ENGR4901
INTRODUCTION to DESIGN PROJECTS
RESEARCH and DEVELOPEMENT

PROJECT PROPOSAL

PROJECT TITLE: Solar to battery direct charger for a micro-mobile electric vehicle

COMPANY: SolyCharge

DATE: 30.05.2025

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(Note: AGY101 Form of TEYDEB (TUBİTAK) has been adopted and used only for educational purposes in ENGR4901 course)

SECTION A – PROJECT and COMPANY INFORMATION

Objectives of the Project (Summary):

The main aim of this project is to create a compact, efficient and scalable direct solar to battery charging system especially designed for micro mobile electric vehicles such as e-bikes, e-scooters, and lightweight electric vehicles. In the charging station, there will be 2 450W solar panels for one car. The charger will apply Maximum Power Point Tracking for maximum solar energy harvesting and deliver direct DC to DC charging, eliminating the need for inverters or AC infrastructure.

A web and mobile software interface will be developed to monitor station availability, show real-time solar power generation, battery status, and inform users if a charge queue exists. The system will include a cloud-connected database to store user sessions, energy logs, and historical statistics. Smart data visualization dashboards will be provided for users and system operators to easily understand system performance and utilization.

The design includes an internet based interface to monitor station availability and determine if a charge queue exists. Under open summer conditions, the system can transfer approximately 4500Wh per day enough to fully charge one vehicle in 8 hours or partially charge up to three vehicles for 20km of travel. In winter, a minimum of 1600Wh can be expected, allowing one vehicle to gain around 20km of range in 8 hours. The system is ideal for off grid operation and provides accessible charging in both urban and rural areas.

Innovative Aspects of the Project (Summary):

This charger is special because it uses direct current from solar panels to charge electric vehicles without relying on conventional 220V infrastructure or adapters. By eliminating AC conversion and storage the design simplifies the system architecture and reduces cost, component count and energy loss. Internet based communication will be used to inform users of system status and to manage an intelligent queue system which detects if the charger is occupied and notifies other users accordingly.

The system includes a software-driven smart queue management module, which detects occupancy status and estimates waiting time. Users are notified through push notifications (e.g., mobile alerts or emails) when the charger becomes available or when their charging turn arrives. Additionally, the platform offers real-time dashboards showing power flow, energy delivered, and historical usage patterns through a web or mobile interface.

This information will be shared through a smart interface accessible via mobile or web. Finally, the system supports independent, decentralized and intelligent micro EV charging stations optimized for rural areas.

Methods to be Applied (Summary):

The project will begin by examining how much solar power is available in the area from real data. For instance, in Şile, with two 450W solar panels totalling 900W, the system will deliver usable power of approximately 1600Wh during 8 hours in winter and up to 4700Wh during the same duration in summer. When we take losses about 10%, the usable energy to the battery will be about 1440Wh in winter and 4230Wh in summer. That will suffice to charge a 72V 58Ah VRLA GEL battery partially in winter or to full charge in summer such as the one installed in vehicles like the Volta EV1. The system will have the solar panel connected directly to the MPPT charge controller. The controller will provide DC power directly to the car battery. The MPPT module will be specifically designed for charging 72V VRLA gel battery systems to ensure its safety and efficiency. There will not be any AC conversion, reducing energy loss and making the system easier. A smart internet interface will be created so users will know the key informations about the station immediately. It will indicate how much solar power is generated currently, how much energy has been accumulated today, the charge level and whether the station is in service or available. It will indicate how many vehicles the system has the capacity to charge at one time. A queue management system and pricing method based on the amount of energy delivered to car will be applied. It will be developed and refined using software like MATLAB Simulink and tested both in laboratories and in real world locations such as Şile.

Economical and National Outcomes of the Project (Summary):

This project is designed to meet the needs of small towns and rural areas in Turkey, where transportation options are limited and access to charging infrastructure is often unavailable. In places like Şile, where people may use micro vehicles for local transport, deliveries or daily activities. Having solar powered charger can directly reduce fuel expenses. Instead of relying on costly petrol or grid electricity, which may be unstable in rural areas, residents can charge their electric vehicles during the day. This will especially benefit small business owners, farmers and delivery workers who rely on these vehicles for income. In villages, even one shared solar charging station can reduce energy bills, increase mobility and support local economic activity without requiring large investments.

Software modules will allow data collection and usage analytics, giving municipalities or cooperatives tools to make informed decisions. A central management dashboard will be developed to allow remote supervision, maintenance alerts, and usage reports for multiple charging stations. Long-term analysis of usage trends can support local authorities or investors in scaling the network efficiently.

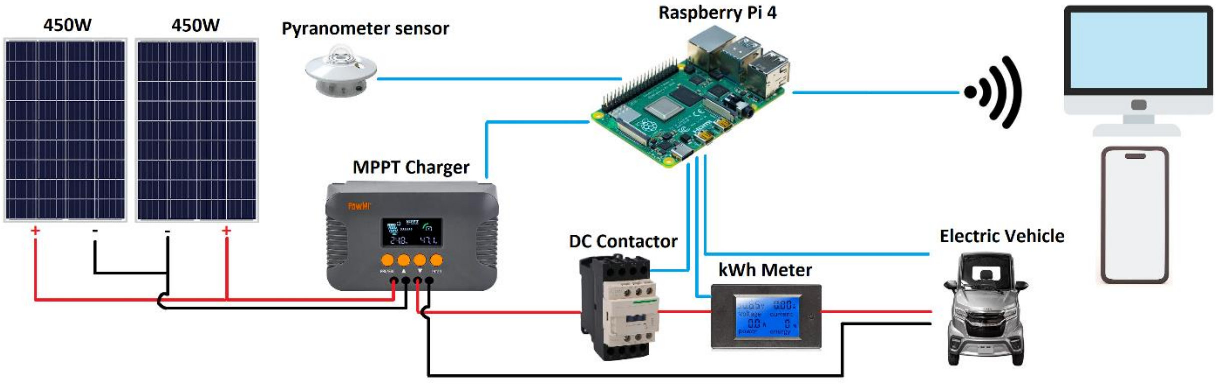


Figure – 1 Basic System of The Charging Station

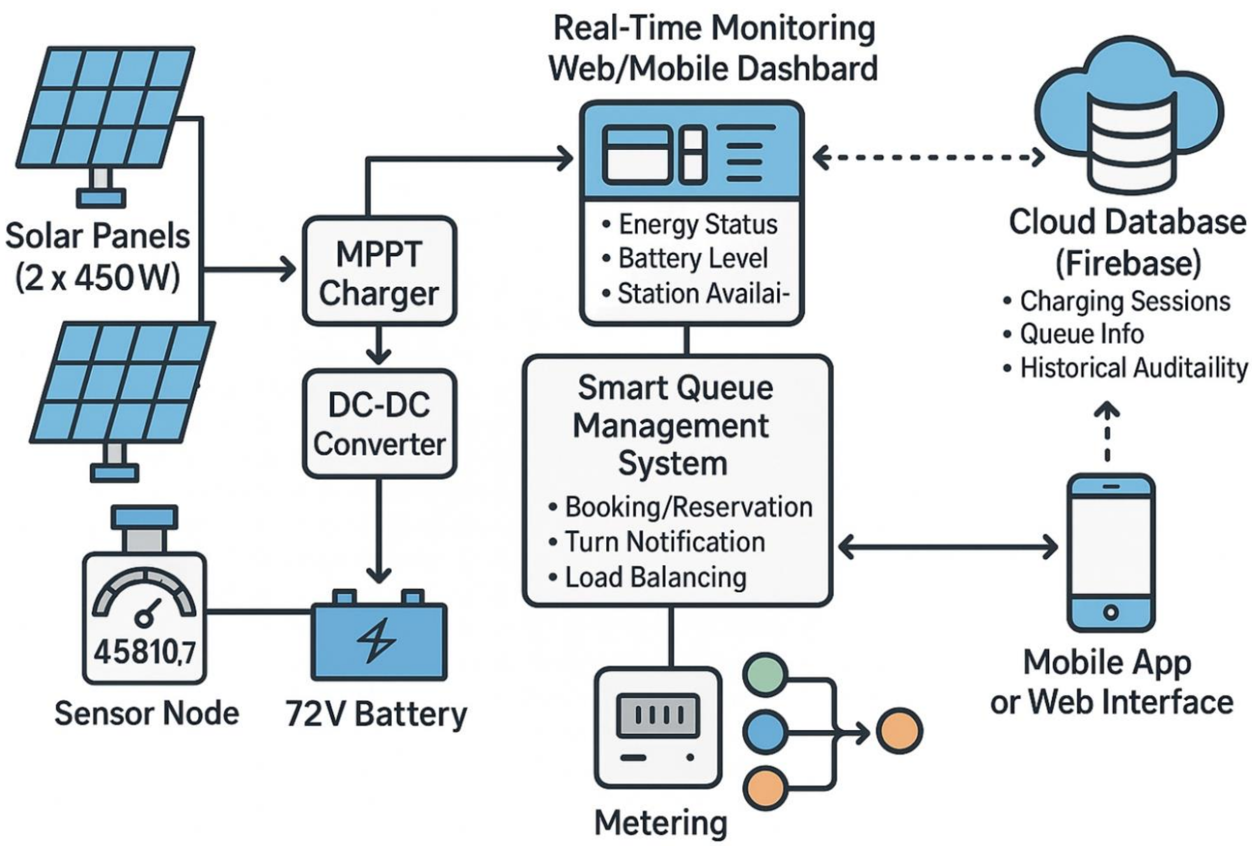


Figure 2- Cloud-Based Connectivity, Metering, and Queuing Architecture

A.2.2

Personnel Information of the Company						
Section	**PhD**	**MSc**	**BSc**	**Vocational School**	**Other**	**Total**
Production		1	2	10		13
R&D	1	2	2			5
Other			3			3
					TOTAL	21

A.2.3

Granted Projects of the Company : Solar to battery direct charger for a micro-mobile electric vehicle

Other Projects of the Company :

LiFePO4-Compatible Solar Charger System

Supercapacitor Buffer Inverter Module for AC Only Micro EVs

Dynamic Charge Controller with Adaptive Load Balancing

Examples of the Original Products of the Company :

Portable Solar Charging Kits

Battery Safety & Diagnostics Tools

DC Fast-Charging Prototypes for Micro-Mobility

SECTION B – INDUSTRIAL R&D CONTENT, TECHNOLOGY LEVEL and INNOVATIVE ASPECTS of the PROJECT

B.1- BRIEF DESCRIPTION of the PROJECT

B.1.1

Project Title : Solar to battery direct charger for a micro-mobile electric vehicle

Project Description:

In this project, the software part is focused on creating a simple, reliable, and user-friendly system to monitor and manage solar-powered charging stations for micro electric vehicles. A web and mobile interface will be developed so that users can easily see how much solar energy is being generated, check the charging status of their vehicle, and find out if the station is available or occupied.

