Urban Electric Mobility Revolution: Advancing Electric Mobility through Integrated Dynamic Wireless Charging Infrastructure

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STP- Project Proposal Draft 6
EMGT 5220
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Table of Contents

Letter of Transmittal

Date: 06/23/2023
Dr. Johnson Triston,
Northeastern University,
Boston, MA – 02115

Dear Professor,

Enclosed herewith is a project proposal for the development of Urban Electric Mobility Revolution: Advancing Electric Mobility through Integrated Dynamic Wireless Charging Infrastructure. The proposed infrastructure aims to enhance the convenience, flexibility, affordability, and efficiency of charging electric vehicles while minimizing downtime. It addresses the limitations of stationary charging stations, such as long waiting times, high installation costs, and compatibility issues with different connector models.

The proposal begins by outlining the process of gathering requirements and identifying the problem at hand, followed by a creative solution to address the identified challenges. A technical overview is provided to demonstrate the feasibility of implementing a Dynamic Wireless Charging infrastructure for Electric Vehicles that caters to the needs of electric vehicle owners. The implementation and execution plan detail the schedule and allocation of resources.

To ensure successful project management, a preliminary risk analysis and budget justification have been included. We value your guidance and constructive feedback throughout the project's development, which will contribute to our growth as aspiring project managers.

We trust that you will find this proposal effective and compelling. We sincerely appreciate your guidance and support in shaping this project and contributing to our growth as potential future project managers.

Sincerely,
Team Members

Executive Summary

The primary aim of this venture is to develop and implement an innovative wireless charging solution for electric cars that is adaptable and efficient. This solution will employ inductive charging technology, with Transmitters discreetly positioned underground and Receivers conveniently retrofitted onto the vehicles. The project encompasses multiple objectives, such as encouraging the widespread adoption of electric vehicles, analyzing the requisite logistics and financial aspects for implementation, and evaluating the system's viability, potential cost savings, technical feasibility, and environmental benefits when compared to traditional stationary charging stations.

The project is divided into four well-defined stages: initiation, planning, execution, and closure, and it is estimated to take approximately one year to complete. During the planning and execution phases, a comprehensive responsibility chart and resource allocation framework were created to clearly outline the roles and duties of team members and to ensure the efficient allocation of resources, avoiding both excessive and insufficient utilization. The stakeholders involved in the project include product managers, project managers, engineers, testing teams, and other relevant individuals or groups.

The process of project monitoring involves recognizing potential risks and promptly implementing appropriate measures to maintain the project's quality. This encompasses monitoring various aspects such as costs, time, and technical considerations. Project control mechanisms are established to guarantee that the project is completed within the defined timeframe, budget limitations, and quality standards. During the project auditing phase, an assessment will be conducted on the technical elements of the project, as well as its overall progress, risks, procurement procedures, compliance with relevant laws and regulations, and the effectiveness of implemented quality assurance measures.

The project team adopted a bottom-up budgeting method to establish the total budget of $7,430,000. By employing this budget plan, the team can ensure the efficient and effective allocation of resources to achieve the project's objectives. In essence, the project strives to deliver an inventive charging solution for electric vehicles, enhancing sustainability and convenience.

1.0 Problem

Why there isn't an efficient and convenient wireless motion charging system for electric vehicles while minimizing environmental impacts?

Wireless charging for electric vehicles confronts challenges due to lower efficiency, a lack of standardized infrastructure, and the requirement for exact alignment. These limitations impede usability, compatibility, and broad adoption. Furthermore, the manufacturing and disposal of wireless charging components have an influence on the environment and electronic waste.

1.1 Solution

To solve this issue, we'll implement a strategy with **two phases**. In the beginning, we will develop and implement a network of inductive charging station locations. Furthermore, to enable quick and secure charging, a framework for interaction will be developed between the charging infrastructure and EVs.

Phase 1: Designing and Deployment of Inductive Charging Station Network

1. Initiation: This process involves identifying the need for the project and obtaining approval to proceed. It would include conducting a feasibility study, identifying stakeholders, and securing funding for the project.
2. Planning: In this process, the project team would develop a comprehensive plan for the design and deployment of the charging station network. This would include defining project objectives, creating a work breakdown structure, estimating resources and costs and developing a project schedule.
3. Execution: Once the planning is complete, the project team would proceed with the implementation of the charging station network. This would involve procuring the necessary equipment, coordinating with vendors and contractors for installation, and conducting site inspections and quality control.
4. Monitor & Control: During the execution phase, the project team would regularly monitor the progress of the charging station deployment and control any deviations from the plan. This would involve tracking key performance indicators, conducting regular inspections, addressing any issues or risks that arise, and ensuring that the project is on track.
5. Closing: The closing process would involve completing and finalizing the deployment of the charging station network. This would include conducting final inspections, obtaining necessary permits and approvals, documenting lessons learned, and transitioning the project deliverables to the operations and maintenance team.

Phase 2: Development of Framework for Interaction between Charging Infrastructure and EVs

1. Initiation: Like the first phase, this process would involve identifying the need for developing the interaction framework and obtaining approval to proceed. It would include conducting a feasibility study, identifying stakeholders, and securing funding for the project.
2. Planning: In this process, the project team would develop a comprehensive plan for the development of the interaction framework. This would include defining project objectives, identifying required sensors and communication protocols, estimating resources and costs, and developing a project schedule.
3. Execution: Once the planning is complete, the project team would proceed with the implementation of the interaction framework. This would involve integrating sensors and communication systems, developing and testing vehicle-to-grid systems, and implementing data-sharing technologies.
4. Monitor & Control: During the execution phase, the project team would regularly monitor the progress of the framework development and control any deviations from the plan. This would involve tracking key performance indicators, conducting tests and simulations, addressing any issues or risks that arise, and ensuring that the framework is being developed according to the requirements.

5. Closing: The closing process would involve completing and finalizing the development of the interaction framework. This would include conducting final tests and validations, obtaining necessary certifications and approvals, documenting lessons learned, and transitioning the framework to the operations and maintenance team.

1.2 Specifically, what are we going to produce and how are we going to produce it?

To make it simple and accessible for electric vehicles to be charged, we will create an integrated dynamic wireless charging infrastructure. We will develop a flexible and adaptable system that includes cutting-edge technologies and standards in wireless charging through extensive research and adherence to architecture and engineering principles. Advanced power management strategies will be used to improve performance and shorten charging times, while security mechanisms guarantee a safe charging environment. Scalability is prioritized to allow for future developments and rising EV demand. Real-time monitoring and thorough analytics will optimize performance. Intelligent load management systems and compatibility with different charging protocols will provide an effective and scalable solution for electric vehicle users and accommodate the growing number of electric vehicles.

