FTI Initiative Energy Model Region

Publishable final report

Programme control:
Climate and Energy Fund

Programme management:
The Austrian Research Promotion Agency (FFG)

Final Report
created on
16/12/2024

AC/DC – Automatic Charging / Dynamic Charging

Project number: 35149366

Call	3. Call FTI Initiative Energy Model Region
Project Starting Date	01/10/2020
Project Ending Date	30/09/2024
Total duration of project (in months)	48 Months (36 planed)
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AC/DC

Automatic Charging / Dynamic Charging

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2 Introduction

As the demand for electric vehicles continues to grow, the need for advanced charging infrastructure that is both efficient and adaptable to evolving fleet and energy grid requirements becomes essential. The research project "AC/DC – Automatic Charging and Dynamic Charging" addresses this demand by developing an innovative, automated, and dynamic charging and fleet management system supported by an automatic charging robot. AC/DC aims to optimize charging processes for electric vehicles, creating an integrated system that balances energy demands, meets user needs, and is suitable for wide deployment in urban and commercial environments.

The project involves a series of structured work packages, each employing targeted methodologies to achieve distinct milestones. Work Package 1, focusing on Project Management, utilizes dedicated project management tools across tasks to ensure effective coordination, monitoring, and reporting. This includes regular project meetings, resource management, and risk assessments.

To analyze system boundaries and prototype requirements, Work Package 2 employs market research, SWOT analysis, desk research, and stakeholder workshops. These methods facilitate a comprehensive understanding of current market conditions and user requirements, guiding the design of automated charging solutions. The prototype concept developed in Work Package 3 is informed by desk research and collaborative sessions with project partners, along with additional stakeholder workshops to refine customer interface concepts.

Product and software development in Work Package 4 utilizes software and product development methodologies, focusing on the creation of software interfaces for fleet and load/charge management as well as the further development of the charging robot to operate reliably in public spaces. Testing and evaluation in Work Package 5 include a range of approaches, from operation testing to stakeholder workshops and surveys, and data processing with software such as MATLAB Simulink for simulations and assessments. SWOT analysis and user feedback ensure iterative improvements in functionality and user experience.

Lastly, Work Package 6 centers on establishing a roadmap and disseminating project outcomes, using desk research, business modeling (Business Model Canvas), and a suite of dissemination materials like fact sheets, presentations, and scientific publications to effectively communicate the project’s results.

With its use of structured project management tools, thorough market and technical analysis, continuous testing, and comprehensive communication of results, the AC/DC project aims to significantly advance automated electric vehicle charging. This approach gives the opportunity to develop a scalable, user-friendly solution with potential for broad application across various sectors.

3 Content presentation

This section provides a structured overview of the project's work packages, outlining the key tasks and responsibilities undertaken by consortium partners. Each work package is designed to address specific aspects of the project, from technical development and system integration to user testing, market analysis, and dissemination of results. Together, these interconnected tasks aim to deliver an innovative and efficient automated charging solution, advancing both technical feasibility and user acceptance. The detailed descriptions offer insight into the milestones achieved, the methodologies employed, and the collaborative efforts driving the project toward its goals.

3.1 Work Package 1: Project Management

This work package includes the creation of a detailed project structure, the distribution of tasks and resources, the organization of regular project meetings as well as project controlling and accounting to ensure the expected quality of milestones and communication with the funding agency.

Task 1.1: Project coordination
Coordination, organization and documentation of meetings to push forward project progress. Regular meetings will take place quarterly to ensure that the project is on the right track. This task also includes preparation of and participation at any program relevant events and consultations. For information exchange, a project related platform is implemented.

Task 1.2: Project controlling and risk management
The project progress in terms of target achievement, milestones and deliverables is monitored in compliance with the given time schedule and budget specifications. Upon identifying risks (technical, time and budget risks), appropriate risk mitigation measures are developed in close cooperation with the project partners.

Task 1.3: Reporting and accounting
All obligatory program and funding related reports as well as accountings are developed and submitted within the given time schedule. The interim reports to the funding organizations are submitted on a yearly basis

3.2 Work Package 2: Analysis of system boundaries and prototype requirements

This work package creates a thorough understanding of the existing market for automated charging solutions and its technical and legal requirements to implement automated charging technologies on the company premise of Energie Graz. It also creates an overview of existing load/charge and fleet management systems along with their requirements, their individual components and synergies. Furthermore, it provides insights into essential customer requirements for fleet management systems.