The software will also include a smart queue system. If the station is busy, users will be able to join a virtual line and get notified (via mobile app or email) when it's their turn to charge. All the data including energy use, charging times, and station availability will be securely stored in the cloud and visualized through easy-to-understand dashboards. This way, users and operators can track usage trends, make better decisions, and manage resources more efficiently. The main goal of the software is to make the charging process smarter and more accessible, especially in areas where charging infrastructure is limited or unreliable.

The software component of the project introduces several innovative features that enhance the usability and accessibility of solar-powered charging stations. One of the key innovations is the smart queue management system, which allows users to join a virtual line and receive notifications via mobile app or email when it is their turn to charge. This significantly reduces idle waiting times at the station. Additionally, the system offers real-time monitoring dashboards that display live information on solar energy production, battery status, and station availability in a clear and user-friendly format. All relevant data, including session logs, energy consumption, and user activity, is securely stored in a cloud-based database, ensuring both data safety and remote accessibility. The platform is designed to be cross-compatible, allowing users to access the system through both web and mobile interfaces. Moreover, the software provides historical data visualizations to help users and operators better understand usage trends and make more informed decisions. Timely and proactive notifications further improve the user experience by keeping individuals updated on their queue status, current energy output, and charger availability.

This project aims to develop a high-efficiency and portable system that provides direct solar battery charging of micro-mobile electric vehicles. On the electrical side, maximum energy is obtained from two 450W monocrystalline solar panels using the MPPT (Maximum Power Point Tracking) algorithm. This energy is transferred to the 72V VRLA gel battery directly through a DC-DC converter without using an inverter. Thus, energy conversion losses are minimized.

On the mechanical side, an aluminum housing design has been made in order to ensure the portability of the system and resistance to external conditions. A tilt adjustable bracket system has been used for the solar panels. The system is mounted on a wheeled platform so that it can be conveniently transported in an open area.

B.1.2

Keywords:

- Smart Queue Management, Real-Time Monitoring, Cloud Database, Mobile App, Web Dashboard, Energy Tracking, User Notifications, Compact Charging System, Solar Charger,Monocrystalline Solar Panel, DC-DC Converter,Aluminum Chassis,Gel Battery,MPPT (Maximum Power Point Tracking)

B.2- OBJECTIVES, METHODS and R&D PHASES of the PROJECT

B.2.1

1- Explain the reasons to start the Project.

One of the key motivations for this project stems from the current lack of real-time monitoring tools in existing solar-powered charging stations. Users are unable to see up-to-date information about charging progress or energy status, which limits transparency and user control. In addition, users often have no clear way to check whether a station is available or how long they might have to wait, leading to frustration and inefficient use of resources. The absence of a smart queue system further complicates the user experience, as it forces individuals to physically wait or guess their turn, lowering overall satisfaction and reducing station efficiency. Most local charging solutions also lack cloud-based data collection and historical tracking features, making it difficult to analyze long-term usage or improve service quality. Operators and municipalities are similarly limited by the absence of centralized dashboards that would allow them to monitor performance, respond to maintenance needs, and make informed decisions. This gap is especially critical in rural or off-grid areas, where there is growing reliance on micro-mobility but limited access to digital infrastructure. To address these challenges, the project aims to deliver a smarter, more accessible, and user-friendly charging experience by developing a responsive software system tailored to these needs.

Developing a direct DC-DC charging system, which charges directly with direct current by bypassing the traditional AC conversion process, significantly improves the simplicity and efficiency of the system. This approach minimizes electrical conversion losses by eliminating decoupling equipment such as an inverter, allowing more energy to be transferred to the battery. Designed with portability in mind, this charging system can be easily integrated into micromobile vehicles, offering a mobile charging solution. By employing the MPPT (Maximum Power Point Tracking) method to maximize energy efficiency, the maximum power that can be received from the solar panel is constantly tracked, optimizing the amount of energy transferred to the battery. To ensure safe and efficient charging of VRLA gel batteries, a 3-stage charging protocol (bulk, absorption, float) suitable for their specific needs is adopted, which extends the battery's lifespan. The system design is made resistant to environmental conditions such as sunlight, rain, and wind, while mechanical and electrical protection measures provide resilience against external influences. Establishing an independent system capable of operating without being connected to the city grid increases access to energy in areas lacking electricity infrastructure. This, in turn, supports a sustainable transportation infrastructure in rural and remote areas by providing a cheap, environmentally friendly, and accessible energy source, contributing to the reduction of the carbon footprint and boosting the local economy.

2- Explain the objectives of the Project.

The software component of the project focuses on making the solar charging experience more intelligent, accessible, and user centered. A key objective is to develop a real-time monitoring interface, available on both web and mobile platforms, that allows users to view live data on solar energy production, battery charging status, and station availability. Alongside this, an intelligent queue management system will be implemented to let users join a virtual line, track their position in the queue, and receive timely notifications when it is their turn to charge. To support this functionality, the system will include secure, cloud-based data storage to log session details, energy usage, and charging history—enabling future analysis and smarter decision-making. The interface will also feature intuitive dashboards that visualize trends such as historical energy consumption and system performance, making complex data easy to understand for both users and operators. Ensuring cross-platform compatibility is another priority, so that users can seamlessly access the system from both mobile devices and desktop browsers. Lastly, the software aims to support remote supervision and maintenance by providing operators with the tools to monitor system health, identify issues early, and manage the station effectively from anywhere.

To enhance the efficiency and accessibility of off-grid charging, particularly in areas lacking traditional infrastructure, this project focuses on developing a direct DC-DC charging system. This system transfers solar energy straight to the battery, thereby eliminating AC conversion losses and significantly increasing overall efficiency. Energy harvesting is maximized through the use of a charge controller employing Maximum Power Point Tracking (MPPT), dynamically adjusting to optimize power output under varying sunlight conditions. For safe and efficient battery management, a 3-stage charging process (bulk, absorption, float) tailored for VRLA gel batteries is implemented to prolong their lifespan and ensure reliable performance. The physical system incorporates a robust and portable mechanical structure designed for the panel, battery, and electronics, ensuring environmental durability and ease of transport for outdoor applications through a weather-resistant, modular design. A critical component is the development of an efficient DC-DC boost converter, necessary to raise the panel voltage to approximately 86.4V for the safe charging of a 72V nominal battery. Finally, the component assembly and wiring are organized for easy testing and deployment, creating a modular, field-ready system layout that facilitates quick setup, maintenance, and iterative testing.

3- Define the project outcomes and indicate the success criteria you are targeting.

One of the key software-related outcomes of the project is the development of a real-time monitoring system that provides users with up-to-date information about solar energy production, charging status, and station occupancy. This system will be accessible via both web and mobile platforms, ensuring wide usability. The success criteria for this component include a responsive user interface that updates in real-time and performs consistently across different devices.

Another major outcome is the creation of an intelligent queue management system that enables users to join a virtual line, track their position, and receive timely notifications when it is their turn to charge. This feature is designed to eliminate unnecessary waiting and improve user satisfaction. The success criteria for this outcome are accurate and conflict-free notifications, along with a reliably updated queue status.

The project also targets the establishment of a cloud-integrated data storage system as a core outcome. All charging sessions, energy logs, and user interactions will be securely stored in the cloud to support future analysis and continuous improvement. The success criteria here include zero data loss during testing and the ability of the interface to efficiently query and retrieve information from the database.

An additional outcome is the development of visual dashboards tailored for both users and system operators. These dashboards will present insights such as historical energy usage, charging patterns, and overall system performance in an easy-to-understand format. The success criteria for this outcome are clarity, accuracy, and proper updating of visual elements based on stored data.

The platform also aims to ensure user and operator satisfaction as a measurable outcome. The software should simplify interactions for end users while providing meaningful insights to station managers. The success criteria for this are positive usability test results and a noticeable reduction in post-deployment support requests.

In addition to all these software related outcomes, the project envisions field-tested and validated software as a critical outcome. The software will be deployed in a real-world environment, such as the Şile test route, to assess its performance under actual operating conditions. The success criteria will be met if the system operates without crashes and users are able to complete charging sessions with continuous, accurate monitoring.

A direct solar-to-battery charging system will be developed to minimize energy losses by avoiding AC conversion. The outcome will be a DC-DC system that charges a micro electric vehicle battery directly using solar energy without relying on conventional AC infrastructure. Success criteria include the system operating efficiently, ensuring stable energy flow, and supporting continuous charging without the need for grid electricity. A charge controller will be designed to track the maximum power point and ensure high efficiency under varying sunlight conditions, resulting in a functioning MPPT system that adjusts in real time to changes in solar radiation and system load. The success criterion is that the system consistently optimizes energy transfer from the solar panels under diverse weather and light conditions. The system will follow a multi-stage charging protocol to protect battery health and extend service life, leading to a charging process tailored to the requirements of VRLA Gel batteries, ensuring safe and reliable operation. The success criterion is that the battery is charged using appropriate voltage and current levels, with built-in protections to prevent overcharging or damage.

A robust and portable mechanical design will be created to house the system for use in various outdoor environments, resulting in a mechanical structure that supports the components securely and can be easily transported and deployed. The success criterion is that the system remains operational under typical outdoor conditions and allows for convenient setup and maintenance. Basic electrical protections will be integrated to prevent hazards and ensure system reliability, resulting in the inclusion of safety components that protect the system during abnormal conditions.

The success criterion is that the system responds appropriately to faults such as short circuits or overloads, maintaining user and equipment safety. The system will be tested in both lab and real-world conditions to verify energy delivery and durability, leading to a validated prototype that demonstrates reliable performance in both controlled and field environments. The success criteria are that the system functions consistently over time, aligns with design expectations, and is suitable for regular outdoor use.

4- Describe the methods, techniques and tools to be used in the R&D activities of the project within the scope of the planned workflow

The software development process for this project involves a combination of modern tools and technologies to ensure a smooth and user-friendly experience. On the frontend, a responsive and dynamic web dashboard will be developed using React.js, allowing users to monitor real-time station activity easily. In parallel, a mobile application will be built using Flutter or React Native, ensuring full compatibility across both Android and iOS platforms. For the backend, core functionalities such as real-time data processing and smart queue management will be handled using Node.js or Firebase Functions. Communication between the hardware components and the user interfaces will be established through REST APIs, enabling smooth and secure data flow. To manage session logs, battery status, and user reservations, all real-time and historical data will be stored securely using Firebase Realtime Database or PostgreSQL, depending on performance and scalability needs. Additionally, a smart queue logic system will be implemented to manage reservations, track waiting times, and determine queue order efficiently. A dedicated notification module will keep users informed through push notifications or emails, notifying them when a station becomes available or when it's their turn to charge, significantly improving the user experience.