1.3 Why is there hope that we'll solve the problem where others have failed?

What will differentiate our approach is our commitment to creating an environmentally conscious infrastructure. We will integrate renewable energy sources, such as solar or wind, into the charging infrastructure to minimize reliance on fossil fuels and ensure that the energy used for charging is clean and renewable. Furthermore, we will deploy smart grid technologies to optimize energy distribution, reduce overall energy consumption, and promote eco-friendly practices in the infrastructure's design and operation. We will also collaborate with local environmental agencies and organizations to ensure compliance with sustainability standards and to ensure minimalistic environmental impact. Ultimately, we are striving for a solution that provides EV users with efficient and sustainable charging experiences and thus promotes the wider adoption of electric cars.

2.0 Project Topic

Urban Electric Mobility Revolution: Advancing Electric Mobility through Integrated Dynamic Wireless Charging Infrastructure

2.1 Purpose

The purpose of our project is to build a complete infrastructure for wirelessly charging electric cars (EVs) with inductive charging technology. The initiative intends to achieve the following:

1. Create a **strong and adaptive** wireless charging system capable of accommodating future technology breakthroughs and rising EV demand.
2. Ensure **high charging efficiency** and dependability, minimizing energy losses and providing a stable power supply for EVs.
3. Create a scalable system that can cover wider regions and support an increasing number of electric cars.
4. Deliver a **scalable wireless charging system** that can be expanded to cover bigger regions and support a rising number of electric cars, ensuring EV owners have simple and accessible charging alternatives as the industry expands.
5. Intends **to prioritize customer convenience** by building a user-friendly wireless charging technology that provides electric car users with smooth and intuitive charging experiences. The infrastructure will be built with the needs of the user in mind, assuring simplicity of use, accessibility, and a simplified charging procedure that improves the overall EV ownership experience.

By attaining these objectives, the project aims to provide EV users with easy and sustainable charging experiences, therefore promoting the wider adoption of electric cars and lowering reliance on fossil fuels.

2.2 Goals

The goal of this project is to deliver a progressive wireless charging infrastructure designed for electric vehicles, utilizing the principles of inductive charging. The project entails constructing a circular track spanning 2 miles in Boston, where vehicles can charge while in motion.

2.3 Objectives

The following are the objectives needed to accomplish the project goal of delivering a progressive wireless charging infrastructure designed for electric vehicles.

The objectives of our project are:

1. **Design the wireless charging infrastructure** to be 1) Scalable (allowing for future expansions to cover larger areas and accommodate a growing number of electric vehicles) and 2) Future-proofed (ensure that the wireless charging infrastructure is adaptable and future-proof, capable of accommodating technological advancements and increasing demand for EVs.
2. **Develop a wireless charging infrastructure** electric vehicles (EVs) using inductive charging technology with the following criteria: highly efficient and reliable, minimizing energy losses during the charging process and provide consistent and stable power supply.
3. **Assess the quality of the developed wireless charging system,** determining whether it has been subjected to extensive system-wide testing, such as functional testing of charging stations and user interfaces, compatibility verification with various EV models and charging standards, and reliability and security testing of the communication framework. Furthermore, the establishment of metrics and assessment criteria, followed by performance and usability evaluations, is used to measure the quality of the developed system.
4. **Deliver and deploy the wireless charging infrastructure to the client,** including a thorough walkthrough of installation and configuration, as well as user training and documentation for

system operation and maintenance. The infrastructure is subsequently handed over to the customer, and client acceptance is gained, along with sign-off on the project deliverables, indicating the project's successful completion.

3.0 Technical Description [Aman Maheshwari, Mithul Shyam Gopal Jayasankar, and Sumant Vinodchandra Shete]

In the Technical Description section, the project focuses on developing an integrated dynamic wireless charging infrastructure based on inductive charging technology for urban electric transportation. It describes in detail the project's technology, systems, procedures, and components. It also serves as a resource for the project's team members, stakeholders, and technical specialists. gives a thorough grasp of the project's technical intricacies and aids in efficient project planning, implementation, and assessment.

The goal is to change the way electric vehicles are charged by allowing them to charge wirelessly without the need for physical connections. It emphasizes the core technology of inductive charging, which effectively and with little energy loss transmits electricity between charging infrastructure and automobiles. Further, it emphasizes the project's emphasis on scalability, infrastructure future-proofing, seamless interaction with urban infrastructure, and assuring high charging efficiency and dependability.

3.1 Inductive Charging Technology (ICS)

The project aims to revolutionize urban electric mobility by implementing an integrated dynamic wireless charging infrastructure based on inductive charging technology. Inductive charging (see Figure 3.1[ICS]) enables electric vehicles to charge without the need for physical connections, providing convenience and flexibility to electric vehicle users. The key technology is the connection between the road (charging conductor) and the energy transfer to the car (inductive pick-up). The system will be designed to efficiently transfer power between the charging infrastructure and the vehicles, ensuring high charging efficiency and minimal energy losses.

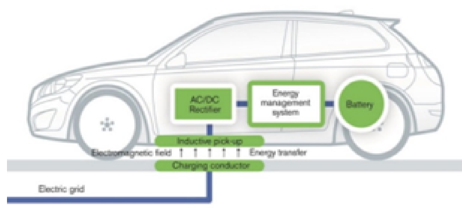


Figure 3.1: Inductive Charging System

3.2 Scalable and Future-proof Infrastructure

The wireless charging infrastructure will be designed to be scalable, allowing for future expansions to cover larger urban areas and accommodate the growing number of electric vehicles. This flexibility will ensure that the infrastructure can adapt to technological advancements and the increasing demand for electric mobility. The system will be future-proofed to integrate emerging technologies and support evolving industry standards, ensuring long-term viability and compatibility. The dynamic wireless charging system comprises transmitter coils (Refer to Figure 3.2.1 & Figure 3.2.2) that have been specifically designed to operate within a frequency range of 20 to 140 kHz. These coils are connected to a power electronic converter, which is in turn connected to the power grid. The coils are optimized to provide a minimum power output of 120 kW, enabling effective wireless charging for electric vehicles.

In addition, the system includes a control unit with an output of 11 kW, which is responsible for regulating the power supplied to the coils. This control unit ensures that the charging process is efficient and reliable. The system itself is designed to be robust and capable of withstanding heavy vehicle weight and adverse weather conditions. To enhance durability, the coils are enclosed in protective rubber insulation and are placed 4 inches below the road surface.