Task 2.1: Market research
First, an analysis of competitors in the field of automated charging solutions including but not limited to ACDS, ACDU as well as inductive and conductive charging technologies is conducted. Secondly, a comparative analysis of existing load/charge management systems is performed. Based on SWOT analyses, the system boundaries for the prototype being developed are defined.

Task 2.2: Technical and legal requirements
In this task, the technical and legal requirements necessary to implement automated charging technologies is determined. First, the requirements for the installation of charging infrastructure (which is connected to the charging robots) and its electrical network supply on the company premise of the Energie Graz are defined. Second, the requirements for the adaptation of electric vehicles are identified as well as the requirements for the synergies between load, charge, and fleet management.

Task 2.3: Customer requirements
Existing fleet management systems including their booking applications are analyzed, paying special attention to its customer operability. Based on a SWOT analysis, a workshop with customers is held to evaluate existing and determine new aspects that are vital for successful booking applications. The workshop is held with a small group of employees from Energie Graz (cocreation group) familiar with the existing booking application. Both, the SWOT analysis and the customer workshop supports the development of the fleet management system while the user’s perspective is integrated from the very beginning.

3.3 Work Package 3: Prototype concept

In this work package, a concept for the prototype is developed. The prototype refers to the entire system and includes the load/charge management, the fleet management as well as the automated charging station/charging robot. Due to the complexity of this project, it is necessary to understand how these systems communicate and interact with one another. Furthermore, a concept for the graphical user interface is developed.

Task 3.1: Load/charge management concept
In this task, the load/charge management concept is developed. It ensures to charge electric vehicles with the automated charging system according to the customer requests. The charging robot starts charging automatically when a vehicle has parked in a space equipped with the automated charging technology. The charging speed depends on the overall number of customer requests and surrounding conditions (f.e. weather conditions), which defines charging priority and charging speed. Should one vehicle require priority or faster charging, the load/charge management can redirect electricity to that vehicle while reducing charging speeds for the rest of the car fleet. Additionally, the load/charge management systems supports the energy grid as the integration of both systems avoids unnecessary peaks in energy demand. Furthermore, a photovoltaic module on the roof of the Energie Graz will deliver renewable energy to reduce peaks even further.

Task 3.2: Fleet management concept

In this task, the fleet management concept is developed. It allows registered users to reserve vehicles via the web interface of the booking application. Users define the pick-up date and time, booking duration and the planned route length. Based on that information, the fleet management system defines a suitable vehicle among all vehicles in the company fleet.

Task 3.3: Integration of fleet management with load/charge management

In this task, a concept to integrate fleet management with load/charge management is developed. The communication between those systems is processed via an interface, which enables the data exchange between the two modules. In order for the fleet management to identify a suitable vehicle fulfilling a user's booking request, a correlating request has to be sent to the automated charging station/charging robot. The charging station sends back information on the vehicles battery status/level and if the vehicle can be charged in time to fulfill the according user request.

Task 3.4: Concept for graphical interface

Based on the customer requirements identified in WP2, distinctive customer stories for the booking application are defined. A concept for a graphical user interface is developed. For this purpose, mockups are designed to visualize the defined elements of the booking application. Feedback from the workgroup from WP2 will be gathered in a second workshop to make sure that the concept meets the customers requirements.

3.4 Work Package 4: Product and Software Development

In this work package, the software tools required to implement the prototype are developed and the automated charging robot is further developed to be applied in public space since it has been designed for indoor applications only.

Task 4.1: Software development for fleet management

A software tool is developed that constitutes the interface between the fleet management system and the charging robot. It enables the live communication and data exchange between the charging robot and the vehicles battery status/level with the fleet management system. Based on the customer requirements identified in WP2 and the concept for the graphical user interface in WP3, the booking application is developed as part of the fleet management system.

Task 4.2: Software development for load/charge management

A software tool is developed that constitutes the interface between the load/charge management system and the energy grid. It enables the live communication and data exchange between the energy grid and the load/charge management system, which is determined by the customer request integrated into the fleet management system.

Task 4.3: Product development of public charging robot
The automated charging robot that has been developed by VOLTERIO prior to this project, is developed further to enable public charging applications. The current robot is intended for indoor use only such as parking garages and has to be adapted to enable a consistent functionality in outdoor conditions (f.e. weather conditions, cars driving over the system, etc.). Among other things, it has to be guaranteed that the positioning system of the robot arm, which uses ultrasound, can function when the sensor is obscured by dirt or snow.

3.5 Work Package 5: Test and Evaluation Phase

In this work package, the different system components (i.e. charge/load and fleet management system as well as charging robot) are tested and evaluated throughout the project duration. Thereby, the focus is set on both, the technical system and the user-friendliness. The data collected is used to make improvements and increase the overall efficiency of the different system components.