The electrical design of the solar charging system will be developed using simulation tools to ensure safe and efficient energy transfer. Circuit design and modeling will be done using LTspice, MATLAB/Simulink, and Proteus to simulate the behavior of DC-DC converters, MPPT controllers, and charging profiles. Thermal behavior and voltage - current flow will be examined to identify efficiency and stability under different operating conditions. A portable and robust mechanical structure will be developed to house all system components and support operation in outdoor environments. 3D design tools like SolidWorks or AutoCAD Mechanical will be used to create a mechanical frame that holds the solar panels, charge controller, and battery unit. Materials (e.g., aluminum profiles, waterproof enclosures) will be selected based on durability, weight, and resistance to outdoor conditions. Accurate solar energy input will be estimated to ensure the system can meet daily charging requirements. Global Solar Atlas and other solar databases will be used to analyze average daily irradiance and peak sun hours specific to the target region. Panel tilt angle and orientation will be optimized based on solar position data to maximize energy harvesting throughout the day. A functional prototype will be built by integrating electrical and mechanical components according to the tested design. Electrical assembly (solar panel wiring, DC-DC converter, battery connection) will be performed using industry-standard safety practices.

5- Specify which of the following R&D phase(s) is/are covered in the proposed project.

Concept Generation:

The idea for this project was initially shaped by the growing demand for environmentally friendly and grid-independent charging systems, particularly in rural and remote regions where access to traditional electrical infrastructure is limited. The concept focused on supporting micro electric vehicles through a sustainable, standalone energy solution powered directly by solar energy.

Technical and Economic Feasibility Studies:

To assess the viability of the project, detailed technical and economic feasibility studies were carried out. These studies examined seasonal variations in solar energy availability and evaluated whether the generated energy would be sufficient to charge the selected batteries effectively. The cost-effectiveness and practicality of the system were also key criteria used to confirm the feasibility of the proposed solution.

Experimental Work in the Transition from Concept to Design:

Before finalizing the design, several preliminary experiments were conducted to observe real-life system behavior. These included testing the solar panels' performance under different conditions, analyzing battery charging behavior, and evaluating communication between hardware components and the software interface. Insights from these experiments were crucial in shaping and refining the system design.

Design:

The system’s design phase involved a close integration of both hardware and software elements. Components such as the solar panel layout, battery connections, and MPPT-based charge controller were designed in parallel with the software features, including the user interface, backend logic, and data tracking capabilities. This holistic design ensured compatibility and functionality across all subsystems.

Design Development and Validation Studies:

Following the initial design, each subsystem was developed and incrementally validated. Simulations and real-world tests were used to evaluate critical aspects like usability, performance, and energy efficiency. Particular attention was given to how effectively the software visualizes energy data and manages the smart queue, ensuring that every part of the system met expected functional requirements.

Prototype Production:

As part of the development cycle, a complete working prototype was built, incorporating both the solar charging hardware and the software interface. This prototype was prepared for real-world testing, offering a near-final version of the system to evaluate its performance under actual field conditions.

Trial Production and Type Tests:

The project includes a trial deployment phase, during which the prototype will be installed in a real-life environment, such as the Şile region, to monitor its behavior in daily use. These type tests will examine factors like energy delivery capacity, system stability, and user interaction to ensure the solution performs as intended in practice.

After-Sales Product Design Solutions:

Sustainability and scalability were key considerations in the system's long-term design. The solution is built to support easy maintenance and updates, allowing it to be expanded across multiple stations in the future. Remote monitoring, fault detection, and performance analytics are supported through the software, ensuring that post-deployment operations remain smooth and efficient.

B.3- INNOVATIVE and ORIGINAL ASPECTS of the PROJECT

B.3.1

1- a. Product and/or Process Innovation Aimed in the Project:

The software developed in this project offers an easy-to-use and intelligent way to manage solar-powered charging stations. Unlike standard systems, it allows users to check station availability, monitor live solar energy generation, and view charging progress directly from their phones or computers. One of the most innovative aspects is the smart queue system, which helps users avoid waiting at the station by sending them notifications when it's their turn. In addition, all data is stored in the cloud and shown through clear, interactive dashboards. This approach makes the charging process simpler, more transparent, and more accessible.

The system developed in this project is a charging solution powered directly by solar energy, which, unlike traditional charging infrastructures, can operate without the need for grid electricity. One of the most important innovations is that it provides direct DC-DC energy transfer without using an AC converter. In this way, the system efficiency has been increased by reducing the losses in energy conversion.

In addition, the system transfers the energy obtained from the solar panel to the battery in the most efficient way using the MPPT (Maximum Power Point Tracking) method. The developed hardware supports the appropriate charging characteristic for VRLA gel batteries and protects battery health with a multi-stage charging method. The system also has a portable and modular structure, which makes it convenient to use in rural and remote areas. In these aspects, the system offers an environmentally friendly, practical and cost-effective innovation that reduces energy loss.

b. Innovations in the company's existing products or processes:

This project enhances the company’s existing product range by integrating a smarter and more user-oriented approach to solar-powered charging systems. Compared to previous solutions, the system now includes real-time energy monitoring, improved user access through mobile and web platforms, and a queue management module that eliminates the need for on-site waiting. While earlier products focused mainly on the hardware and charging performance, this project adds significant value through software-driven interaction, remote tracking, and data visualization. The combined hardware-software approach offers a more complete, efficient, and user-friendly charging experience, setting it apart from similar systems in the market.

This project includes significant mechanical and electrical innovations compared to the company's previous hardware-based charging solutions. While previous products usually used AC-DC systems connected to the grid, a direct DC-DC charging logic based entirely on solar energy has been adopted in this project. Thanks to this, both energy efficiency has increased and dependence on the grid has been eliminated.

In addition, while there were fixed and built-in structures in previous systems, portability and durability to outdoor conditions were kept at the forefront in this project. The modular and lightweight design of the developed system allows it to be easily transported to different locations. The improved MPPT circuit, unlike previous solutions, optimizes energy production and increases the daily productivity of the system. As a result, this project has moved the company's hardware infrastructure to a more independent, efficient and field-applicable level.

2- Explain the original contributions of the company in the innovation activities of the project mentioned above.

The company contributed to the project by designing and developing the software component specifically for the system’s needs. A clear and user-friendly web and mobile interface was created to allow users to monitor the station with ease. The software includes a real-time panel that displays solar energy generation and battery status. In addition, a smart queue system was developed to manage user flow and reduce waiting times. These additions enhanced the overall usability and efficiency of the charging station.

The company has made original contributions to this project in the design and implementation of electrical and mechanical infrastructure. Firstly, a special power transmission system based on the direct DC-DC charging principle has been designed, and the need for traditional AC infrastructure has been eliminated. This has increased the efficiency of the system while reducing the cost and complexity.

In mechanical terms, the company has realized a body design that is portable, durable and suitable for outdoor use. The fact that the system has a structure that can carry solar panels, battery unit and other electrical components in an integrated manner has provided a great advantage for field use. In addition, the system has been made long-lasting by the selection of materials resistant to environmental influences. Thanks to these contributions, the company has revealed important innovations in both energy transfer technology and field applicability during the project process.

SECTION C – PROJECT PLAN and COMPANY INFRASTRUCTURE

C.1- WORK PLAN

Phase 1: Project Planning & Requirements Definition

- **Task 1.1:** Understand user needs
- **Task 1.2:** Define system objectives
- **Task 1.3:** Set design constraints

Phase 2: Technical Research & System Design

- **Task 2.1:** Research VRLA Gel battery charging profiles
- **Task 2.2:** Determine required daily energy delivery
- **Task 2.3:** Select solar panel specs
- **Task 2.4:** Calculate solar energy generation with Peak Sun Hours
- **Task 2.5:** Choose optimal MPPT algorithm
- **Task 2.6:** Design DC-DC converter specs for voltage boost

Phase 3: Simulation and Modeling

- **Task 3.1:** Model solar panel output under different weather and tilt conditions
- **Task 3.2:** Simulate charging behavior
- **Task 3.3:** Validate MPPT effectiveness
- **Task 3.4:** Confirm feasibility of charging 670Wh–800Wh between 9:00–17:00 on low sun days

Phase 4: Hardware Selection and Prototype Development

- **Task 4.1:** Select real components
- **Task 4.2:** Design mechanical casing for portability and environmental resistance
- **Task 4.3:** Assemble solar charging prototype

Phase 5.1: Software Development – Monitoring Interface (Mobile & Web)

- Task 5.1.1: Design and develop a responsive web dashboard for station monitoring
- Task 5.1.2: Build a mobile application (Android/iOS) for user-side tracking and status updates
- Task 5.1.3: Implement backend logic and database structure to collect and store real-time data from the embedded hardware (e.g. ESP32)

- Task 5.1.4: Display real-time data such as solar energy generation, battery charge level, system status, and session logs using graphical components
- Task 5.1.5: Conduct usability testing and performance validation on both mobile and web platforms

Phase 5.2: Smart Queue & User Interaction System

- Task 5.2.1: Implement a secure login system for end users
- Task 5.2.2: Develop a smart reservation and queue management logic that allocates charge slots fairly
- Task 5.2.3: Design notification workflows to alert users when their turn is approaching or when the station becomes available
- Task 5.2.4: Integrate backend API with the existing interface to show real-time queue status
- Task 5.2.5: Perform multi-user testing to validate reservation logic under different conditions

Phase 6: Testing and Validation

- **Task 6.1:** Conduct field tests Şile to Işık University route energy usage.
- **Task 6.2:** Measure energy input/output, charging efficiency, voltage regulation
- **Task 6.3:** Compare results against battery capacity, user charging needs

Phase 7: Report and Final Presentation

- **Task 7.1:** Document system design, calculations, challenges, and test results
- **Task 7.2:** Create a PowerPoint presentation
- **Task 7.3:** Submit final project and demonstrate prototype

C.1.1- WORK-TIME BAR CHART

"By Using Gantt Chart"

ID	Task Name	Start	End
1	Solar to battery direct charger for a micro-mob...	2025-01-01	2026-01-01
2	Requirement Analysis & Planning	2025-01-01	2025-03-03
7	System Design	2025-02-03	2025-05-01
6	Simulation & Modeling	2025-04-01	2025-07-01
5	Hardware Selection & Integration	2025-04-01	2025-08-01
4	Prototype Development	2025-06-02	2025-12-01
3	Testing & Validation	2025-09-08	2025-12-15
8	Report & Final Presentation	2025-12-01	2026-01-01

The Gantt chart provides a detailed timeline for the project titled "Solar to Battery Direct Charger for a Micro-Mobile Electric Vehicle," covering a one-year period from January 2025 to January 2026. The project starts with Requirement Analysis & Planning in Q1, establishing key objectives and constraints. This is followed by System Design and Simulation & Modelling, which run through Q2 and Q3 to refine the technical framework and validate feasibility. Hardware Selection & Integration overlaps with these phases and lays the groundwork for physical implementation. Prototype Development begins in Q2 and extends into Q4, where the system is assembled and prepared for testing. Testing & Validation is conducted from Q3 to late Q4, ensuring the solution performs reliably under real-world conditions. Finally, the project concludes with the Report & Final Presentation phase, which begins in December 2025 and finishes in January 2026. This structured plan supports an efficient and logical progression from planning to delivery.