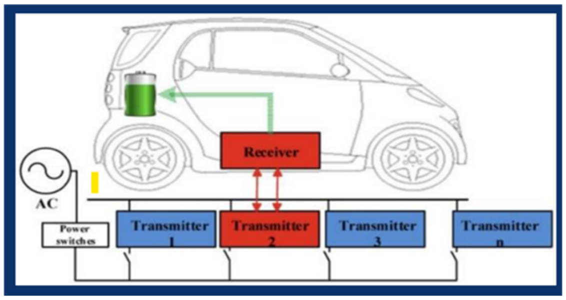


Figure 3.2.1 System Module Layout

Figure 3.2.2 Transmitter Assembly Layout

3.3 Integration with Urban Infrastructure

The project will focus on the seamless integration of the wireless charging infrastructure with existing urban infrastructure. This includes integrating the charging system with road networks, smart city initiatives, and other urban planning considerations. By leveraging the existing infrastructure, the project aims to minimize the disruption and cost associated with deploying the charging infrastructure, promoting its widespread adoption in urban environments.

3.4 Charging Efficiency and Reliability

Efficient and reliable charging is essential for promoting electric mobility. The wireless charging system will be engineered to provide high charging efficiency, minimizing energy losses and maximizing the amount of power transferred to the vehicles. The system will also ensure a stable and consistent power supply, delivering a reliable charging experience to electric vehicle users. This will enhance user confidence and encourage the wider adoption of electric vehicles.

4.0 Implementation Plan [Sakshi Manish Kherde, Saloni Madhusudan Bhutada, and Aaryan Mehta]

4.1 Schedule

Scheduling is vital for the project since it allows for the determination of the project timetable, tracking progress, and allocating resources to each task. To create the project schedule, we built on the experiences of previous real-world projects and split the work breakdown structure into reasonable time intervals.

We used MS Project, a software program (like Asana), to construct and maintain the project schedule, assuring accuracy and efficiency throughout the project. The schedule will be designed to ensure efficient project execution and timely completion, enabling the deployment of the infrastructure within the specified timeframe.

The project is anticipated to take approximately two years to complete, beginning in July 2023 and ending in July 2024 (refer to Appendix 4.1). It is vital to note that this timetable includes weekends and American holidays into account, allowing for more realistic scheduling. The planning and execution stages, which function as a pilot project, are expected to take up roughly 81% of the total project duration. Given the nature of the project, which involves road construction and charging infrastructure installation, the project follows a mostly sequential waterfall schedule. It should be emphasized; however, that component procurement can be done concurrently with other project operations.

Work Breakdown Structure:

1. **Design Phase**
   - 1.1. Conduct research on wireless charging technologies and standards
   - 1.2. Define requirements for the wireless charging infrastructure
   - 1.3. Design the network of charging stations
     - 1.3.1. Determine optimal locations for charging stations based on demand and accessibility
     - 1.3.2. Design electrical and structural plans for charging stations
     - 1.3.3. Select necessary equipment and materials
   - 1.4. Design a future-proof infrastructure
     - 1.4.1. Research emerging technologies and standards in wireless charging
     - 1.4.2. Evaluate compatibility with different charging standards and protocols
     - 1.4.3. Design a modular and flexible infrastructure to accommodate future advancements
   - 1.5. Design user-friendly interfaces and payment systems
     - 1.5.1. Identify user requirements and preferences
     - 1.5.2. Design an intuitive interface for EV owners to initiate and monitor charging
2. **Development Phase**
   - 2.1. Install charging station equipment
     - 2.1.1. Source reliable suppliers and vendors

2.1.2. Procure charging station hardware and components

2.1.3. Install charging stations at designated locations

2.2. Develop a communication framework for seamless and secure charging

2.2.1. Establish protocols and encryption mechanisms for communication between charging infrastructure and EVs

2.2.2. Implement authentication and authorization processes

2.2.3. Test and verify communication protocols and security measures

2.3. Ensure high efficiency and reliability of the charging process

2.3.1. Optimize inductive charging technology to minimize energy losses

2.3.2. Conduct performance tests on charging stations to ensure consistent and stable power supply

2.4. Develop user-friendly interfaces and payment systems

2.4.1. Create interface technology

2.4.2. Integrate secure and convenient payment options

3. Quality Assurance and Testing

3.1. Conduct system-wide testing of the wireless charging infrastructure

3.1.1. Perform functional testing of charging stations and user interfaces

3.1.2. Verify compatibility with different EV models and charging standards

3.1.3. Test communication framework for reliability and security

3.2. Evaluate the quality of the developed system

3.2.1. Establish metrics and criteria for assessing system quality

3.2.2. Conduct performance and usability evaluations

3.3. Modify the system for improved performance

4. Deployment and Delivery

4.1. Finalize installation and configuration of the charging infrastructure

4.2. Conduct user training and provide documentation for system operation and maintenance

4.3. Handover the wireless charging infrastructure to the client

4.4. Obtain client acceptance and sign off on the project deliverables

4.2 Responsibility Chart

A responsibility chart, also known as a RACI chart, was critical in defining and clarifying the roles and duties of the project team members. The abbreviation RACI stands for Responsible, Accountable, Consulted, and Informed, which are the four essential categories utilized in the infographic. We were able to build a clear framework for each stakeholder's engagement in the tasks indicated in the work breakdown structure by utilizing the responsibility chart.

The responsibility chart specifies each job or deliverable within the project and assigns explicit duties to the team members involved. These duties are as follows:

1. **Responsible**: This category highlights team members who are directly accountable for accomplishing tasks or delivering project results.
2. **Accountable**: The accountable position is allocated to the individual who is ultimately responsible for the job or deliverable. They have the power to make judgments and take appropriate actions throughout the project.
3. **Consulted**: The consulted position is assigned to those who are sought out for their knowledge or insight on certain tasks or deliverables. They give crucial insights and help to guarantee a successful finish.
4. **Informed**: This category includes team members who require to be kept up to date on the status of a task or deliverable, even if they are not actively involved in its execution.

We used the responsibility chart (refer to Appendix 4.2) to ensure that all project team members were aware of their assigned roles and duties. This clarity improved communication, increased responsibility, and ultimately led to the project's overall success. Note that each work task has clearly defined roles and responsibilities of each team member involved in the project. This will ensure effective coordination, accountability, and utilization of individual expertise. The chart will outline the specific tasks assigned to each team member, promoting a smooth workflow and efficient project management.

4.3 Resource Allocation

The project incorporates a resource allocation system that divides resources into two distinct categories: human resources and material resources. We used the current average and hourly rates in the United States to calculate standard rates. Each work within the project is assigned precise resources, and care is taken to avoid resource overallocation or under allocation. The project manager is designated as a vital work resource, with the maximum number of assigned work hours for the life of the project. Furthermore, the testing team and engineers have been identified as the second-highest priority work resources, with considerable work hours dedicated to their respective jobs. The resource allocation strategy is optimized and linked with project timeframes, taking unexpected delays and unforeseen events into consideration.

Effective resource allocation is critical for the successful implementation of the project. The allocation of resources, including personnel, equipment, and materials, will be carefully planned to support the deployment of the wireless charging infrastructure. Adequate resources will be allocated to ensure the smooth progress of the project, considering factors such as budget constraints, procurement processes, and resource availability.