Task 5.1: Maintenance and operation testing
Electrical equipment is checked at monthly intervals to ensure that the charging infrastructure operates smoothly and without errors. In addition to the regular maintenance cycles, Energie Graz carries out unscheduled maintenance and repair work when necessary. Further, particular inspections are planned to guarantee that the moving pieces of the charging robot are functioning as intended.

Task 5.2: Alpha test of the prototype with co-creation group
An alpha test of the prototype is conducted with the same co-creation group involved in WP2. It is important that the customers understand the functionality of the different system elements, i.e. booking, driving and charging. In a feedback workshop with the co-creation group, a special focus is set on their experiences and understanding of the whole system, which also serves as a basis to develop a system tutorial. Based on the workshop results, the system is improved and further developed.

Task 5.3: System tutorial and beta-test of prototype
Based on the insights of the previous tasks and the final version of the prototype, a system tutorial for customers is prepared and distributed among all employees of Energie Graz. The system is tested and evaluated through a quantitative and qualitative user survey comprising the evaluation of their booking, driving and charging experiences.

Task 5.4: Recommendation for future developments
Based on the data collected and analyzed throughout the demonstration phase (user data, data of maintenance requirements, charging data, etc.) and a SWOT analysis, recommendations for future developments to improve user acceptance and the efficiency of the system are given.

Task 5.5: Derivation of demand – profiles and hand-over to linked project "UserGRIDs"
Continuous evaluation of the system functionality through the entire project further enables the collection of a broad range of data from integrated subsystems. Based on gathered data from the charging management system, dynamic charge demand profiles of observed vehicles will be derived. These profiles serve as the basis for charge demand projections of future electric vehicle fleets and will be handed over and linked to the task interface of project "UserGRIDs". Therein, derived charge demand profiles from real world fleet operation will be used as input for charge demand estimations. Results from project "UserGRIDs" will be discussed regarding transferability to the present project.

3.6 Work Package 6: Roadmap and project dissemination

In this work package, a roadmap for automated charging infrastructure is developed. The innovative components that are developed in this project have a wide array of use-cases, which need to be researched and analysed in order to create a business plan and a strategy to market the product efficiently.

Task 6.1: Potential use cases and target groups
Based on the results of the previous work packages, potential use cases and target groups are identified to apply the developed system. Potential applications for the public and/or private sector might involve e-carsharing providers, e-taxi companies or other fleet operators.

Task 6.2: Business plan development
Energie Graz already operates charging stations for customer groups such as fleet operators, taxi fleets and e-carsharing providers (Holding Graz, operator of "tim" carsharing). Based on the existing expertise of Energie Graz, a business plan to cater to the individual needs of the target groups is developed applying the business model canvas.

Task 6.3: Future development timeline for mass market adoption
The automated charging system developed in this project is a one-off prototype. In order to create a scalable product with global appeal, a timeline has to be developed to reach a mass production stage. This step is essential to create an economical feasible and sustainable product.

Task 6.4: Dissemination of project results
The project results are presented and disseminated through the communication channels of the project partners (website, newsletter, partner events, etc.). Scientific partners in the project consortium plan to publish at least 2 scientific publications. Further, the project results are presented at (inter)national conferences and according events related to automated charging solutions.

4 Results and conclusions

In the following chapter, the outcomes from each of the six main sections, along with their respective sub-sections, are presented in detail. This chapter provides a comprehensive overview of the findings, systematically summarizing the insights and data gathered throughout the project. Each section and sub-section highlights key results, contributing to a thorough understanding of the project's achievements and offering a solid basis for the final conclusions.

4.1 Work Package 1 Project Management

Task 1.1: Project coordination
Throughout the project, the coordination efforts were vital in managing organizational, administrative, and technical aspects effectively, ensuring that the project goals were successfully achieved. A well-organized kick-off meeting set the foundation, where all partners aligned on key details like the consortium agreement, budget, and updated project timeline. The initial discussions and adjustments provided clarity on critical elements such as financing, confidentiality, exploitation, and cooperation, laying the groundwork for the project's success.

With the official launch in June 2021, the consortium implemented targeted measures to address early delays and enhance communication, such as the decision to hold monthly meetings (Jour Fixes) for continuous updates. These meetings allowed the partners to review progress across work packages, identify synergies, and plan next steps, contributing directly to the achievement of the project objectives.