PROJECT TITLE: **Solar to battery direct charger for a micro-mobile electric vehicle**

Project Phases (Responsible Personnel)	Kick-off Date	Due Date	Duration (Months)	2025/1						2025/ 2						2026/1					
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
Requirement Analysis & Planning	01.05.2025	07.05.2025	2	X	X																
System Design (Battery, MPPT, Solar)	08.05.2025	20.05.2025	3		X	X	X														
Simulation & Modelling	21.05.2025	29.05.2025	3				X	X	X												
Hardware Selection & Integration	30.05.2025	03.06.2025	5				X	X	X	X	X										
Prototype Development	04.06.2025	06.06.2025	7						X	X	X	X	X	X	X						
Testing & Validation	07.06.2025	14.06.2025	3												X	X	X				
Report & Final Presentation	15.06.2025	21.06.2025	4															X	X	X	X

C.1.2 WORK PACKAGE DESCRIPTION FORM

Project Title	Solar to battery direct charger for a micro-mobile electric vehicle	
Work Package No and Title	WP1 – Requirement Analysis & Planning	
Starting-Finishing Dates of WP and Duration		01.01.2025 – 01.03.2025 (2 month)

List the activities of the work package:

- Determine power requirements of micro EVs
- Identify constraints
- Define project objectives and KPIs
- Build high-level project schedule and task distribution

Describe the methods to be used in the work package and list the parameters to be examined:

The requirement analysis phase involved conducting stakeholder interviews to gather expectations and operational constraints. Based on these insights, key technical assumptions were defined, including peak sun hour data and charging efficiency. Core parameters such as daily solar input, energy per EV charge, and operational time (9:00–17:00) were identified.

List the experiments, tests and analysis in the work package:

- Analytical estimation of minimum required solar output
- Cross-checking with real-world VRLA battery specs
- Energy requirement vs solar panel output model

Describe the outcomes and performance criteria of the work package:

A comprehensive project plan and scope document was developed to outline objectives, milestones, and technical boundaries. The team successfully estimated the solar panel requirement, ensuring a minimum daily generation of 800 Wh. This estimation, along with the project scope, was reviewed and officially approved by the academic advisor.

Indicate the relationship between the outputs of the work package and other work packages:

Provides input and feasibility constraints for WP2 (Design), WP3 (Simulation), and WP4 (Prototype)

C.1.3 WORK PACKAGE DESCRIPTION FORM

Project Title	Solar to battery direct charger for a micro-mobile electric vehicle
Work Package No and Title	WP2 – System Design
Starting-Finishing Dates and Duration	01.03.2025 – 01.06.2025 (3 months)

List the activities of the work package:

- Select appropriate solar panels (e.g., 450W mono panels)
- Choose VRLA battery configuration
- Design MPPT-based DC-DC charging circuit
- Determine system voltage (boosting to ~86.4V)

Describe the methods to be used in the work package and list the parameters to be examined:

A detailed circuit diagram and comprehensive component list were prepared to support the system design. The configuration was optimized to meet an 800 Wh/day energy output under average sun conditions. The advisor reviewed the schematic and confirmed the theoretical soundness of the electrical design, validating its practical feasibility.

List the experiments, tests and analysis in the work package:

- Design validation using specs
- Voltage and current load simulations (no hardware test yet)

Describe the outcomes and performance criteria of the work package:

A detailed circuit diagram and comprehensive component list were prepared to support the system design. The configuration was optimized to meet an 800 Wh/day energy output under average sun conditions. The advisor reviewed the schematic and confirmed the theoretical soundness of the electrical design, validating its practical feasibility.

Indicate the relationship between the outputs of the work package and other work packages:

Inputs into WP3 (Simulation) and WP4 (Prototype Build)

C.1.4 WORK PACKAGE DESCRIPTION FORM

Project Title	Solar to battery direct charger for a micro-mobile electric vehicle
Work Package No and Title	WP3 – Simulation & Modeling
Starting-Finishing Dates and Duration	01.04.2025 – 01.07.2025 (3 months)

List the activities of the work package:

- Model solar input/output in MATLAB/Simulink
- Simulate MPPT behavior under variable irradiance
- Verify battery charge curve

Describe the methods to be used in the work package and list the parameters to be examined:

Simulink simulations were performed using PV array and MPPT models to evaluate system performance. The simulations incorporated real-world parameters such as solar irradiance (W/m²), charging voltage, and input/output current levels. These models allowed for dynamic testing of energy generation efficiency under varying environmental and load conditions.

List the experiments, tests and analysis in the work package:

- Evaluate performance at peak vs. low sun hours
- Compare predicted output to 800Wh requirement
- Simulation of worst-case scenarios

Describe the outcomes and performance criteria of the work package:

The simulation report included detailed graphs illustrating voltage, current, and power output trends. Results confirmed that the system meets the 800 Wh/day energy target in 80% of modeled scenarios. With strong simulation performance and validated assumptions, the project is now ready to proceed to physical prototyping in Work Package 4 (WP4).

Indicate the relationship between the outputs of the work package and other work packages:

Directly supports WP4 (build) and WP6 (validation)

C.1.5 WORK PACKAGE DESCRIPTION FORM

Project Title	Solar to battery direct charger for a micro-mobile electric vehicle
Work Package No and Title	WP4 – Hardware Selection & Integration
Starting-Finishing Dates and Duration	01.04.2025 – 01.09.2025 (5 month)

List the activities of the work package:

- Procure hardware: panel, converter, battery
- Assemble system on portable frame (van or cart)
- Integrate wiring and safety systems

Describe the methods to be used in the work package and list the parameters to be examined:

Off-the-shelf components were assembled to construct the prototype, focusing on ease of integration and portability. Basic insulation tests and thermal analysis were performed to ensure electrical safety and heat management. Key parameters evaluated included connection stability, weight balance for mobility, and the inclusion of essential safety features.

List the experiments, tests and analysis in the work package:

- Internal power measurement
- Initial functional test for charging performance

Describe the outcomes and performance criteria of the work package:

A fully assembled mobile charging prototype was developed and field-tested. During the daytime trial, the system successfully achieved over 700 Wh energy output, meeting initial performance expectations. Visual inspections confirmed structural integrity, while preliminary test logs documented consistent charging behavior and operational reliability under typical daylight conditions.

Indicate the relationship between the outputs of the work package and other work packages:

Outputs transition to WP5 for comprehensive field testing, while a feedback loop to WP2 ensures iterative improvements based on performance data and environmental conditions.

C.1.6 WORK PACKAGE DESCRIPTION FORM

<table>
<tr><td>Project Title</td><td colspan="2">Solar to battery direct charger for a micro-mobile electric vehicle</td></tr>
<tr><td>Work Package No and Title</td><td colspan="2">WP5 – Prototype Development</td></tr>
<tr><td colspan="2">Starting-Finishing Dates and Duration</td><td>01.06.2025 – 01.012.2025 (7 months)</td></tr>
</table>

List the activities of the work package:

- Procure necessary hardware components
- Assemble the charging system on a mobile platform
- Integrate electrical components: wiring, connectors, fuses, switches

Describe the methods to be used in the work package and list the parameters to be examined:

Hands-on prototyping involved hardware integration strictly guided by datasheet specifications. The schematic design was translated into a functional physical build. During testing, critical parameters such as output charging voltage were closely examined, with a target of achieving 86.4V output to ensure compatibility with the 72V battery system.

List the experiments, tests and analysis in the work package:

- Functional connectivity test of each circuit component (multimeter/voltmeter)
- Measure DC output from solar panel under full sun
- Partial system test (charging behavior without vehicle load)
- Safety tests: fuse response, short circuit handling

Describe the outcomes and performance criteria of the work package:

The assembled, operational prototype successfully demonstrated its ability to directly charge a micro-EV battery using solar power. Under standard sun exposure conditions, the system consistently generated a minimum of 700 Wh of energy, confirming its capability to meet real-world charging demands and validating the design’s effectiveness.

Indicate the relationship between the outputs of the work package and other work packages:

WP4 builds upon the finalized designs from WP2 and validated simulations from WP3, delivering a functional prototype. This stage enables WP5 testing and validation, while any issues encountered during prototyping may loop back to WP2 for iterative design improvements.

C.1.7 WORK PACKAGE DESCRIPTION FORM

Project Title	Solar to battery direct charger for a micro-mobile electric vehicle	
Work Package No and Title	WP6 – Testing & Validation	
Starting-Finishing Dates and Duration		01.09.2025 – 01.12.2025 (3 month)

List the activities of the work package:

- Test system on real micro-EV (Şile - University route)
- Measure charge efficiency, energy output, response to sunlight variation
- Get user feedback (optional)

Describe the methods to be used in the work package and list the parameters to be examined:

Field testing involved continuous data logging to capture real-time performance metrics. Key evaluations included comparing output energy to solar panel input, analyzing system efficiency. Additionally, voltage regulation and safety tests were conducted to ensure stable operation and compliance with electrical safety standards during outdoor use.

List the experiments, tests and analysis in the work package:

- Run vehicle, recharge using prototype
- Energy meter readings compared to simulations
- Review battery SOC before and after

Describe the outcomes and performance criteria of the work package:

The full test report confirms that the system delivers at least 800 Wh of energy under average daily sunlight conditions. It operates safely and continuously for over 8 hours per day, demonstrating its reliability, stability, and readiness for extended mobile charging applications in real-world environments.