4.4 Stakeholders

An in-depth stakeholder analysis will be conducted to identify the individuals, organizations, and communities impacted by the project. The analysis will consider the interests, expectations, and influence of each stakeholder group to ensure their active involvement and support throughout the project. Effective stakeholder engagement strategies will be developed to promote collaboration, address concerns, and align the project with the needs and aspirations of the stakeholders.

4.5 Stakeholder Power-Interest

A power-interest grid (see Figure 4.X) will be developed to categorize stakeholders based on their level of power and interest in the project. This will help prioritize stakeholder engagement efforts and tailor communication.

Government Officials: Government officials, such as policymakers, urban planners, and transportation authorities, hold significant power and influence over the implementation of the wireless charging infrastructure. Their decisions, regulations, and funding support are crucial for the success of the project.

Electric Vehicle Manufacturers: Electric vehicle manufacturers have a high interest in the project as the availability and convenience of wireless charging infrastructure can significantly boost the demand for electric vehicles. Their collaboration and support in integrating wireless charging technology into their vehicles are important for seamless compatibility.

General Public: The general public, including electric vehicle users, commuters, and residents of urban areas, have a high interest in the project. They are the primary beneficiaries of the wireless charging infrastructure, which offers increased convenience, accessibility, and reduced range anxiety. Public support and acceptance are crucial for the long-term sustainability and adoption of electric mobility.

Local Community Groups: Local community groups, such as environmental organizations, neighborhood associations, and advocacy groups, have a relatively lower power but a high interest in the project. They can influence public opinion, raise awareness about the benefits of electric mobility, and advocate for the deployment of wireless charging infrastructure in their communities.

4.6 Commitment Assessment

The Commitment Assessment Matrix is critical in assessing stakeholder commitment to the project, which is focused on promoting electric transportation through integrated dynamic wireless charging infrastructure. This matrix enables project managers to categorize stakeholders depending on their level of engagement and commitment to the project's objectives. Based on their active engagement, resource contribution, and impact on decision-making, stakeholders are divided into three categories: high commitment, moderate-commitment, and low commitment. Project managers may prioritize engagement initiatives, distribute resources efficiently, and adjust communication plans for each stakeholder group by analyzing commitment levels. The matrix is regularly updated and reviewed, ensuring that engagement tactics are altered to reflect changes in stakeholder commitment over time. The project may harness support, and collaboration, and promote the successful progress of electric mobility through integrated dynamic wireless charging infrastructure by efficiently managing stakeholder commitment.

5.0 Execution Plan

The major goal of project monitoring for this 2-mile Dynamic Wireless Charging pilot project is to guarantee that the project is completed on time and under budget. The process includes recognizing potential risks and quickly adopting appropriate solutions to preserve project quality. To do this, a work stream based on the Work Breakdown Structure and RACI Matrix will be created to track the important aspects and indications critical to the project's performance throughout its life cycle.

5.1 Project Monitoring

Cost: Without effective monitoring, the costs connected with the creation of a wireless charging system might quickly grow. All project costs, including project funding, budgeting, and expenditures, will be tracked. A cost monitoring feedback loop allows project managers to define a budget and cost projections for the building of the road, charging infrastructure, and vehicle system, track actual expenses against them, due amounts to employees, vendors, and manufacturers, and identify any unexpected expenses or possible overruns.

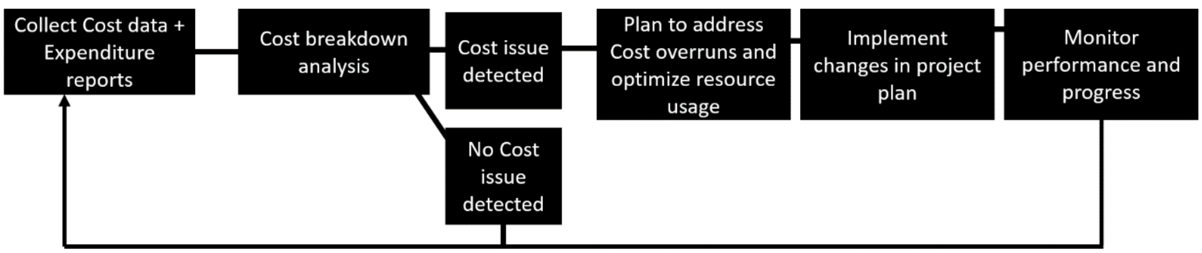


Figure 5.1: Cost Monitoring Feedback Loop

Time: A time-monitoring feedback loop will allow project managers to create realistic schedules and targets, validate progress against them, and observe any delays or possible delays in the development of the road, charging infrastructure, and vehicle system. Project managers may tweak schedules and targets as needed and continually improve scheduling by inspecting the causes of delays and taking remedial action.

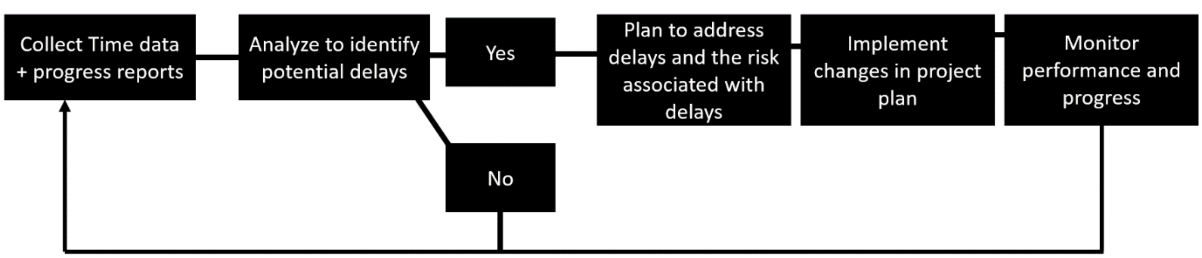


Figure 5.2: Time Monitoring Feedback Loop

Technical monitoring: The wireless charging system's technical performance is important to its efficient operation. It will also allow us to track progress against objectives and identify any variations or prospective deviations. Project managers can alter technical requirements and specifications as needed and continuously improve project technical performance by assessing the causes of deviations and taking corrective action.

Staff: The project will monitor personnel acquisition, staff contract agreements, role or responsibility, number of staff required, staff training, staff availability, and the amount of time each position will be required to accomplish their separate functions based on the RACI Matrix.