Further consultations with KPC and FFG provided essential support, enabling the consortium to remain adaptable throughout the project. This flexibility allowed for responsive adjustments to key aspects, such as testing and acquisition for the demonstration phase, ensuring that milestones were met on time. Overall, the coordinated approach fostered collaboration, transparency, and a structured environment, which were crucial in facilitating steady progress and the successful attainment of the project goals.

Task 1.2: Project controlling and risk management
The project controlling and risk management processes have been integral to the coordination of the charging robot project, with a particular focus on monitoring milestones and deliverables to ensure adherence to the project timeline. The consortium successfully achieved the first milestone (M1.1) during the Kick-Off meeting on June 23, 2021, and the completion of the interim report marks the attainment of the second milestone (M1.2) and the first deliverable (D1.1).
However, the project faced delays primarily due to a late start and deviations in the first year, necessitating rigorous monitoring of the project timeline. The regular Jour Fixes served as crucial platforms for identifying potential risks—technical, financial, and temporal—and discussing mitigation strategies, including adaptations to the time plan and the request for a three-month project extension to alleviate more severe risks.

The latest updates indicated that delays in the start of work packages and deviations in their finalization were documented, with necessary adaptations discussed for the testing infrastructure and software implementation. The consortium held additional meetings to address the project's current status and next steps, ensuring that all partners remained aligned and proactive in overcoming challenges.

In conclusion, while the project has encountered significant delays, ongoing risk management and strategic discussions have enabled the consortium to adapt to these challenges effectively. The commitment to close monitoring and collaboration positions the project to move forward with greater assurance of meeting its objectives within the adjusted timeline.

Task 1.3: Reporting and accounting

The reporting and accounting processes were central to the effective administration and financial oversight of the project. Regular and timely submission of interim reports to funding organizations ensured compliance with funding regulations and established a reliable framework for financial management. Adjustments, such as reallocating the budget from the Grazer Energieagentur to the Graz University of Technology, and the reassignment of leadership for Work Packages 3 and 4, demonstrated adaptability and responsiveness to project needs. These strategic changes aligned resources and responsibilities with the strengths of the respective partners, improving operational efficiency.

Energie Graz's meticulous handling of accounting tasks and the coordination efforts of the Grazer Energieagentur ensured the smooth execution of project activities within the financial and administrative scope. The approved extension of the reporting period provided additional time to align financial tasks with the project's evolving requirements.

In Conclusion the structured and adaptive approach to reporting and accounting significantly contributed to the project's stability and transparency. By reallocating resources and redefining responsibilities, the consortium was able to optimize processes and address challenges effectively. This systematic framework not only supported compliance and accountability but also laid a strong foundation for future decision-making and collaboration among the partners. The experience highlights the importance of flexibility, detailed financial oversight, and consistent communication in managing complex, multi-stakeholder projects.

4.2 Work Package 2: Analysis of system boundaries and prototype requirements

Task 2.1: Market research

First, an analysis of competitors in the field of automated charging solutions including but not limited to ACDS, ACDU as well as inductive and other conductive charging technologies is conducted. Secondly, a comparative analysis of existing load/charge management systems was performed. Based on SWOT analyses, the system boundaries for the prototype being developed are defined.

The detailed market research and analysis was performed and documented in the first interim report. The conclusion of the research was that currently there are no alternatives to cable based conventional charging on the market. The most promising approach for automated charging systems was wireless inductive charging in past. However, none of the systems made it to market because of many technological challenges and the fundamental high price of far above 5.000 EUR. Automatic underbody charging technologies are still a quite new research field and Volterio with its vast patent portfolio and strong partnerships with leading Tier-1 suppliers such as Continental and various OEMs is clearly leading the field. These efforts are supported by numerous standardisation bodies in ISO and IEC for establishing a global standard for automated conductive charging. To sum up, besides the best possible technology the price of such a system is the thriving key factor for a widespread market adoption. This goal will be only achieved with strong partnerships with global leaders in the automotive supply industry as well as with high volume OEMs. Volterio is clearly taking the edge.

Task 2.2: Technical and legal requirements
The analysis in this section outlines a comprehensive set of technical and legal requirements for the successful implementation of the Volterio charging system. The detailed specifications, as summarized in document D 2.2, cover both the physical infrastructure and operational parameters necessary for optimal functionality. These requirements provide a solid foundation for the system's design and installation process, ensuring compatibility with existing infrastructure and regulatory standards.

Key technical requirements include the implementation of a charging infrastructure with a maximum power of 22 kW, a connector type 2 for the charging interface, and a 24V power supply unit for the charging robot. The system is designed for both above-ground (VolterioHOME) and underground (VolterioPRO) installations, with specific considerations for load management, safety, and space requirements around the robot.