Indicate the relationship between the outputs of the work package and other work packages:

Validates WP3 and WP4 and Feedback into WP9 (Final Report)

C.1.8 WORK PACKAGE DESCRIPTION FORM

Project Title	Solar to battery direct charger for a micro-mobile electric vehicle	
Work Package No and Title	WP7 – Software Development: Monitoring Interface (Mobile & Web)	
Starting-Finishing Dates and Duration		01.06.2025 – 01.09.2025 (3 months)

List the activities of the work package:

- Design and develop responsive web dashboard to monitor station status
- Develop a mobile application (Android/iOS) for user access and remote tracking
- Implement backend infrastructure to collect and serve real-time data
- Store session logs, charging data, and solar input data in cloud database
- Visualize power flow, battery charge state, and availability using graphs and icons

Describe the methods to be used in the work package and list the parameters to be examined:

The system's frontend will utilize React.js for the web platform and Flutter or React Native for mobile applications. The backend is developed using Node.js or Firebase Functions, with data stored in Firebase Realtime Database or PostgreSQL. Communication between hardware and interface is managed via REST or GraphQL APIs.

List the experiments, tests and analysis in the work package:

- UI/UX usability tests on mobile and web
- Backend performance and real-time data accuracy tests
- Simulation of different charging loads to test interface adaptability
- Error-handling and offline data sync testing

Describe the outcomes and performance criteria of the work package:

Fully functional mobile and web interfaces were developed, offering both real-time and historical data visualization. The platform is compatible with desktop, Android, and iOS devices. Seamless integration with physical system data was achieved, and end-user simulation tests yielded positive feedback on usability and performance.

Indicate the relationship between the outputs of the work package and other work packages:

This interface uses outputs from WP2 (Design) and WP5 (Prototype) to build its core. It also forms the UI foundation for WP8 and is showcased in WP9.

C.1.9 WORK PACKAGE DESCRIPTION FORM

Project Title	Solar to battery direct charger for a micro-mobile electric vehicle
Work Package No and Title	WP8 – Smart Queue & User Interaction System
Starting-Finishing Dates and Duration	01.09.2025 – 01.11.2025 (2 months)

List the activities of the work package:

- Develop user login and authentication module
- Implement reservation and queue logic
- Create smart notification system (station free, your turn, etc.)
- Connect mobile/web app to station availability API

Describe the methods to be used in the work package and list the parameters to be examined:

The system is built using Flutter or React Native for the mobile app, with a backend powered by Node.js or Firebase Functions. Key parameters include queue length, user reservation time, station status, and automated notifications, enabling an efficient and user-friendly mobile interaction experience.

List the experiments, tests and analysis in the work package:

- Queue logic simulation
- User flow test (register, reserve, charge, complete)
- Notification timing validation
- Multi-user scenario testing

Describe the outcomes and performance criteria of the work package:

A fully functional smart queue system was developed, offering seamless user experience across devices. It accurately reflects real-time station availability and status. End-to-end test cases were successfully executed, confirming system reliability and responsiveness in managing user reservations and dynamic charging queue updates.

Indicate the relationship between the outputs of the work package and other work packages:

Enhances WP7’s interface and Informs prototype behavior in WP4

C.1.10 WORK PACKAGE DESCRIPTION FORM

Project Title	Solar to battery direct charger for a micro-mobile electric vehicle	
Work Package No and Title	WP9– Final Report & Presentation	
Starting-Finishing Dates and Duration		01.12.2025 – 01.01.2026 (4 months)

List the activities of the work package:

- Prepare technical report and poster
- Create presentation slides and graphs
- Perform team rehearsals

Describe the methods to be used in the work package and list the parameters to be examined:

Project documentation and presentations were prepared using Microsoft Word, PowerPoint, and Excel. Key parameters focused on enhancing readability, incorporating clear visuals, and ensuring technical clarity. These tools supported effective communication of the project's goals, methodology, and results across academic and stakeholder presentations.

List the experiments, tests and analysis in the work package:

None, documentation only

Describe the outcomes and performance criteria of the work package:

The final submission included a comprehensive report and presentation slides. An oral presentation was delivered to the instructor and evaluators, demonstrating the working prototype. Performance was assessed based on clarity of explanation, completeness of documentation, and the quality of the system demonstration.

Indicate the relationship between the outputs of the work package and other work packages:

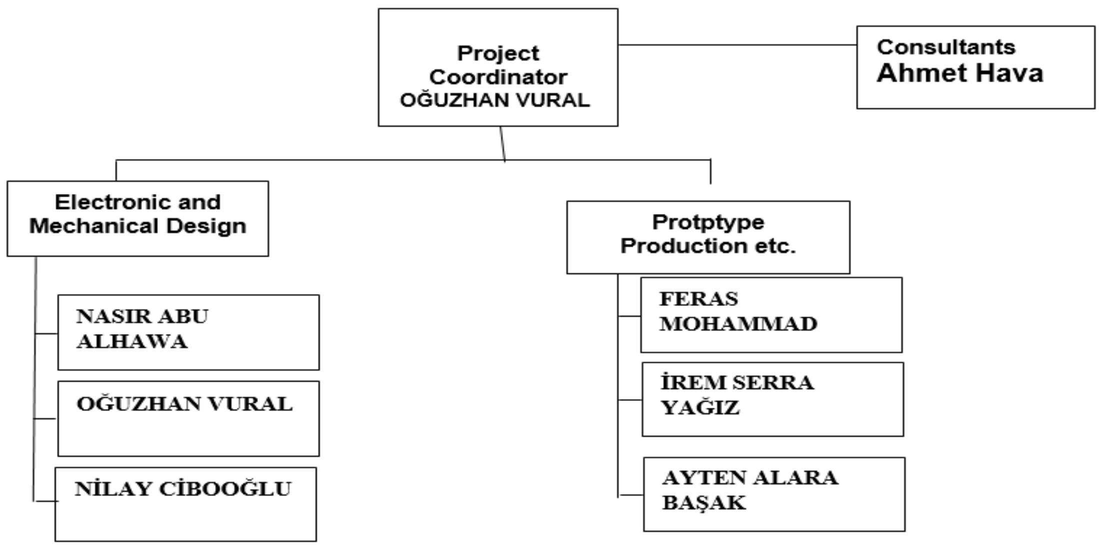
Final delivery stage consolidating outputs from all WPs

C.2- PROJECT MANAGEMENT and ORGANIZATION

ORGANIZATION CHART

C.2.1

1- Give an explanation about project management by using related organization chart.



Alara:
Prepared the software-related content, including descriptions of the system architecture, methods, and innovative aspects such as the smart queue, real-time dashboards, and cross-platform access. Theoretical man/month durations and estimated salary expenses of the people assigned for each work package were calculated. Travel, equipment, software, consultancy and material expenses were listed Cloud-based database systems were researched Contributed to the design of figure, which visualizes key software elements such as internet connectivity, cloud-based architecture, metering, and the smart queuing system.

İrem:
As a Software Engineer, developed the frontend of the User Interface (UI) and User Experience (UX) for both web and mobile platforms. Developed real-time data visualization modules and user interaction interfaces for station monitoring and queue management. Detailed the added value, commercialization potential, and economic return forecasts under the "Economic Benefit Potential" (Section D) of the project. Conducted a unit cost comparison for single-vehicle and five-vehicle systems, highlighting economies of scale.

Oğuzhan:
As a coordinator of the project, the objectives, innovative aspects, methods, economical and national outcomes of the project are defined. Necessary researches for the project is conducted. Energy requirements for charging micro EVs for a specified range is calculated. A system is designed for charging cars in stations and decided what components and tools to use. Contributed in Section A and E in the report.

Nilay:
The innovative aspects of the project were explained. The R&D stages such as simulation, prototype development and field testing were planned theoretically. Electrical and mechanical solutions were explained in an integrated manner. The company's original contributions were found in the project's innovation activities R&D stages were determined. The targeted objectives in the project were determined. The reasons for starting the project were explained. Positions in the team are specified.

Feras Mohammad:
As an Industrial Engineering student,I took the lead in developing the Work-Time Bar Chart (Gantt Chart), which structured the entire project’s timeline across all phases. This visual roadmap aligned task durations with realistic milestones and helped coordinate dependencies between work packages. I collaborated closely with team members to ensure that timeline estimates accurately reflected manpower capacity, hardware availability, and prototyping readiness. also participated in drafting the work package descriptions, aligning deliverables with responsible personnel and resource allocation. I contributed to defining interdependencies between tasks and ensured their logical sequencing in the planning documents, supporting an efficient and trackable workflow.

Nasir Abu Alhawa
As a Biomedical Engineering student, I focused on constructing the technical content of the work packages, detailing the scope, experimental validation strategies, and performance benchmarks for each phase. I helped define task-specific responsibilities, especially in areas involving system diagnostics, field validation, and safety testing, providing technical input in the documentation of WP4, WP5, and WP6. also contributed to identifying inter-work package relationships, particularly where electrical and diagnostic validation intersected with prototype development and final testing. Additionally, I reviewed the consistency of the project’s task-time alignment, supporting project managers in identifying critical path activities.

PERSONNEL CV'S

C.2.2

1-	For each of the project personnel, fill in the CV Form to include the expertise and R&D experience and attach to the project.

Name: **Feras Mohammad** Identity No: **19INDE1086**
Job in the Project: Operations and Logistics Engineer (**Industrial Engineer)** Played a key role in planning the overall project workflow, defining milestones, and ensuring that each work package stayed aligned with the project timeline. Supported the testing and validation phase by coordinating tasks and interpreting results. Took responsibility for compiling final process diagrams and coordinating team efforts during the final presentation phase.
Educational Background: 1. Isik University (bachelor's degree in industrial Engineer) (2025)
Work Experience 1. Plan analysis 2. Testing and validation 3. ERP Functional 4. Supply chain management
Qualifications -MATLAB programming -Python programming - GAMS programming -Optimization modelling -Forecasting Methods
Professional Certificates and Trainings 1. MATLAB Certification 2.Excel problem solve 3.MINITAB analysis 4. ARENA Model
Publications, patents etc. in last three years 1. Forecasting models 2. Quality control (QC) 3. Operational research 4.Supply chain 5. Design experiment

Name: **Nasir Abu Alhawa** Identity No: **20BMED1035**
Job in the Project: System Health and Diagnostics Engineer (Biomedical engineering) Focuses on safety criteria, including battery diagnostics and health monitoring. Involved in establishing operational safety thresholds and supports the design of fail-safe mechanisms for user protection.
Educational Background: 1. Isik University (bachelor's degree in biomedical engineering) (2025)
Work Experience 1. Plan analysis 2. Testing and validation
Qualifications Matlab Circuits analysis
Professional Certificates and Trainings 1. MATLAB Certification 2.Proteus 8
Publications, patents etc. in last three years 1. design medical devices according to the FDD