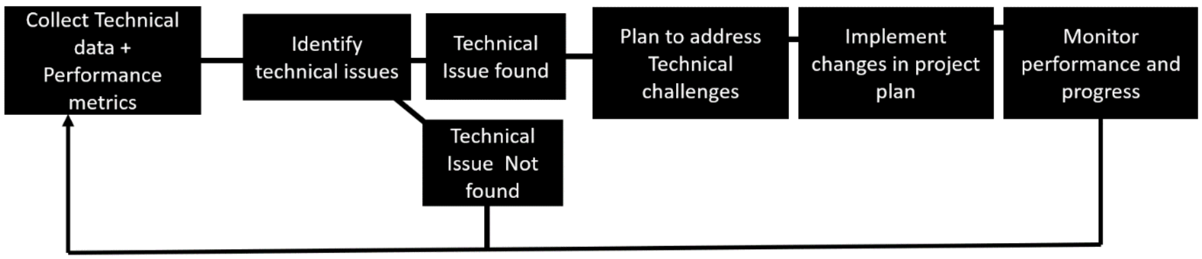


Figure 5.3: Technical Project Monitoring Feedback Loop

Quality: Operational guidelines and norms will be developed to facilitate proper collaboration among project teams and to ensure a high-quality Dynamic Wireless Charging Infrastructure. The following publications and standards will be implemented: Manufacturing norms for design, Electrical design standards, and testing procedure standards. Furthermore, observations obtained will be recorded, and monthly quality audits will be carried out.

5.2 Project Control

Considering the project involves technical aspects at every phase, it is essential and critical to ensure that the project is governed by the correct decisions at each stage. These measures will enable the project manager to make qualified choices at each phase of the task, thus ensuring it completes on schedule, within budget, and meets the quality standards that are required. The go/no-go controls include approval from management, allocation of resources, managing risks, budgeting, requirement acquisition, planning, infrastructure and vehicle system installation, and the completion of the project.

The below table is an illustrates of the Go/No-Go controls.

Factor	**Go Decision**	**No-Go Decision**
Aims and Objectives	Project aims and objectives are attainable and in accordance with stakeholders.	Not attainable or in line with the expectations of stakeholders.
Scope and Requirements of the Project	The scope and requirements are well-defined and achievable.	Insufficiently specified or feasible.
Project Time Frame and Scheduling	Timeline is realistic and achievable.	Timeline is not realistic or not achievable.
Budget and Resource	Sufficient funds and resources are available.	Insufficient funds or resources.

Quality Standards	The project deliverables fulfil the quality criteria and requirements.	Quality standards and requirements are not met by project deliverables.
Regulatory and Legal Requirements	The project meets all regulatory and legal criteria.	The project fails to meet regulatory and legal criteria.

5.3 Project Auditing

The project's execution phase, which comprised creating and testing the wireless charging system, incorporating it with the currently in place EV charging infrastructure, and carrying out pilot testing based on inductive charging in a real-world setting, was the subject of the audit.

Technical Audit:
This Audit will be conducted by the engineers involved in developing this project, and their plan is as follows:

1. **Review Project Documentation**: Along with the audit team, the project manager will analyze and discuss project documentation, the design phase, the technical aspects, and the overall project plan.

2. **Conduct Numerous Site Visits**: The audit team will visit the charging stations where the wireless charging system will be installed and evaluate their preparedness for the system during site inspections with the site surveyor.

3. **Analyze the implementation process**: The project manager, engineers, and the audit team will assess the infrastructure's implementation process, including site conditions, system installation, and commissioning.

4. **System test performance**: The testing and audit team will test the performance of the wireless charging system to ensure it works according to the requirements and matches the goals of the approved project.

5. **Identify Areas of Improvement**: The audit team, testing team, and quality assurance team will get the results and can provide recommendations for the areas of improvement.

6. **Report findings**: The audit team will work with the product team to create a technical audit report that compiles the audit's findings, conclusions, and recommendations. The report will then be presented to the project team and stakeholders.

Project Audit:
The following tasks will be carried out by the project audit team, which will primarily be made up of project managers and other associates depending on the type of work.

1. **Review Project Documentation:** All pertinent project material, such as the project plan, technical specifications, and financial reports, will be examined by the audit team, which consists of the project manager and the financial team.

2. **Determine Project Status**: The audit team, which consists of the project manager and a quality control officer, will assess the project's progress to make sure it is adhering to the set deadlines, budget, and goals.

3. **Investigate Project Risks**: The audit team will evaluate all project-related risks, including technical, financial, and legal risks, along with the risk management team.

4. **Examine the procurement process**: The procurement team and the audit team will assess the project's procurement procedure to make sure it is reasonable, effective, and sufficient.

5. **Assess quality control and compliance**: Both the audit team and the legal team will evaluate whether the project complies with applicable laws, rules, and industry standards. The audit team will evaluate the quality control measures employed in the project to make sure they are adequate and efficient; they will do this in conjunction with a quality control specialist.

5.4 Project Closure

It is essential to make sure that the project scope, budget, and timeline are on track when the Dynamic Wireless Charging infrastructure for electric vehicles is established and implemented. It will be crucial to assess whether the system satisfies the scope criteria and whether it was financially successful in accordance with expectations when the project is over. The project's success will reveal whether it is in line with the company's objectives and whether any adjustments might have been made to get better results.

It is crucial to consider both the advantages and disadvantages of the Dynamic Wireless Charging System for upcoming projects. If the project is successful, it might serve as a model for subsequent endeavors, while any failures would be useful information in areas of improvement for the company. This feedback is crucial for company’s future in the market.

6.0 Risk Assessment Management Plan [Mithul Shyam Gopal Jayasankar, Sumant Vinodchandra Shete, Aaryan Mehta]

Risk Management Planning involves the process of defining how risks will be identified, assessed, analyzed, and managed throughout the project lifecycle. Effective risk management planning is crucial for project success as it allows the team to proactively identify and address potential risks and uncertainties. It helps mitigate the negative impact of risks, improves decision-making, and ensures the project stays on track.

If the project is funded, the team will develop a comprehensive Risk Management Plan. This plan will outline the approach, roles, responsibilities, and procedures for identifying, assessing, analyzing, and responding to risks. It will also define the risk tolerance levels, escalation procedures, and contingency plans to effectively manage risks throughout the project lifecycle.

6.1 Risk Identification

Risk Identification involves systematically identifying potential risks that may arise during the project execution. It includes capturing both internal and external risks that could impact the project objectives. Risk identification is essential as it enables the project team to proactively identify and assess potential risks that could hinder the project's success. It allows for early mitigation measures to be put in place, reducing the likelihood and impact of negative events.

If the project is funded, the team will conduct a thorough risk identification process. This will involve brainstorming sessions, stakeholder consultations, historical data analysis, and leveraging industry best practices. The identified risks will be documented along with their potential causes and impacts.

6.3 Qualitative/Quantitative Risk Analysis

Qualitative/Quantitative Risk Analysis involves evaluating the identified risks based on their likelihood of occurrence, potential impact, and urgency. Qualitative analysis assigns subjective ratings, while quantitative analysis quantifies risks using numerical methods. Qualitative/Quantitative Risk Analysis helps prioritize risks based on their severity, allowing the project team to focus on addressing high-priority risks. It provides a basis for decision-making, resource allocation, and risk response planning.