The charging robot’s operational specifications include a defined radius of action, with detailed instructions on positioning and maintaining clearance for optimal functionality. It is also equipped to handle environmental conditions, with specific safety measures outlined for both VolterioHOME and VolterioPRO variants, ensuring secure operation under varying conditions, such as exposure to dirt or snow. Legal guidelines, such as compliance with building codes and excavation regulations, are also integrated into the installation requirements to ensure compliance with local laws.

In terms of power supply, the system requires a minimum grid capacity of 22 kW per charging unit, with the potential for integration with a load management system to optimize energy use. The option for photovoltaic (PV) integration further enhances the sustainability and flexibility of the system.

Conclusion:
The well-defined technical and legal requirements form a clear roadmap for the implementation of the Volterio charging system. By following these guidelines, the system can be effectively deployed while meeting all necessary safety, regulatory, and operational standards. This structured approach ensures that the project objectives are met, providing a reliable and scalable charging solution for both residential and commercial applications.

Task 2.3: Customer requirements

Grazer Energieagentur conducted a market analysis on systems for booking, charging, and load management. The study reviews various projects and systems, describing each one's market status (research, testing, or market-ready) and where it is in use. It also examines user interfaces for usability and whether systems support special energy tariffs (e.g., night rates or local PV production). Additionally, it looks at whether systems prioritize charging for certain vehicles based on booking times.

The analysis found that 8 out of 20 systems meet these criteria. Key solutions include Ubstack, eLISA BW, Ampcontrol, Coneva, SmiLE, PSIsmartcharging, Siemens E-Car Operation Center, and Greenflux. Specific attention is given to:

- Ubstack for its data visualization
- Ampcontrol for its integrated approach
- SmiLE for AI-driven load forecasting.

Existing products can coordinate charging based on vehicle needs, concurrent processes, and grid availability, with some even prioritizing based on user scheduling. The following table represents a matrix that clearly shows the functions/features of the projects and products examined.

Name	**Fleet management**	**Charge management**	**Load / Energy management**	**Fully integrated approach**
Ubstack	X	X	X	**X**
eLISA BW	X	X	X	**X**
Ampcontrol	X	X	X	**X**
Coneva	X	X	X	**X**
SmiLE	X	X	X	**X**
Power2Load		X	X	
PSIsmartcharging	X	X	X	**X**
ePlanB		X	X	
OptiCharge PLUS	X	X	X	
Charge Pilot		X	X	
Ibiola	X			
Bidirectional Charging Management			X	
Smatrics		X	X	
E-MOB		X		
Siemens E-Car Operation Center	X	X	X	**X**
Smart Charging Management		X		
Flo MOBIL	X	X		
Carpanion	X			
Die Lademeisterei	X	X		
Greenflux	X	X	X	**X**

Figure 1: Evaluation matrix for the examined projects/products

Originally planned, a SWOT analysis was meant to be conducted for the whole preparation and work in advance of the workshops and evaluation of the customer needs. On the basis of collective experience and the market analysis about fleet management systems and booking applications, which are based on similar or even same approaches, it was concluded that a SWOT analysis would not be the right tool to create a basis for customer needs. Therefore, the new focus was put on the stakeholder workshop, which was split up into a workshop with the fleet managers of Energie Graz and Holding Graz and a workshop with the co-creation group, consisting of employees of Energie Graz.

Integration of users:

The whole process of the Stakeholder involvement is described in the figure below.