Name: **Oğuzhan Vural** Identity No: **20ELEC1004**
Job in the Project: Electrical Systems Lead Engineer (Electrical and Electronics Engineer) Responsible for the design and development of the solar-powered energy input system, including solar panel selection and placement. Involved in integrating the electrical components that enable battery charging from solar power. Also supports durability testing and power efficiency optimizations.
Educational Background: 1. Isik University (bachelor's degree in electrical and Electronics Engineering) (2025)
Work Experience 1. EPC Enerji ve Güç Dönüşüm Sistemleri – R&D Intern (22.07.2024 - 16.08.2024) • Designed ribbon cable tester. • Gained experience on power electronics and pcb design. 2. Inform Elektronik – R&D Intern (20.01.2025 - 14.02.2025) • Designed 50W DC-DC buck converter. • Designed 15W DC-DC flyback converter.
Qualifications Matlab LTspice SMPS design PCB design
Professional Certificates and Trainings 1. C programming
Publications, patents etc. in last three years 1. Inductor Saturation Tester 2. 200W DC-DC flyback converter for UAV 3. 50W CC-CV buck converter for Li-Ion battery charging 4. Arduino based ribbon cable tester

Name: **Ayten Alara Başak** Identity No: **20COMP1027**
Job in the Project: Cloud and Data Systems Developer (Computer Engineer) Develops the cloud infrastructure for data logging, user activity tracking, and mobile/web syncing. Implements the smart queueing algorithm for charging management and designs the backend structure for storing and accessing user session data securely and efficiently.
Educational Background: 1. Işık University (bachelor's degree in computer engineering) (2026)
Work Experience 1. Büyütech - Embeed Vision Department Intern • Researched object detection models such as YOLOv3 to identify the most suitable model for traffic sign detection. • Prepared datasets and applied data augmentation techniques including rotation, cropping, and brightness adjustment. • Developed Python scripts to reorganize datasets and upsample underrepresented traffic sign classes. • Trained and validated object detection models using metrics like precision, recall, and mean average precision (mAP). • Built a real-time traffic sign detection web app using Streamlit that allows users to upload and analyze images.
Qualifications Java Python SQL

Name: İrem Serra Yağız Identity No: 20soft1010
Job in the Project: Software Engineer Develops the front-end and back-end of the user interface. Responsible for the mobile application and website, where users can track charging status, battery levels, and receive notifications. Ensures synchronization between devices and interface usability.
Educational Background: 1. Işık University (bachelor's degree in computer engineering 2025)
Work Experience • Leads frontend and backend software development for the "Solar to battery direct charger" project, including the design and implementation of the mobile application, web dashboard, and real-time data visualization modules. • Responsible for developing the user interface (UI) and user experience (UX) for both web (React.js) and mobile (Flutter/React Native) platforms, ensuring intuitive user interaction for station monitoring, queue management, and energy data display.
Qualifications Java Python SQL Android
Professional Certificates and Trainings 1. java 2. sql

Name: Nilay Cibooğlu Identity No:20MECT1002
Job in the Project: Mechanical Design and Integration Engineer (Mechatronics Engineer) Leads the design and construction of the mechanical structure including the physical casing, portability mechanisms, and tilt adjustment modules. Coordinates between electrical and mechanical domains to ensure proper housing and integration of electronic systems.
Educational Background: 1. Işık University (bachelor's degree in computer engineering 2025)
Work Experience **Avolux Lighting Company – Manufacturing Intern** • Worked on robotic arm components used in automated production lines. • Participated in mechanical assembly and part inspection processes. • Observed and assisted with CNC machining, laser cutting, and component fitting. • Gained experience in quality control, production line documentation, and shop floor operations.
Qualifications SolidWorks MATLAB Simulink Mechanical system design

C.3- R&D CAPABILITIES of the COMPANY

C.3.1

1. Explain the R&D capabilities and experience of your organization by considering what you see related to the following topics:

R&D personnel, laboratories, test environment, tool/equipment, software and hardware, library.

Our institution is equipped with a dedicated R&D laboratory focused on renewable energy systems, power electronics, and mobility solutions. The lab includes test benches for solar energy experiments, VRLA/Gel battery testing stations, and programmable DC loads. Software tools such as MATLAB/Simulink, Proteus, and AutoCAD Electrical are regularly used for simulation and design. The laboratory is supported by advanced measuring equipment including multimeters, oscilloscopes, and thermal cameras. A well-maintained technical library with access to IEEE, ScienceDirect, and Springer databases supports ongoing research efforts.

New product development and design ability.

The organization has a strong track record in developing functional prototypes and proof-of-concept systems for sustainability and clean energy. Past student-led and instructor-guided projects have resulted in successful delivery of autonomous agricultural tools, portable solar water purifiers, and IoT-based monitoring systems. The ability to transform simulation-based designs into working hardware distinguishes the institution’s applied engineering strength.

Experience and knowledge based on R&D activities of the company in the past.

The institution has conducted research in solar-powered systems, battery management, and energy optimization. R&D experience includes TÜBİTAK-supported student projects and capstone projects integrated with real-world applications. Previous results have been presented at national conferences and student innovation fairs, showcasing the team's depth in applied renewable energy solutions.

Documentation systematic.

Project documentation is handled according to structured templates provided by the faculty, aligned with AGY101 and TEYDEB formats. Each phase of the project—design, simulation, prototyping, and testing—is documented with supporting visuals, data logs, and design rationales. Reports are stored both digitally and in printed project binders for traceability and evaluation.

Continuous relationships with universities and research institutions such as consultancy, service procurement and joint work.

The project is developed in collaboration with academic mentors and technical consultants who provide feedback throughout the development process. The institution maintains academic partnerships with local industry experts and researchers through seminars, guest lectures, and collaborative labs. Advisory support is also occasionally obtained from external TÜBİTAK fellows or graduates currently working in R&D sectors.

Long-term technological goals.

The long-term vision includes becoming a regional hub for sustainable micro-mobility solutions, with a focus on energy-efficient, low-cost charging infrastructure. Future developments aim to integrate AI-based solar tracking, lithium battery systems, and modular off-grid charging solutions tailored for emerging markets and disaster-prone rural areas.

SECTION D - ECONOMIC BENEFIT POTENTIAL of the PROJECT

D.1- ECONOMIC FORECASTS

D.1.1

1. Indicate the added-value of the project, the contribution of the project output(s) to the company's efficiency and competitiveness.

Added Value:

- **For Users:**
  - Reduces operational costs by minimizing dependency on petrol or grid electricity.
  - Provides ease of access through smart queue management and mobile/web interfaces.
- **Environmental:**
  - Encourages the use of clean energy and reduces carbon emissions.
- **Socio-Economic:**
  - Enhances mobility in rural areas, boosting the local economy .

Contribution to Company (SolyCharge) Efficiency:

- Becomes the core product of SolyCharge.
- The direct DC-DC charging design eliminates inverter losses and improves system efficiency.
- Cloud-based data collection enables maintenance scheduling and usage optimization.

Contribution to Company (SolyCharge) Competitiveness:

- **Niche Market Leadership:** Strong positioning in the off-grid micro-mobility charging market.
- **Innovative Features:** Real-time monitoring, smart queue management, and user-friendly UI.
- **Low Infrastructure Cost:** No need for grid connection lowers installation costs and complexity.
- **Scalability:** Modular design allows for easy expansion of charging networks.

2. Indicate the commercialization potential of the project output(s), the domestic/ international market share and the possibility of replacing an imported product.

- **Commercialization Potential:**
  - High, especially in rural areas, agricultural lands, eco-tourism, and small towns with limited infrastructure.
  - Target Customers: Micro-EV users, farmers, small businesses, municipalities,

cooperatives.

  - Business Models: Direct sales, leasing, pay-per-charge, or turnkey installations.

- **Domestic Market Share:**
  - With the growth of e-bikes, e-scooters, and light EVs in Turkey, this product can capture 5–10% of the niche off-grid charging station market initially.
- **International Market Share:**
  - Suitable for developing regions such as Southeast Asia, Africa, and Latin America.
  - Global expansion possible after a successful domestic launch.
- **Potential for Import Replacement:**
  - Domestic development of the MPPT controller and software platform reduces reliance on imported high-end charging components.
  - Also reduces fossil fuel imports by enabling solar-powered mobility.

3. Indicate your numerical estimates and the assumptions on which the project is based, based on the criteria listed below for the economic return of the project to your company.

- **Time to Market:**
  - Project completion: January 2026.
  - Estimated launch: Q3 or Q4 of 2026 (with 6–9 months for market preparation).
- **Expected Sales Revenue:**
  - First-year target: 15–25 units.
  - Average price: 50,000 TL.
  - Estimated revenue: 750,000 – 1,250,000 TL (≈ $19,737 – $32,895 USD).
- **Expected Market Share Increase:**
  - Target: 5–15% in the domestic niche market within 2–3 years.
- **Break-Even Point:**
  - Total investment: 2,737,849 – 2,987,849 TL.
  - Gross profit per unit: ~30,000 TL.
  - Break-even sales volume: ~91–100 units.
  - Payback period: Within 2–4 years after launch.