If the project is funded, the team will conduct both qualitative and quantitative risk analysis. Qualitative analysis will involve assessing risks based on their probability, impact, and urgency using risk assessment matrices. Quantitative analysis will involve numerical methods such as Monte Carlo simulations to quantify the overall project risk and assess the effectiveness of risk mitigation strategies.

6.4 Risk Response Planning

Risk Response Planning involves developing strategies and action plans to mitigate, accept, transfer, or avoid identified risks. It includes defining risk response owners, specific actions, and timelines. Risk Response Planning is crucial for project success as it allows the team to proactively address and control potential risks.

6.5 FMEA Figure

The figure provides a structured approach to identifying potential failure modes, their causes, effects, and the existing controls or preventive measures. Below is an example:

FMEA Table

Failure Mode	**Potential Causes**	**Effects**	**Current Controls**	**Severity**
Power outage	Grid failure, equipment malfunction	Disruption of charging service	Backup power supply, maintenance protocols	High
Inadequate charging capacity	Insufficient infrastructure, higher demand than expected	Insufficient charging availability	Scalable infrastructure design, regular capacity assessments	Medium
Incompatibility with EV models	Lack of standardized charging protocols	Charging failure, potential damage to EV	Compatibility testing, adherence to standards	Medium
Communication breakdown	Technical glitches, network issues	Inability to monitor and control charging process	Redundant communication systems, regular maintenance	Low

Table 6.4 FMEA

RPN (RPN = Severity (S) X Probability (P) X Detection (D)) Table

Risk Categorization	**RPN 1 / RPN 2**
High	48-125
Medium	18-45
Low	1-16

Failure Modes and Effects Analysis - FMEA

SR.No:	Risk Factors	Mitigation of Risk	Severity (S)	Probability (P)	Detectability (D)	RPN (S*P*D)	Risk Acceptance (Y/N)
1.	Unavailability of resources	Creating a resource management plan outlining the project's resource requirements and availability	**3**	**3**	**2**	**18**	**Y**
2.	EV losing contact with the electric wires	Sensors for detecting electric wire disconnection are to be developed.	**3**	**5**	**1**	**15**	**Y**
3.	Fire or explosion:	Implementing safety requirements	**5**	**3**	**4**	**60**	**Y**
4.	Electrical hazards	Monitoring electrical equipment on a regular basis	**6**	**4**	**3**	**72**	**Y**
5.	Infrastructure failure:	Sensors, control devices, and communication devices are placed to oversee the charger's operation and communicate data between the car and the charging system.	**6**	**2**	**2**	**24**	**Y**

6.	Stabilizer malfunction	Installation of a backup power source and a secondary stabilizer. This will help to lessen the likelihood of downtime and the consequences of equipment failure.	**5**	**3**	**4**	**60**	**Y**
7.	Cybersecurity risks	Defined appropriate security controls to protect against cyber-attacks, such as encryption, authentication, and access controls.	**5**	**2**	**1**	**10**	**Y**
8.	Frequency distribution problem	Regular maintenance will aid in the prevention of faults and guarantee that the equipment performs at peak efficiency.	**5**	**2**	**2**	**20**	**Y**

9.	Climatic changes impacting transmitter.	Installed environmental controls, such as temperature and humidity control systems, to guarantee that the equipment performs within approved parameters.	**3**	**1**	**2**	**6**	**Y**
10.	Budget shortage	Notifying stakeholders of any changes to the project budget and keeping them updated on the project's financial situation	**3**	**3**	**3**	**27**	**Y**

6.7 Risk Matrix Figure

Probability	33.3%	☐ EV losing contact with the electric wires ☐ Cybersecurity risks ☐ Climatic changes impacting transmitter	☐ Infrastructure failure ☐ Malfunctioning electrical hardware ☐ Electrocutions	☐ Failure of facility standards ☐ Intellectual property
	66.6%	☐ Frequency distribution problem ☐ Charging malfunction ☐ Defective materials	☐ Unavailability of resource ☐ Budget shortage ☐ Lack of workforce	☐ Fire or explosion ☐ Stabilizer malfunction ☐ Demand risk
	100%	☐ Compliance with the safety standards ☐ Delay in installation ☐ Performance risk	☐ Design failure or not met the required specifications ☐ Power supply Insolvency	☐ Electrical hazards ☐ Exceeding budget ☐ Project termination
		Low	**Medium**	**High**
	Severity			

7.0 Financial Plan with Budget

7.1 High-Level Budget Details [Sakshi Manish Kherde, Saloni Madhusudan Bhutada, Aman Maheshwari]

Personnel:

The personnel budget includes the salaries of key team members involved in the project, such as the Project Manager, Electrical Engineer, Civil Engineer, Software Engineer/Developer, Environmental Specialist, Financial Analyst, Procurement Manager, Quality Assurance/Testing Specialist, Stakeholder Engagement Manager, Legal Advisor, and Engineering Manager. The allocated amounts are based on market rates and the expertise required for their respective roles that is shown in the table below:

Budget Details

Position	Salary per Year	Hourly Salary	Hours Worked (9-5)
Project Manager	$100,000	$48.08	2,080
Electrical Engineer	$90,000	$43.27	2,080
Civil Engineer	$80,000	$38.46	2,080
Software Engineer/Developer	$85,000	$40.87	2,080
Environmental Specialist	$75,000	$35.90	2,080
Financial Analyst	$70,000	$33.65	2,080
Procurement Manager	$80,000	$38.46	2,080
Quality Assurance/Testing Specialist	$75,000	$35.90	2,080
Stakeholder Engagement Manager	$85,000	$40.87	2,080
Legal Advisor	$90,000	$43.27	2,080
Engineering Manager	$95,000	$45.67	2,080

7.1 High-Level Team Budget Details

The hourly salary is calculated based on the assumption of 2,080 working hours per year (52 weeks x 40 hours per week), and the number of hours worked is assumed to be 8 hours per day from 9 AM to 5 PM.

Materials & Equipment:

The materials and equipment budget covers the necessary components for the wireless charging infrastructure, including charging stations, inductive charging technology components, construction materials for the circular track, power distribution equipment, software development tools, and licenses, and testing and validation equipment. The estimated amounts are based on research and market prices for the required materials and equipment.

Charging Stations and Infrastructure: $2,000,000
Inductive Charging Technology Components: $500,000
Construction Materials for Circular Track: $1,500,000
Power Distribution Equipment: $300,000
Software Development Tools and Licenses: $150,000
Testing and Validation Equipment: $200,000

Consultants:

The consultants' budget includes fees for external experts who provide specialized technical support and conduct an environmental impact assessment. The allocated amounts are based on anticipated fees for their services.