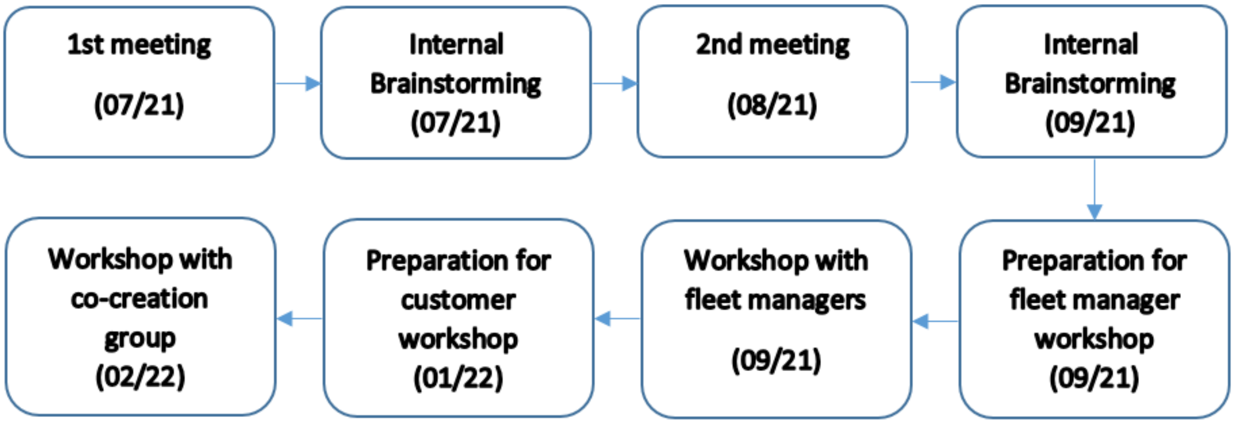

Figure 2: Process of the stakeholder involvement

– Fleet Managers of Holding Graz and Energie Graz

By the end of September 2021, Grazer Energieagentur and ilogs collaborated with fleet managers from Holding Graz and Energie Graz to define requirements for a new fleet booking system. ilogs created initial mock-ups, which were reviewed by the managers for feedback. These mock-ups were finalized for the first end-user workshop in February 2022, held online due to Covid restrictions.
The new fleet management system, coordinated by Holding Graz, will integrate all vehicles, allowing for detailed information storage, including vehicle types, billing, and operational issues such as damages. It will be compatible with the existing eTermin system to streamline fleet and charging operations. The aim is to increase efficiency, improve vehicle usage, and provide a logbook to simplify trip accounting and billing.

– End-users - a group of employees of Energie Graz

The approved drafts from Holding Graz and Energie Graz fleet managers were presented in the first end-user workshop in February 2022, held online due to Covid. After an introduction by Manuela Beran from Grazer Energieagentur, Energie Graz's fleet manager discussed future challenges. Cornelia Sicher from ilogs then showcased the initial mock-ups, followed by a feedback session. The feedback highlighted the need for easy car availability and a user-friendly booking system without complex structures. The workshop addressed employee concerns about reserving cars and planning trips.

4.3 Work Package 3: Prototype concept

Task 3.1: Load/charge management concept

A charging and load management system was developed to prioritize vehicles based on their State of Charge (SoC) and usage timing, incorporating real-time data and a self-learning algorithm. Integration with a Charging Point Management System (CPMS) enables optimized charging schedules. Web and mobile applications were designed for users to manage charging preferences and monitor progress, with provisions for scheduling during energy-efficient periods. Initial solutions for fleet and residential applications include features like household energy prioritization and boost charging. Charging speeds can also adapt to renewable energy availability, such as solar power, supported by basic models for planning and scenario simulations.

However, further development is needed to stabilize algorithms for complex scenarios and enhance escalation mechanisms for grid overload and bidirectional charging. Broader interoperability with different charging infrastructures and vehicles is required, along with improvements in user interfaces to simplify operations. Regulatory compliance and market-specific adjustments, including business model definitions for fleets and residential setups, remain open points. While the system offers a strong foundation, these enhancements are critical to achieving full scalability and market readiness.

Task 3.2: Fleet management concept

The Fleet Management concept includes automated vehicle and driver allocation based on SoC, travel routes, and user preferences to optimize fleet utilization. A reservation system with real-time SoC and availability checks ensures efficient bookings. Integration with load and charge management enables prioritized charging and cost-effective off-peak operations, while automatic data collection (e.g., energy consumption and trip distance) supports better decision-making. User-friendly web and mobile interfaces provide access to reservations, charging status, and energy consumption reports.

Compatibility with a wider range of charging infrastructures and better energy forecast algorithms are needed. User profiles must account for individual preferences, and interfaces with external systems like accounting tools require enhancement. Local market requirements and incentive programs must also be addressed. Additionally, user interfaces and booking processes should be simplified to improve the overall experience. While the concept is robust, these refinements are crucial to meet the demands of larger fleets and diverse markets.

Task 3.3: Integration of fleet management with load/charge management

The system successfully integrates fleet and charge management, enabling automated data transfer for charging needs and fully implemented vehicle reservation functionality for fleets. Initial simulations for residential use cases, such as multi-tenant buildings, were conducted, including a boost function for fast charging. Basic charging prioritization for time-critical trips has been established, ensuring a foundation for efficient energy management.

To achieve full market readiness, further enhancements are needed. While the system provides key functionalities, scalability must improve to handle larger fleets and networks effectively. The user interface requires optimization for a more intuitive experience, and charging prioritization needs greater adaptability to grid load and energy availability. Additionally, regulatory alignment and the refinement of business models for monetization are necessary. Overall, the system demonstrates strong progress, with further refinements positioned to unlock its full potential.