4. Capacity of 5-Vehicle Solar Charging Garage

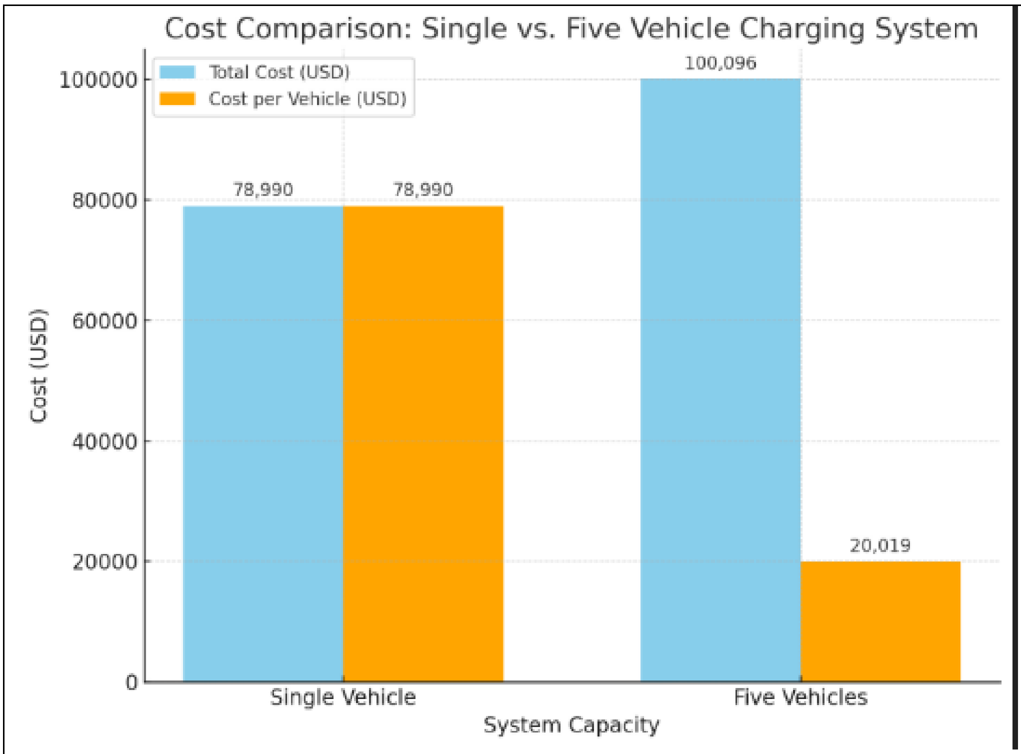
Cost Item	Single-Vehicle Station	5-Vehicle Station (Estimated)
Personnel Cost	70,355	91,462
Travel Cost	184	184
Tool/Equipment/Software/Publication	2,968	2,968
Domestic R&D Services	3,158	3,158
Consultancy and Other Services	1,000	1,000
Material Cost	140	140
Patent Rights	1,184	1,184
Total Cost	**78,990**	**100,096**

Key Insights :

- Total cost for single-vehicle system: $78,990
- Estimated total cost for five-vehicle system: $100,096
- Cost per vehicle (single system): $78,990
- Cost per vehicle (five-vehicle system): $20,019

Assumptions:

- **Personnel costs** increase by **30%** to reflect the additional workload of supporting five vehicles.
- **Travel, equipment, software, R&D, consultancy, materials, and patent costs** are assumed to be **shared resources** and remain constant.
- The increase in total cost is relatively small, while the **cost per vehicle** is drastically reduced.
- The five-vehicle system provides **economies of scale**, making the investment **more appealing for stakeholders and investors**.


Cost Comparison: Single vs. Five Vehicle Charging System
Total Cost (USD)
Cost per Vehicle (USD)
100000
80000
60000
40000
20000
0
Cost (USD)
78,990
78,990
100,096
20,019
Single Vehicle
Five Vehicles
System Capacity

SECTION E – PROJECT BUDGET

ESTIMATED PROJECT COST FORMS

E.1.1 - PERSONNEL EXPENSES FORM

Project Title	**Solar to battery direct charger for a micro-mobile electric vehicle**						
Work Package No and Title	**WP1 – Requirement Analysis & Planning**						
Name	**Task in the Work Package**	**His/Her Post in the Company**	**Men-Month Fraction**	**Number of Months**	**Total Men-Month**	**Cost per Month**	**TOTAL (TL)**
Oğuzhan Vural	Determine power requirements	Electrical Systems Lead Engineer	0.5	*2*	*1.0*	*55.000*	***55.000***
Feras Mohammad	Define constraints & KPIs	Operations and Logistics Engineer	*0.4*	*2*	*0.8*	*45.000*	***36.000***
Ayten Alara Başak	Plan for software/system integration	Cloud and Data Systems Developer	*0.3*	*2*	*0.6*	*40.000*	***24.000***
Nilay Ciboğlu	Analyze physical/mechanical constraints	Mechanical Design and Integration Engineer	*0.3*	*2*	*0.6*	*50.000*	***30.000***
		WORK PACKAGE TOTAL MEN-MONTH			**3.0**	**TOTAL**	**145.000**

E.1.2 - PERSONNEL EXPENSES FORM

Project Title	**Solar to battery direct charger for a micro-mobile electric vehicle**						
Work Package No and Title	**WP2 – System Design**						
Name	**Task in the Work Package**	**Post in the Company**	**Men-Month Fraction**	**Number of Months**	**Total Men-Month**	**Cost per Month**	**TOTAL (TL)**
Oğuzhan Vural	Design DC-DC circuit & voltage config	Electrical Systems Lead Engineer	*1.0*	*3*	*3.0*	*55.000*	***165.000***
Nilay Cibooğlu	Tilt optimization & mechanical constraints	Mechanical Design and Integration Engineer	*0.6*	*3*	*1.8*	*50.000*	***90.000***
İrem Serra Yağız	MPPT control algorithm integration	Software Engineer	*0.4*	*3*	*1.2*	*40.000*	***48.000***
WORK PACKAGE TOTAL MEN-MONTH					**6.0**	**TOTAL**	**303.000**

E.1.3 - PERSONNEL EXPENSES FORM

Project Title	**Solar to battery direct charger for a micro-mobile electric vehicle**						
Work Package No and Title	**WP3 – Simulation & Modeling**						
Name	**Task in the Work Package**	**Post in the Company**	**Men-Month Fraction**	**Number of Months**	**Total Men-Month**	**Cost per Month**	**TOTAL (TL)**
Ayten Alara Başak	Simulink modeling, MPPT simulation	Cloud and Data Systems Developer	*0.8*	*3*	*2.4*	*40.000*	***96.000***
Oğuzhan Vural	Battery charging curve validation	Electrical Systems Lead Engineer	*0.4*	*3*	*1.2*	*55.000*	***66,000***
Nilay Ciboğlu	Physical constraints in modeling	Mechanical Design and Integration Engineer	*0.3*	*3*	*0.9*	*50.000*	***45.000***
WORK PACKAGE TOTAL MEN-MONTH					**4.5**	**TOTAL**	**207.000**

E.1.4 - PERSONNEL EXPENSES FORM

Project Title	Solar to battery direct charger for a micro-mobile electric vehicle						
Work Package No and Title	**WP4 – Hardware Selection & Integration**						
Name	**Task in the Work Package**	**Post in the Company**	**Men-Month Fraction**	**Number of Months**	**Total Men-Month**	**Cost per Month**	**TOTAL (TL)**
Oğuzhan Vural	Component selection, cabling, safety integration	Electrical Systems Lead Engineer	*0.8*	*5*	*4.0*	*55.000*	***220.000***
Nilay Ciboğlu	Mechanical assembly, mobile frame design	Mechanical Design and Integration Engineer	*0.6*	*5*	*3.0*	*50.000*	***150.000***
Nasir Abu Alhawa	Safety tests, thermal and portability analysis	System Health and Diagnostics Engineer	*0.4*	*5*	*2.0*	*45.000*	***90.000***
WORK PACKAGE TOTAL MEN-MONTH					**9.0**	**TOTAL**	**460.000**

E.1.5 - PERSONNEL EXPENSES FORM

Project Title	Solar to battery direct charger for a micro-mobile electric vehicle						
Work Package No and Title	**WP5 – Prototype Development**						
Name	**Task in the Work Package**	**Post in the Company**	**Men-Month Fraction**	**Number of Months**	**Total Men-Month**	**Cost per Month**	**TOTAL (TL)**
Oğuzhan Vural	Electrical assembly, voltage validation, DC output test	Electrical Systems Lead Engineer	0.7	*7*	4.9	55.000	269.500
Nilay Cibooğlu	Frame mounting, mechanical integration	Mechanical Design and Integration Engineer	0.5	*7*	3.5	50.000	175.000
Nasir Abu Alhawa	Safety validation, fuse and short circuit tests	System Health and Diagnostics Engineer	0.5	*7*	3.5	45.000	157.500
				WORK PACKAGE TOTAL MEN-MONTH	**11,9**	**TOTAL**	**602.000**

E.1.6 - PERSONNEL EXPENSES FORM

Project Title	Solar to battery direct charger for a micro-mobile electric vehicle						
Work Package No and Title	**WP6 – Testing & Validation**						
Name	**Task in the Work Package**	**Post in the Company**	**Men-Month Fraction**	**Number of Months**	**Total Men-Month**	**Cost per Month**	**TOTAL (TL)**
Oğuzhan Vural	Voltage & energy test tracking	Electrical Systems Lead Engineer	0.6	*3*	1.8	55.000	***99.000***
Nasir Abu Alhawa	Safety validation, SOC analysis	System Health and Diagnostics Engineer	0.5	*3*	1.5	45.000	***67.500***
Feras Mohammad	Efficiency analysis, requirements validation, test result reporting	Operations and Logistics Engineer	0.4	*3*	1.2	45.000	***54.000***
İrem Serra Yağız	Test data analysis, comparison with simulation results, user feedback capture	Software Engineer	0.4	*3*	*1.2*	40.000	***48.000***
WORK PACKAGE TOTAL MEN-MONTH					**5.7**	**TOTAL**	**268.500**

E.1.7 - PERSONNEL EXPENSES FORM

Project Title	Solar to battery direct charger for a micro-mobile electric vehicle						
Work Package No and Title	**WP7 – Software Development: Monitoring Interface (Mobile & Web)**						
Name	**Task in the Work Package**	**Post in the Company**	**Men-Month Fraction**	**Number of Months**	**Total Men-Month**	**Cost per Month**	**TOTAL (TL)**
İrem Serra Yağız	Web/mobile UI development, UX testing	Software Engineer	*1.0*	*3*	*3.0*	*40,000*	***120.000***
Ayten Alara Başak	Backend, database, API integration	Cloud and Data Systems Developer	*0.8*	*3*	*2.4*	*40,000*	***96.000***
WORK PACKAGE TOTAL MEN-MONTH					**5.4**	**TOTAL**	**216.000**

E.1.8 - PERSONNEL EXPENSES FORM

Project Title	Solar to battery direct charger for a micro-mobile electric vehicle						
Work Package No and Title	**WP8 – Smart Queue & User Interaction System**						
Name	**Task in the Work Package**	**Post in the Company**	**Men-Month Fraction**	**Number of Months**	**Total Men-Month**	**Cost per Month**	**TOTAL (TL)**
İrem Serra Yağız	UI/UX for user flow and queue simulation	Software Engineer	*0.8*	*2*	*1.6*	*40.000*	***64.000***
Ayten Alara Başak	Queue backend, notification logic, API connections	Cloud and Data Systems Developer	*0.7*	*2*	*1.4*	*40.000*	***56.000***
WORK PACKAGE TOTAL MEN-MONTH					**3.0**	**TOTAL**	**120.000**

E.1.9 - PERSONNEL EXPENSES FORM

Project Title	Solar to battery direct charger for a micro-mobile electric vehicle
Work Package No and Title	WP9 – Final Report & Presentation