External Engineering Consultant: $150,000 (for specialized technical expertise)
Environmental Impact Assessment Consultant: $100,000 (for conducting environmental assessments)

Other Expenses:

The other expenses budget comprises various additional costs associated with the project. It includes expenses for permits and regulatory compliance, travel and accommodation for site visits and stakeholder meetings, and a contingency amount to account for unforeseen circumstances or cost overruns.

Permits and Regulatory Compliance: $100,000
Travel and Accommodation: $150,000
Contingency (10% of Total Budget): $440,000

7.2 Budget Justification

The budget is presented in the table below monthly for a period of 12 months.

July 2023 - August 2023, Planning and Research:

Task	Personnel Cost	Materials & Equipment	Consultant Cost	Other Expenses
Planning and Research	31,667	50,000	0	20,000

The personnel costs for planning and research are estimated based on the team's effort during the initial phase, allocating 75% of their time. The materials and equipment expenses cover research materials and initial purchases. There are no consultant expenses during this phase. Other expenses include permits and regulatory compliance.

September 2023 - December 2023, Infrastructure Development:

Task	Personnel Cost	Materials & Equipment	Consultant Cost	Other Expenses
Infrastructure Development	125,000	2,900,000	0	50,000

The personnel costs for infrastructure development increase to 100% effort as the team dedicates their full time to the project. The materials and equipment expenses are significantly higher during this phase as they cover the procurement of charging stations, construction materials, power distribution equipment, software development tools, and licenses. There are no consultant expenses during this phase. Other expenses primarily cover travel and accommodation costs for site visits.

January 2024 - March 2024, Testing and Validation:

Task	Personnel Cost	Materials & Equipment	Consultant Cost	Other Expenses
Testing and Validation	100,000	200,000	250,000	40,000

The personnel costs for testing and validation remain at 100% effort. The materials and equipment expenses cover the purchase of specialized testing and validation equipment. Consultant expenses include fees for an external engineering consultant providing specialized support. Other expenses cover ongoing permits and regulatory compliance.

April 2024 - June 2024, Launch and Stakeholder Engagement:

Task	Personnel Cost	Materials & Equipment	Consultant Cost	Other Expenses
Launch and Stakeholder Engagement	86,250	500,000	100,000	50,000

The personnel costs decrease to 75% effort during the final phase as some team members transition to project finalization activities. The materials and equipment expenses include additional materials for final adjustments and improvements. Consultant expenses cover an environmental impact assessment consultant. Other expenses are allocated for stakeholder meetings and final regulatory compliance.

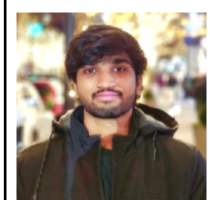
Budget Details Summary:

The budget details summary provides a comprehensive overview of the budget distribution across personnel, materials and equipment, consultants, and other expenses. The contingency amount is included to address unforeseen expenses or budget adjustments that may arise during the project.

Budget Category	Total Cost
Personnel	1,740,000
Materials & Equipment	4,700,000
Consultants	350,000
Other Expenses	200,000
Contingency	440,000
Total Budget	7,430,000

Table 7.2 Budget Summary

8.0 Team Credentials

#	Name	Degree	Relevant Work Ex.	Project Role	Photo
1.	Sumant Vinodchandra Shete	MS Industrial Engineering	Worked at KOHLER in Supply Chain Planning in PMO	Role: **Supply Chain Planning and strategy** Value: Strategic planning and product implementation and optimization.	
2.	Aaryan Mehta	MS in Industrial Engineering B.E in Mechatronics Engineering	Worked in Autoliv as safety supplier intern under the Procurement department	Role: **Procurement Manager** Value: To negotiate with suppliers and get the parts required to develop a wireless charging system.	
3.	Mithul Shyam Gopal Jayasankar	MS in Engineering Management BE in Mechanical Engineering	Worked at Hyundai Mobis in Supply Chain and Product Development Departments	Role: **Product Architect Manager** Value: Designing and implementing the system integrations required for wireless charging infrastructure.	
4.	Sakshi Manish Kherde	MS in Engineering Management BS in Electronics Engineering	Worked with the Government of India in the product development team for a project.	Role: **Project Manager** Value: Manage the production of the required deliverables by planning and monitoring the project. Delegation and use of project assurance roles within agreed reporting structures.	
5.	Saloni Madhusudan Bhutada	MS in Data Analytics Engineering BS in Software Engineering	Worked at Mu Sigma as a Decision Scientist	Role: **Financial Manager** Value: To oversee financial planning, manage budgets, get funding, and analyze financial risks to ensure the project's financial success and sustainability.	

6.	Aman Maheshwari	MS in Data Analytics Engineering BS in Mechanical Engineering	Worked at Camber Racing as a Project Manager	Role: **Engineering Manager** Value: Leading and organizing technical teams to develop dependable wireless charging systems for electric cars, assuring product quality, keeping track of project statuses, and promoting innovation.	

References

1. MDPI: Dynamic Wireless Power Transfer Charging Infrastructure for Future EVs: From Experimental Track to Real Circulated Roads Demonstrations
2. MotorBeam: Volvo Develops Wireless Charging Technology for Electric Vehicles
3. Research Gate

