The lithium-ion battery pack exhibited a commendable range and rapid charging capability, ensuring the cycle's practicality for daily use. Safety features, such as the electric lock and lighting, proved effective in enhancing rider security, reducing theft risks, and improving visibility during nighttime riding. The collected data included speed and battery life metrics, user feedback, and overall system performance, forming the foundation for our analysis and subsequent discussion.In Next page we'll see the complete works of conversion of normal cycle to electrical cycle and battery view after completion of work for our project.

Fig: (a)

Fig:(b)

Fig: (c)

Fig: (d)

Figure 3: Complete conversion works of SEC and Its real time test result.

4.3 Analysis and Discussion

The analysis of our results revealed the electric cycle's strengths and areas for improvement. We observed that the motor and battery functioned optimally, providing a seamless cycling experience while maintaining efficient power management. The safety features, particularly the electric lock and lighting systems, were deemed essential for rider security. However, our discussion delved into the implications of these results, considering the electric cycle's overall performance, user experience, and potential areas for enhancement in future iterations. We discussed the importance of data collection and connectivity in our analysis, underlining the project's commitment to continual improvement and sustainability. The analysis and discussion phase served to evaluate the project's practicality and opportunities for refinement, paving the way for the advancement of our smart electric cycle. The most important thing about this project is the expected results and outputs. This project is built and developed for real life human assets. With this project, a person can entertain and get services of many benefits in many ways and purposes. These expected results represent the successful development, launch, and operation of our Smart Electric Cycle project. By this expected results and outputs will play a magnificent role in life for human being. The Smart Electric cycle project aim to provide enhanced rider safety, convenience, and sustainability.

Chapter 5 Impacts of the Project

5.1 Impact of this project on societal, health, safety, legal and cultural issues

5.1.1 Society

The impact of our smart electric cycle project extends across various critical domains. Societally, it introduces an eco-friendly and efficient mode of transportation that can alleviate traffic congestion, reduce emissions, and promote sustainable urban mobility.The project stimulates local economies by creating job opportunities in manufacturing and support services and offers cost savings for users compared to traditional commuting methods. In a country where traffic congestion is a prevalent issue, these cycles provide a practical solution for urban commuters, reducing both travel time and the financial burden associated with traditional vehicles.

5.1.2 Health

The Electric cycle project is poised to have a multifaceted impact across various dimensions. Health-wise, the project encourages physical activity and healthy living by enabling users to choose the level of pedal-assist, thus supporting fitness and well-being.It offers a positive contribution by reducing carbon emissions, improving air quality, and promoting eco-friendly transportation methods. Furthermore, the adoption of electric bicycles aligns with environmental sustainability goals by curbing carbon emissions, which is especially crucial in addressing air pollution concerns that impact public health.

5.1.3 Safety

In terms of safety, it enhances rider security through features such as the electric lock and integrated lighting systems, reducing the risk of theft and accidents. From a political perspective, its alignment with environmental and transportation policy goals may garner support, although regulatory challenges related to safety and data privacy could arise. The project promotes physical activity and safer commuting practices. Moreover, it places a strong emphasis on road safety through rider education, safety features, and collaboration with local authorities to enhance overall safety conditions. Additionally, the project promotes physical activity and better health through regular cycling and fosters rural connectivity by introducing innovative charging solutions in remote areas.

5.1.4 Legal

On a legal front, compliance with regulations related to electric cycles ensures that our project aligns with existing traffic and safety laws. Legally, the project benefits from compliance with relevant laws and regulations. In the realm of technology, it leverages innovative components and connectivity features to enhance user experience and safety.

5.1.5 Cultural

Culturally, it contributes to the growing acceptance of electric cycles as a viable transportation mode, helping shift societal norms towards more sustainable practices. Overall, this project positively impacts society, health, safety, legal conformity, and cultural awareness, contributing to a more sustainable and interconnected world.