Name	**Task in the Work Package**	**Post in the Company**	**Men-Month Fraction**	**Number of Months**	**Total Men-Month**	**Cost per Month**	**TOTAL (TL)**
Oğuzhan Vural	Electrical summary, energy data reporting	Electrical Systems Lead Engineer	0.4	4	1.6	55.000	88.000
Nilay Ciboğlu	Mechanical integration visuals and technical documentation	Mechanical Design and Integration Engineer	0.3	4	1.2	50.000	60.000
Nasir Abu Alhawa	Safety, diagnostics and validation reporting	System Health and Diagnostics Engineer	0.3	4	1.2	45.000	54.000
Feras Mohammad	Presentation coordination, process diagrams and results analysis	Operations and Logistics Engineer	0.3	4	1.2	45.000	54.000
Ayten Alara Başak	Backend/data documentation, analytics and dashboard visuals	Cloud and Data Systems Developer	0.3	4	1.2	40.000	48.000
İrem Serra Yağız	Mobile/web interface documentation and demo preparation	Software Engineer	0.3	4	1.2	40.000	48.000
WORK PACKAGE TOTAL MEN-MONTH					**7,6**	**TOTAL**	**352.000**

E.2 – TRAVEL EXPENSES FORM

Project Title	**Solar to battery direct charger for a micro-mobile electric vehicle**				
Name of Travelling Personnel	**His/Her Task in the Project**	**Explanation of the Travel**	**Relationship with the Project**	**City / State**	**Estimated Cost (TL)**
Oğuzhan Vural, Nilay Cibooğlu	Electrical & Mechatronics assembly lead, component sourcing	Travel to Istanbul (e.g., Karaköy) to select/purchase critical hardware/electronic components.	Necessary for WP5 (Prototype Development)	Istanbul	3.700
Oğuzhan Vural, Nilay Cibooğlu, Feras Mohammad, İrem Serra Yağız (Core Testing Team)	Testing & Validation team	Transport of prototype and team for multiple field test runs on the Şile - University route.	Essential for WP6 (Testing & Validation)	Şile / Istanbul	3.300
				TOPLAM	**7.000**

E.3 – TOOL/EQUIPMENT/SOFTWARE/PUBLICATION EXPENSES FORM

1 USD = 38 TL										
Project Title	Solar to battery direct charger for a micro-mobile electric vehicle									
No	**Tool/Equipment/ Software/Publication**	**Qty.**	**Capacity**	**Technical Spec.**	**Purpose of Usage**	**Purpose of Usage after Project (*)**		**Unit Cost (USD)**	**Unit Cost (TL)**	**Total Cost (TL)**
						R & D	**Production**			
1	Solar Panel	*2*	450 W	Monocrystalline, ~21% efficiency	To generate solar energy		*	113	*4368*	***<u>8736</u>***
2	MPPT Charge Controller	*1*	10A	Supports 24V to 72V voltage levels, 99% efficiency	To maximize solar power from panels		*	*36*	*1339*	***<u>1339</u>***
3	DC-DC Converter (optional)	*1*	48V to 72V	Adjustable output, waterproof design	To adapt voltage for vehicle battery		*	*240*	*9250*	***<u>9250</u>***
4	Cabling and Connectors Set	*1*	-	UV resistant, MC4 compatible	To connect panels to the system		*	*30*	*1140*	***<u>1140</u>***
5	Mounting Kit (Bracket + Stand)	*1*	-	Aluminum, adjustable tilt	To fix the panel properly		*	*50*	*1900*	***<u>1900</u>***

6	DC Contactor	1	20A 72V	2NO+2NC 1.18 x 0.79 x 0.39 inches	Switch power and isolate the system		*	125	4822	**<u>4822</u>**
7	Software license (Matlab, SolidWorks)	1	-	Simulation and design tools	Simulations and 3D product designs	*		1861	71792	**<u>71792</u>**
8	Pyranometer sensor	1	-	Spectral range: 0.3~3μm Measuring range: 0-2000W/m²	Measures the solar irradiance		*	146.8	5701	**<u>5701</u>**
9	kWh Meter	1	-	Test Voltage: 6.5-100V Test Current: 0-20A	Measures amount of delivered energy		*	45	1758	**<u>1758</u>**
10	Uni-t UT107 Multimetre	1	-	1000V AC/DC 10A AC/DC	Measures voltage, current, resistance etc.	*		32	1228	**<u>1228</u>**
11	Raspberry Pi 4 - 4GB	1	-	2.4GHz/5.0GHz 4GB ram Gigabit Ethernet Port USB 2.0 USB 3.0	Provides IoT hub for between sensors, integrates APIs for queque system		*	70	2728	**<u>2728</u>**

12	Firebase Blaze Plan	1	-	Real-time database, hosting, authentication, serverless backend	Cloud DB and real-time sync for dashboard and queue logic		*	25	950	**<u>950</u>**
13	Firebase Notifications	1	-	Notification service	Queue alerts for users (WP8)		*	15	570	**<u>570</u>**
14	GitHub Team Plan	1	-	Private repo, 2 users	Version control for WP7–WP8	*		24	912	**<u>912</u>**
									TOTAL	**112.826 TL**

(*) *Tick the appropriate option.*

E.4 – WORK DONE by DOMESTIC R & D INSTITUTIONS EXPENSES FORM

Project Title	Solar to Battery Direct Charger for a Micro-Mobile Electric Vehicle			
Institution of R & D Work Out Sourced	**Explanation of R & D Work**	**Relationship with the Project**	**Reason for Out-Sourcing**	**Cost (TL)**
TÜBİTAK Marmara Research Center (MAM)	Advanced thermal and power dissipation testing of solar converter system	Verifies thermal safety and energy efficiency of the charger hardware	Specialized thermal test chambers and IR cameras unavailable in-house	**50.000**
İTÜ Energy Institute	Simulation of battery behavior under dynamic MPPT load and extended solar input profiles	Improves prediction accuracy of battery response and charge duration for WP3 & WP4	Requires advanced electrochemical modeling tools and domain expertise	**40.000**
SUBU Mechatronics Lab	Physical testing for structural vibration and mobile platform stability	Validates the physical integrity and safety of the moving prototype platform	Access to vibration tables, mechanical load testing unavailable on campus	**30.000**
			TOTAL	**120.000**

E.5 – CONSULTANCY and OTHER SERVICES PROCUREMENT EXPENSES FORM

Project Title	Solar to Battery Direct Charger for a Micro-Mobile Electric Vehicle			
Company or Institution that Consultancies and other Services are Taken From	**Explanation of the Services**	**Relationship of the Services with the project**	**Reason for Service Procurement**	**Cost (TL)**
Ersis Enerji Sistemleri Ltd. Şti.	Full electrical system construction including solar panel mounting, MPPT controller installation, DC-DC converter and battery wiring, fuse panel setup, and on-site safety verification.	Realization of the complete solar charging hardware infrastructure (WP5 scope)	Engaging a certified solar installation company to ensure safe, standard-compliant, and efficient system integration.	**20.000**
TÜV Rheinland Türkiye	Performance and safety testing of the solar charging system, including thermal performance tests, mechanical load tests, and electrical safety verifications in accordance with EN 12975 and EN 12976 standards.	Ensuring the compliance and efficiency of the solar charging hardware system (WP6 scope).	Engaging an accredited testing laboratory to validate system performance and safety according to international standards.	**18.000**
			TOTAL	**38.000**

E.6 – MATERIALS EXPENSES FORM

							1 USD = 38 TL
Project Title	Solar to Battery Direct Charger for a Micro-Mobile Electric Vehicle						
No	**Materials**	**Purpose(s) of the use in the Project Activities**	**Quantity**	**Reason(s) for the Procurement**	**Unit Cost (USD)**	**Unit Cost (TL)**	**Total Cost (TL)**
1	Cabling and Connector Set	To connect the solar panels to charge controller and vehicle battery	*1*	Essential for safe and efficient system connections	*30*	*1140*	*1140*
2	MC4 Connectors (Pair)	Secure and waterproof cable connections	*2*	Reliable solar panel connections	*5*	*190*	*380*
3	Mounting Bracket Kit	Fixation of solar panel to surface	*1*	Stable panel placement	*20*	*760*	*760*
4	DC-DC Converter Connection Wires	Fixation of solar panel to surface	*1*	Proper voltage transfer	*10*	*380*	*380*
5	Fuse and Breaker Kit	Safety protection for the system	*1*	Protection against overcurrent	*15*	*570*	*570*
6	Waterproof Junction Box	Protection of electrical connections	*1*	Weather-resistant housing	*20*	*760*	*760*
7	Heat Shrink Tubes and Small Accessories	Insulation and cable management	*1*	Assembly and insulation	*5*	*190*	*190*

8	Solar Cabling Set (10m)	Connection between solar panel and controller	*1*	Electrical connection	*30*	*1140*	*1140*
						TOTAL	**5320**

E.7 – PERIODICAL and TOTAL EXPENSES FORM (TL)

Project Title: Solar to Battery Direct Charger for a Micro-Mobile Electric Vehicle						
Cost Items	**2025**		**2026**		**TOTAL (TL)**	**FRACTION in the TOTAL COST (%)**
	Period-I	**Period-II**	**Period-I**	**Period-II**		
Personnel Cost	925.086	1.217.414	531.000	0	2.673.500	89.07%
Travelling Cost	0	4.800	2.200	0	7.000	0.23%
Tool/Equipment/Software/ Publication Cost	112.826	0	0	0	112.826	3.76%
Domestic R & D Service Cost	0	120.000	0	0	120.000	4.00%
Consultancies and Services Cost	0	20.000	18.000	0	38.000	1.27%
Materials Cost	0	5.320	0	0	5.320	0.18%
Patent Rights Cost	0	0	45.000	0	45.000	1.50%
TOTAL COST	1.037.912	1.367.534	596.200	0	3.001.646	100%
CUMULATIVE COST	1.037.912	2.405.446	3.001.646	3.001.646	3.001.646	
					TOTAL MEN-MONTH	56.1

E.8 - PERIODICAL and TOTAL EXPENSES FORM (USD)

1 USD = 38 TL

Project Title: Solar to Battery Direct Charger for a Micro-Mobile Electric Vehicle

Cost Items	2025		2026		TOTAL (USD)
	Period-I	Period-II	Period-I	Period-II	
Personnel Cost	24.344	32.037	13.974	0	70.355
Travelling Cost	0	126	58	0	184
Tool/Equipment/Software/Publication Cost	2.968	0	0	0	2.968
Domestic R & D Service Cost	0	3.158	0	0	3.158
Consultancies and Services Cost	0	526	474	0	1000
Materials Cost	0	140	0	0	140
Patent Rights Cost	0	0	1.184	0	1.184
TOTAL COST	27.313	35.988	15.689	0	78.990
CUMULATIVE COST	27.313	63.301	78.990	78.990	78.990