Appendix 4.1

Project Schedule

	Task name	Start date	End date	Durati
		07/03/202	**06/28/202**	2080h
1	**Design Phase**	**07/03/202**	**09/29/202**	**520h**
1.1	Research	07/03/202	07/04/202	h 22m
1.2	Define requirements for the wireless charging infrastruc...	07/24/202	08/14/202	128h
1.3	**Design the network of charging stations**	**08/14/202**	**09/01/202**	**120h**
1.3.1	Determine optimal locations for charging stations ba...	08/14/202	08/18/202	40h
1.3.2	Design electrical and structural plans for charging sta...	08/21/202	08/25/202	40h
1.3.3	Select necessary equipment and materials	08/28/202	09/01/202	40h
1.4	**Design a future-proof infrastructure**	**09/04/202**	**09/22/202**	**120h**
1.4.1	Research emerging technologies and standards in wi...	09/04/202	09/08/202	40h
1.4.2	Evaluate compatibility with different charging standa...	09/11/202	09/15/202	40h
1.4.3	Design a modular and flexible infrastructure to acco...	09/18/202	09/22/202	40h
1.5	**Design user-friendly interfaces and payment systems**	**09/25/202**	**09/29/202**	**40h**
1.5.1	Identify user requirements and preferences	09/25/202	09/27/202	24h
1.5.2	Design an intuitive interface for EV owners to initiate...	09/27/202	09/29/202	24h
2	**Development Phase**	**10/02/202**	**12/29/202**	**520h**
2.1	**Install charging station equipment**	**10/02/202**	**11/10/202**	**240h**
2.1.1	Source reliable suppliers and vendors	10/02/202	10/06/202	40h
2.1.2	Procure charging station hardware and components	10/09/202	10/20/202	80h
2.1.3	Install charging stations at designated locations	10/23/202	11/10/202	120h
2.2	**Develop communication framework for seamless and s...**	**11/13/202**	**12/01/202**	**120h**
2.2.1	Establish protocols and encryption mechanisms for ...	11/13/202	11/17/202	40h
2.2.2	Implement authentication and authorization processes	11/20/202	11/24/202	40h
2.2.3	Test and verify communication protocols and securit...	11/27/202	12/01/202	40h
2.3	**Ensure high efficiency and reliability of the charging pro...**	**12/04/202**	**12/15/202**	**80h**
2.3.1	Optimize inductive charging technology to minimize ...	12/04/202	12/08/202	40h
2.3.2	Conduct performance tests on charging stations to e...	12/04/202	12/15/202	80h
2.4	**Develop user-friendly interfaces and payment systems**	**12/18/202**	**12/29/202**	**80h**
2.4.1	Create interface technology	12/18/202	12/22/202	40h
2.4.2	Integrate secure and convenient payment options	12/18/202	12/29/202	80h
3	**Quality Assurance and Testing**	**01/01/202**	**03/29/202**	**520h**
3.1	**Conduct system-wide testing of the wireless charging in...**	**01/01/202**	**01/31/202**	**184h**
3.1.1	Perform functional testing of charging stations and u...	01/01/202	01/31/202	184h
3.1.2	Verify compatibility with different EV models and ch...	01/08/202	01/31/202	144h
3.1.3	Test communication framework for reliability and se...	01/15/202	01/31/202	104h
3.2	**Evaluate the quality of the developed system**	**02/01/202**	**02/29/202**	**168h**
3.2.1	Establish metrics and criteria for assessing system qu...	02/01/202	02/15/202	88h
3.2.2	Conduct performance and usability evaluations	02/12/202	02/29/202	112h
3.3	Modify system for improved performance	02/01/202	03/29/202	336h
4	**Deployment and Delivery**	**04/01/202**	**06/28/202**	**520h**
4.1	Finalize installation and configuration of the charging i...	04/01/202	04/19/202	120h
4.2	Conduct user training and provide documentation for s...	04/22/202	05/10/202	120h
4.3	Handover the wireless charging infrastructure to the cli...	05/13/202	05/31/202	120h
4.4	Obtain client acceptance and sign off on the project de...	06/03/202	06/28/202	160h

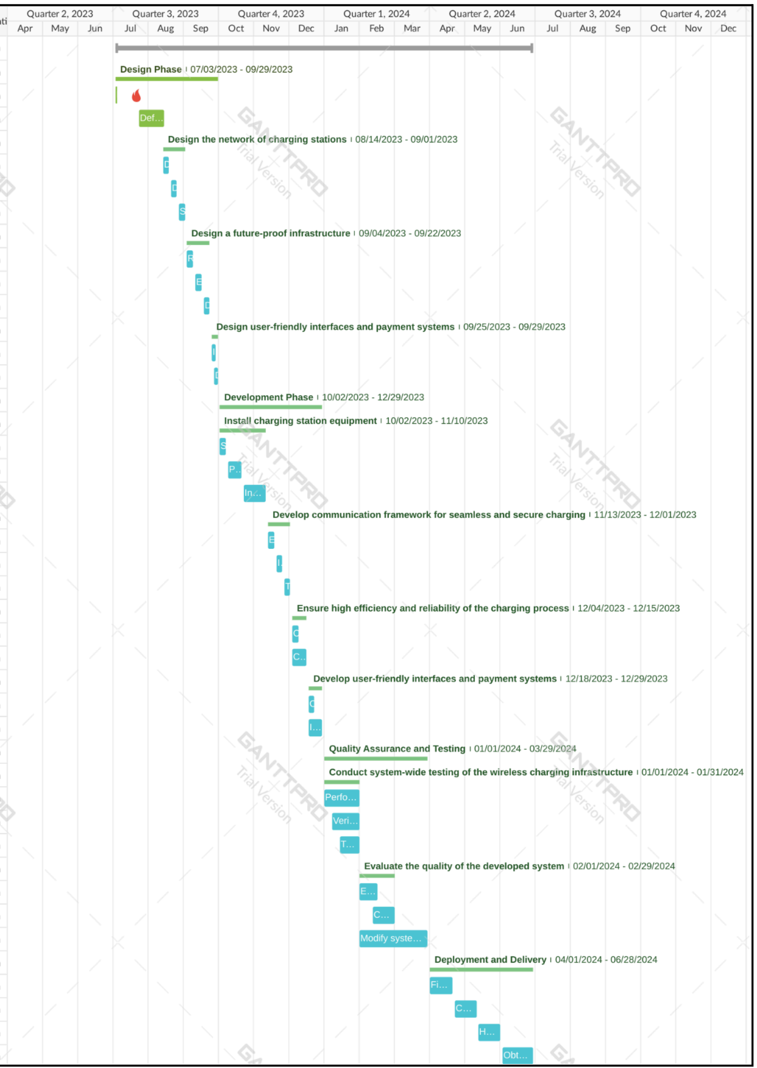


Fig 4.1 Schedule Gantt Chart

Appendix 4.2

Responsibility Chart

	Deliverables / Project Activites	Project Manager	Electrical Engineer	Civil Engineer	Software Engineer/Developer	Environmental Specialist	Financial Analyst	Procurement Manager	Quality Assurance/Testing Specialist	Stakeholder Engagement Manager	Legal Advisor	Engineering Manager
PHASE 1 :Planning and Research	Define project scope and activities	R	I	I	I	I	I	C	I	I	A	I
	Conduct Market Research on Wireless charging technology	R	C	C	C	C	A	I	I			
	Perform feasibility analysis	A					R					
	Develop project budget and financial plan	A					R			R	I	
PHASE 2: Infrastructure Development	Design and engineering of charging stations	A	R	R	C	C	C	A				C
	Install charging stations and power distribution equipment	A	R	R	C	C	C		C			
	Develop software for managing charging process	A	I	I	R		I		I			
	Coordinate contruction activities for the infrastructure	A		R								
PHASE 3: Testing and Validation	Conduct performance testing of charging infrastructure	A	I	I	I	C	A	I	R	I	I	I
	Validate the compatibility of charging station with vehicles	A	I	I	I	I	I	I	R	I	I	C
	Ensure compliance and safety in terms of regulations	A							R			
PHASE 4: Launch and Stakeholder engagement	Engage with government bodies and regulatory bodies	A									R	I
	Conduct Stakeholder meetings and address enquires	A						I		R		I
	Organize a launch event for wireless charging infrastructure	R	I	I	I	I	I	I	I	A	I	I

KEY
R- Responsibile
A- Accountable
C- Consult
I- Inform

Fig 4.2 RACI Chart