Task 3.4: Concept for graphical interface

The development of the graphical interface has resulted in a robust and user-friendly system that integrates fleet management, reservation, and load management functionalities into a single platform. The project achieved significant milestones in delivering an intuitive interface tailored to meet the needs of fleet managers and employees.

Results and Achievements

The interface enables seamless interaction between users and the system, ensuring that vehicle reservations, availability, and charging processes are efficiently managed. The following functionalities were successfully developed and implemented:

Multi-Layered User Access:

- **Fleet Managers (Level 1)**: Administrative users can configure system settings, manage vehicles and users, resolve reservation conflicts, and oversee charging priorities.
- **Employees (Level 3)**: Regular users can create, view, modify, and cancel reservations. The interface provides vehicle suggestions based on the user’s trip details and real-time charging status.

  Dynamic Reservation Process:

  The reservation algorithm ensures conflict-free bookings by validating each request against vehicle availability, charging status, and the planned route. This guarantees that users are assigned vehicles capable of fulfilling their needs.

  Real-Time Information Integration:

  Charging status and readiness are displayed in the interface, allowing users to make informed decisions during the reservation process. For example, employees can see how long it will take for a vehicle to be fully charged or select from currently available vehicles for immediate use

  Streamlined User Interaction:

  A minimalist and responsive design minimizes the steps required for a reservation, offering intuitive navigation through calendar views, filter options, and real-time search functionalities.

  Scalable System Configuration:

  Fleet managers can manage system parameters, such as vehicle attributes, categories, and readiness statuses, without requiring technical programming knowledge. This flexibility supports diverse operational needs and fleet sizes.

Future Development for Market Readiness

The system is well-positioned for further refinement and commercialization. To ensure market readiness, the following steps are planned:

Enhanced Feature Set:

Add functionalities such as carpooling options, integration of buffer vehicles for spontaneous journeys, and live route-based vehicle suggestions.

Expand vehicle management capabilities, including advanced filters for preferences like seating capacity, range, and charging speed.

Mobile Application Development:

Develop a fully responsive mobile application to increase accessibility for users and support real-time decision-making.

Analytics and Reporting Tools:

Introduce advanced analytics to provide fleet managers with insights into vehicle utilization, energy consumption, and overall fleet performance.

Geographic and Climatic Data:

Incorporate external data sources, such as geographical and climatic conditions, to refine vehicle assignment and charging strategies.

Vision Beyond the Project

Post-project, the system will undergo pilot deployments to validate its functionality in real-world environments. Collaboration with corporate fleets and energy providers will further enhance its capabilities, particularly in load management and real-time energy optimization. The goal is to establish the graphical interface as a scalable, modular platform that supports the evolving needs of EV fleet operators and residential users, paving the way for widespread adoption.

4.4 Work Package 4: Product and Software Development

Task 4.1. Software development for fleet management

A modular fleet management system has been developed, allowing for automated vehicle reservations, trip logging, and detailed vehicle monitoring. The system records key trip data, including distances, energy consumption, and the State of Charge (SoC) before and after each trip, enabling precise tracking and analysis. Integration with charge management systems has been implemented to synchronize charging priorities and ensure vehicle availability for operational needs. This ensures that vehicles are charged and ready when required. The reservation process is automated, using real-time data to allocate vehicles based on energy levels and usage schedules. These developments provide a robust foundation for fleet efficiency and operational optimization.

To achieve market readiness, further improvements are required. Real-time data processing must be stabilized for large-scale applications, and scalability enhancements are needed to manage larger fleets and simultaneous reservations effectively. Limited integration with external systems, such as corporate tools and additional charging infrastructures, needs to be addressed. Although predictive analytics for fleet optimization is still in its early stages, the system already demonstrates substantial progress toward meeting the needs of modern fleet operations.

Task 4.2. Software development for load/charge management

A prototype software system for charge management has been developed, enabling the calculation of charging priorities based on vehicle energy requirements and grid capacity. A simulator was created to test charging plans in various scenarios and analyze the distribution of charging power, offering insights into system efficiency under different conditions. Initial prioritization concepts have been implemented, allowing vehicles to be prioritized by urgency and energy needs, though flexibility remains limited. Additionally, the integration with a CPMS enables real-time data processing from charging infrastructure, laying the groundwork for future control and coordination capabilities.