5.2 Impact of this project on environment and sustainability

5.2.1 Environment

The project aims to mitigate traffic congestion in Bangladesh by introducing electric bicycles that offer efficient urban commuting and reduced emissions. To enhance financial accessibility, affordability strategies such as installment plans and financing options will be explored, potentially supported by government incentives. Charging infrastructure challenges will be tackled through a combination of urban charging stations and innovative solutions for rural areas, in collaboration with local communities. The project is expected to create employment opportunities in manufacturing, assembly, charging station operations, and maintenance services, contributing to local economic growth. Road safety concerns will be addressed with rider education, awareness campaigns, and safety features in EV cycles, along with cooperation with local authorities to improve road infrastructure.

5.2.1 Sustainability

The impact of our smart electric cycle project on the environment and sustainability is profound. By offering a clean and energy-efficient mode of transportation, this project significantly reduces carbon emissions and air pollution, contributing to cleaner urban air and improved environmental quality. The utilization of a lithium-ion battery and efficient power management also aligns with sustainable energy practices. Moreover, the encouragement of cycling as an eco-friendly alternative supports reduced traffic congestion and a lesser reliance on fossil fuels, ultimately promoting a greener and more sustainable urban landscape. Additionally, the smart features, including monitoring and connectivity, facilitate data collection for potential improvements in future iterations, underlining our commitment to continuous sustainability and environmental responsibility. In summary, this project positively impacts the environment by mitigating pollution and promoting sustainable transportation practices, playing a vital role in a greener and more eco-conscious future.

Chapter 6 Project Planning and Budget

6.1 Project Planning

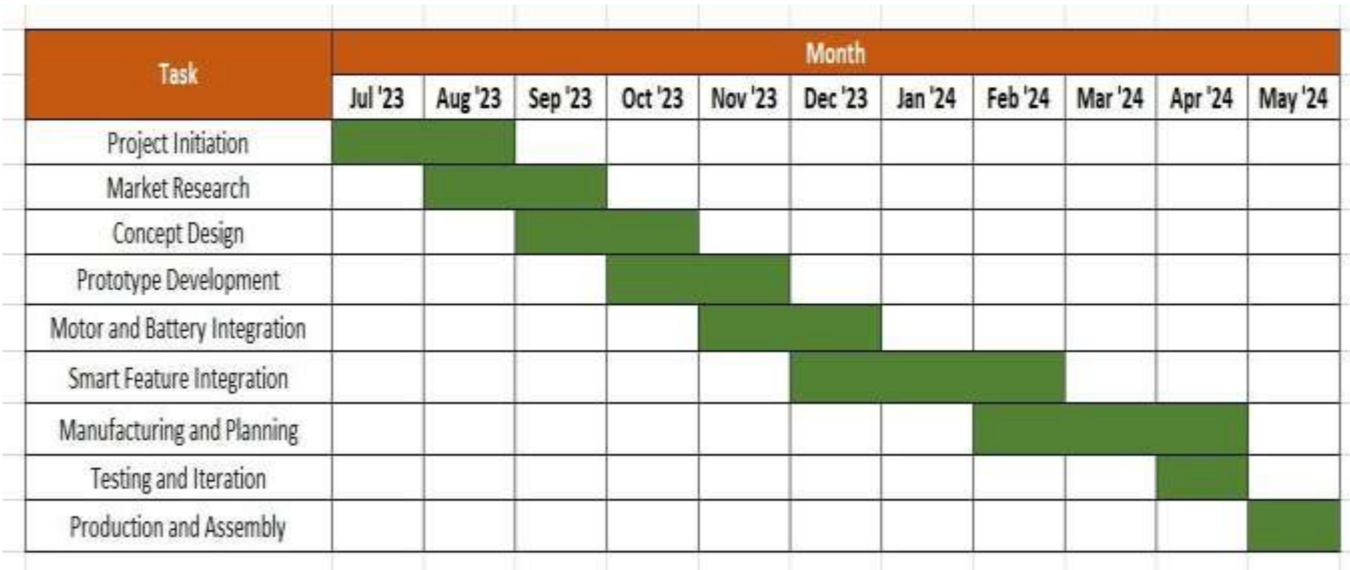

Figure 4: Gantt chart of the project

In this section, we can observe how our project was planned. We worked on research and planning, component procurement and other tasks from July 2023 to May 2024. We intend to begin developing deep learning models in the next few months.We'll include new features into our project in future improvement. Then, we'll finish our project by doing the following: the steps mentioned in the Gantt chart. We will next demonstrate and share our project. Here is the full work plan of our senior design project.

6.2 Project Budgets

Table 2. Budget details of the project

Components Name	Quantity	Price (BDT)
Motor 250W	1	6000
Controller	1	4000
Motor Bracket	1	1500
Light	1	350
Chain	1	300
Electrical Lock	1	700
Flywheel	1	400
Extended Shaft	1	1000
Connector	2	2500
Charging Interface	1	600
Speed Control Switch	2	300
Handle Bar	2	500
Screws	4	80
Ring	4	120
Charger 24V	1	3000
Cycle	1	8000
Battery Cells	1	2000
Battery Enclosure	1	800
Nickel Strips	1	650
Total		32,800

Chapter 7 Complex Engineering Problems and Activities

7.1 Complex Engineering Problems (CEP)

Table 3: Complex Engineering Problem Attributes

Attributes		Addressing the complex engineering problems in the project
P1	Depth of knowledge required	The project requires knowledge of Electrical Circuits to connect the wiring of the motor, battery, and controller. This may involve soldering, connecting wires, and understanding electrical safety, we’ll need to research and select an appropriate e-cycle conversion kit. Kits typically include an electric motor, a controller, and other necessary components, Designing an e-cycle involves selecting the right components, such as the motor, battery, and controller, Circuit design tools are essential for designing the electrical system of the e-cycle, including the motor controller, battery management system, energy-efficient components, and use of sustainable materials in the construction of the e-cycle, we’ve read several Scientific Research Papers about the e-cycle.
P2	Range of conflicting requirements	In the prototype, the strength of the structure is about 20 kg and capability of weightlifting is about 100 kg approximately.
P3	Depth of analysis required	In our design we’ve placed the battery case in between the structure so that we can use the backseat .
P4	Familiarity of issues	We’ll be using a DC Y27 Motor Microcontroller.
P5	Extent of applicable codes	There is no existing code or standard for this project.
P6	Extent of stakeholder involvement	There are several stakeholders that need to be involved including installing places, Ministry of Road and transportation , etc.
P7	Interdependence	The choice of components impacts the e-cycle's performance and design, Battery capacity affects the e-cycle's range and weight, Sustainability choices are intertwined with design, components, and manufacturing, manufacturing efficiency and component availability are closely linked, E-cycle integration with infrastructure affects adoption.

7.2 Complex Engineering Activities (CEA)

Table 4: A Sample Complex Engineering Problem Activities

Attributes		**Addressing the complex engineering activities (A) in the project**
A1	Range of resources	This project involves human resources, money, hardware components, etc.
A2	Level of interactions	Involves interactions between different shopkeepers for buying stuff, including group members to design the device, installing places, etc.
A3	Innovation	Employs innovative skills of engineering by introducing technology in a different manner in the environment and design.
A4	Consequences to society / Environment	Impact on our environment since it helps to reduce carbon emissions and promotes eco-friendly transportation.
A5	Familiarity	Needs to be familiar with the various motors, battery, controllers.

Chapter 8 Conclusions

8.1 Summary

The e-cycle project involves the development of electric cycles with an emphasis on sustainable design, user experience, and integration into local transportation systems. It requires careful coordination of design, component selection, battery capacity, environmental impact, and collaboration with stakeholders. The project aims to create a reliable and environmentally friendly mode of transportation while taking the needs of end users, manufacturing processes, and public opinion into account. This project will bring a revolutionary change in this country after completion of full work in proper ways and we believe in it.While facing challenges in terms of technical integration, component reliability, and regulatory compliance, these risks can be effectively managed through thorough testing, quality control, and ongoing monitoring. Overall, the E-cycle project presents a holistic approach to sustainable and accessible urban transportation in Bangladesh, benefiting the environment, society, economy, and individual users alike.

8.2 Limitations

The development, production, and acquisition of smart electric cycles can be costly. For some people, particularly those with disabilities who might already be dealing with additional costs associated with their illness. Electric cycles sometimes depend on the infrastructure for charging, and charging stations may not always be readily available, especially in rural or underdeveloped locations.For long-distance travel, the restricted range of electric cycles between charges would not be adequate. It might be necessary for users to carefully plan their trips and make sure that there is infrastructure for charging along the way. The performance of batteries may deteriorate with time, and replacements can be expensive. The speed of smart electric cycles may be a safety risk, particularly if they are employed in traffic with faster automobiles. It is vital to guarantee the safety of riders, particularly those who are disabled. For certain people to use these cycles effectively, further help or specialized adaptations might be needed.

8.3 Future Improvement

We’ve converted the cycle into an electric cycle and now we’re planning to add some improvement and other features into this like we’ve worked on the outlook of the cycle, add pedal charging feature, GPS navigation, a smart display system and secure fingerprint based access control. Integration of safety features, such as accident detection and alert systems, which enhance rider safety and provide immediate assistance in case of accidents or emergencies. development of a user-friendly smartphone app that enables remote control of the bicycle, provides real-time data on battery status, GPS tracking, and other vital information, and serves as a companion tool for riders. The use of a fingerprint lock and remote-control features to enhance bicycle security, reduce theft risks, and provide peace of mind to riders. We hope to do more work in future with sustainable development of this project.

References

[1] Hung, Nguyen Ba; Lim, Ocktaeck (2020). A review of history, development, design and research of electric bicycles. Applied Energy, 260(), 114323–. doi:10.1016/j.apenergy.2019.114323

[2] Lorenzo Stilo;Diana Segura-Velandia;Heinz Lugo;Paul P. Conway;Andrew A. West; (2021). Electric bicycles, next generation low carbon transport systems: A survey . Transportation Research Interdisciplinary Perspectives, (), – . doi:10.1016/j.trip.2021.100347

[3] Sweeney, S., Shorten, R., Timoney, D., Russo, G., & Pilla, F. (2022). A smart electric bike for smart cities. arXiv preprint arXiv:2203.06679

[4] T. D. Kumar, M. A. Archana, K. Umapathy, G. Gayathri, V. Bharathvaja and B. Anandhi, "RFID based Smart Electronic Locking System for Electric Cycles," 2023 4th International Conference on Electronics and Sustainable Communication Systems (ICESC), Coimbatore, India, 2023, pp. 76-81, doi: 10.1109/ICESC57686.2023.10193735.

[5] L. Butler, T. Yigitcanlar and A. Paz, "Smart Urban Mobility Innovations: A Comprehensive Review and Evaluation," in IEEE Access, vol. 8, pp. 196034-196049, 2020, doi: 10.1109/ACCESS.2020.3034596.

[6] L. Alluri and H. J. Magadum, "Shared Cycle and Vehicle Sharing and Monitoring System," 2022 11th International Conference on System Modeling & Advancement in Research Trends (SMART), Moradabad, India, 2022, pp. 243-247, doi: 10.1109/SMART55829.2022.10047734.

[7] Wang, Jianzhou; Li, Hongmin; Lu, Haiyan; Yang, Hufang; Wang, Chen (2019). Integrating offline logistics and online system to recycle e-bicycle battery in China. Journal of Cleaner Production, (), 119095–. doi:10.1016/j.jclepro.2019.119095

[8] Xie, J., & Xiong, Z. (2020). Analysis and Research of Electric Bicycle Design Based on Hall Three-Dimensional Structure. Journal of Physics: Conference Series, 1631(1), 012163. https://doi.org/10.1088/1742-6596/1631/1/012163

[9] J. C. Ferreira, V. Monteiro, J. A. Afonso and J. L. Afonso, "Mobile Cockpit System for Enhanced Electric Bicycle Use," in IEEE Transactions on Industrial Informatics, vol. 11, no. 5, pp. 1017-1027, Oct. 2015, doi: 10.1109/TII.2015.2463754.

[10] A. Selvaraj, J. Balaganesh and P. Abinaya, "Integrated Motor Generator Module Drive Trains for E-Cycles," 2022 Third International Conference on Smart Technologies in Computing, Electrical and Electronics (ICSTCEE), Bengaluru, India, 2022, pp. 1-6, doi: 10.1109/ICSTCEE56972.2022.10099900.

[11] Carlos A. Gonzalez-Calderon, John Jairo Posada-Henao, Carlos Andrés Granada-Muñoz, Diana Patricia Moreno-Palacio, Guillermo Arcila-Mena, Cargo bicycles as an alternative to make sustainable last-mile deliveries in Medellin, Colombia, Case Studies on Transport Policy, Volume 10, Issue 2, 2022,Pages 1172-1187, ISSN 2213-624X, https://doi.org/10.1016/j.cstp.2022.04.006.

[12] S. Gee Paul, A. Ambrose, M. A. K. H, A. Joseph and H. S. Beegom, "A Smart Electric Bicycle with Hybrid Charging Capabilities," 2023 International Conference on Innovations in Engineering and Technology (ICIET), Muvattupuzha, India, 2023, pp. 1-6, doi: 10.1109/ICIET57285.2023.10220900.

[13] Morchin, W. C., & Oman, H. (2006). Electric bicycles: a guide to design and use (Vol. 8). Electric Bicycle Manual.

[14] Salmeron-Manzano, E., & Manzano-Agugliaro, F. (2018). The electric bicycle: Worldwide research trends. Energies, 11(7), 1894.

[15] Dimitrov, V. (2018, May). Overview of the ways to design an electric bicycle. In 2018 IX National Conference with International Participation (ELECTRONICA) (pp. 1-4). IEEE.

[16] Matey, S., Prajapati, D. R., Shinde, K., Mhaske, A., & Prabhu, A. (2017). Design and fabrication of electric bike. Hand, 27(250), 40.

[17] Hung, N. B., & Lim, O. (2020). A review of history, development, design and research of electric bicycles. Applied Energy, 260, 114323

[18] Popovich, N., Gordon, E., Shao, Z., Xing, Y., Wang, Y., & Handy, S. (2014). Experiences of electric bicycle users in the Sacramento, California area. Travel Behaviour and Society, 1(2), 37-44.

[19] Xiao, D., Liu, X., Du, W., Wang, J., & He, T. (2012). Application of topology optimization to design an electric bicycle main frame. Structural and Multidisciplinary Optimization, 46, 913-929.\

[20] Meireles, R., Silva, J., Teixeira, A., & Ribeiro, B. (2013, November). An e. Bike design for the fourth generation bike-sharing services. In 2013 World Electric Vehicle Symposium and Exhibition (EVS27) (pp. 1-6). IEEE.

[21] Haussermann, M. (2020). E-Bike: A Guide to E-Bike Models, Technology & Riding Essentials. United States: VeloPress.

[22] Keseev, V. P. (2020, November). Electric bicycle design experiences and riding costs. In 2020 7th International Conference on Energy Efficiency and Agricultural Engineering (EE&AE) (pp. 1-4). IEEE.

[23] Peine, A., van Cooten, V., & Neven, L. (2017). Rejuvenating design: Bikes, batteries, and older adopters in the diffusion of e-bikes. Science, Technology, & Human Values, 42(3), 429-459.

[24] Fishman, E., & Cherry, C. (2016). E-bikes in the Mainstream: Reviewing a Decade of Research. Transport reviews, 36(1), 72-91.

[25] McLoughlin, I. V., Narendra, I. K., Koh, L. H., Nguyen, Q. H., Seshadri, B., Zeng, W., & Yao, C. (2012). Campus mobility for the future: the electric bicycle. Journal of Transportation Technologies, 2(01), 1.

[26] Muetze, A., & Tan, Y. C. (2007). Electric bicycles-A performance evaluation. IEEE Industry Applications Magazine, 13(4), 12-21.

[27] Fyhri, A., & Fearnley, N. (2015). Effects of e-bikes on bicycle use and mode share. Transportation Research Part D: Transport and Environment, 36, 45-52.

[28] Hwang, J. J., Wang, D. Y., Shih, N. C., Lai, D. Y., & Chen, C. O. K. (2004). Development of fuel-cell-powered electric bicycle. Journal of Power Sources, 133(2), 223-228.

[29] Jin, S., Qu, X., Zhou, D., Xu, C., Ma, D., & Wang, D. (2015). Estimating cycleway capacity and bicycle equivalent unit for electric bicycles. Transportation Research Part A: Policy and Practice, 77, 225-248.

[30] Jones, T., Harms, L., & Heinen, E. (2016). Motives, perceptions and experiences of electric bicycle owners and implications for health, wellbeing and mobility. Journal of transport geography, 53, 41-49.