While significant progress has been made, some areas require further refinement for market readiness. The system's scalability needs improvement to handle larger networks reliably. Real-time adaptation to grid conditions, such as overloads or fluctuating energy availability, is currently underdeveloped. The user interface requires enhancements to make the control of charging infrastructure more intuitive for diverse user groups. Integration with additional charging systems and external corporate applications is limited, and further testing is required to validate charging prioritization and escalation functionalities in real-world environments. Finally, the self-learning algorithm needs refinement to improve prediction accuracy and responsiveness.

The prototype demonstrates substantial progress and provides a solid foundation for scalable and efficient charge management, but additional testing and development are required to fully meet the demands of market readiness.

Task 4.3.: Product development of public charging robot

The automated charging robot for home charging that has been developed by VOLTERIO prior to this project, is developed further to enable public charging applications. The current robot is intended for indoor use only such as parking garages and has to be adapted to enable a consistent functionality in outdoor conditions (f.e. weather conditions, cars driving over the system, etc.). Among other things, it has to be guaranteed that the positioning system of the robot arm, which uses ultrasound, can function when the sensor is obscured by dirt or snow.

The development of a dedicated outdoor solution for fleet applications was a major milestone in achieving the best possible conductive charging solution based on current charging standards for several use-cases. In this project a fully automated charging robot was envisioned which is almost invisible and seamlessly integrated in its surroundings. A patented innovative parallel kinematics robot for precise handling of the 360°-AC-connector was developed in several design iterations. The first generation used DC motors with gear heads and a closed-loop control system, which was later upgraded to hybrid stepper motors for even enhancing the precision and speed for the connection sequence.
At the beginning the robot system was an attachment to an existing AC wallbox which emphasis the compatibility to every electric vehicle by utilizing the same charging standards according to J1772. In 2024 the entire charging system was newly developed from the ground based on an Open EVSE system designed to replace the existing AC wallbox and to create an end-to-end charging system, which directly is supplied by the power grid. This was another milestone for a deep system integration. This integrated wallbox allowed for example to directly set the maximum current and therefore, the charging capacity at any time and further advance the remote-control operation of the robot.
The project started by retrofitting an existing fleet of three Renault Zoes. However, even if these were similar models, the vehicle integration was a challenge and differed between the vehicles significantly. The packaging of the retrofitted component had to be modified and adapted to every vehicle which increased the expected integration effort and made the retrofitting more time consuming. Originally it was expected that these three Zoes would be identical electric vehicles with the same building space in the underbody and will use the same switch box for the high voltage integration. In 2024 another completely different vehicle was added to the fleet which is based on Volkswagen’s MEB platform. This ID.4 was by far the biggest challenge to retrofit because all high-voltage components were hardly accessible and the safety features of the vehicle for example usually prevents charging if the side flap of the charging inlet is closed. Volkswagen was implementing some unusual design choices compared to any other EV brand. For normal charging this would never be the case but for the underbody charging system this safety feature was a blocking point for starting the charging process. This made the overall retrofit tricky.
All the challenges and the steady improvement of the overall system, the mechanics, the connectors, the software and the positioning system led to gaining very valuable knowledge for further projects and to increase the overall system maturity by far. This knowledge gain was already utilized in several other OEM projects and Volterio’s entire ecosystem of charging solutions benefited heavily from this project.

4.5 Work Package 5: Test and Evaluation Phase

Task 5.1: Maintenance and operation testing

The charging robot underwent regular, scheduled testing to ensure optimal performance and functionality. During these routine checks, any issues discovered or errors reported by the user group were promptly communicated to Volterio, allowing for immediate troubleshooting and resolution. However, significant error rates persist, suggesting that the system's reliable deployment is not yet guaranteed. Common issues included connection problems with the robot's Wi-Fi, instances of the robot getting stuck, and difficulties with disconnecting from the vehicle. Additionally, frequent malfunctions in the guiding system, often due to software errors, further challenged the robot's dependability.
These problems required the charging robot to be repeatedly removed for maintenance and repair, emphasizing that further improvements are essential to ensure reliable, uninterrupted operation in future deployments.

Task 5.2: Alpha test of the prototype with co-creation group

The initial testing phase with the co-creation group, comprising pre-selected employees of Energie Graz, marked a significant milestone in evaluating the charging robot's functionality. Conducted on June 26, 2023, at Energie Graz, the test provided participants with an opportunity to directly interact with the system, including the modified vehicles, and observe its operational efficiency. This hands-on experience effectively showcased the system's capabilities and its ability to facilitate efficient charging processes.
Following this phase, further development continued throughout 2024, with additional charging cycles completed to refine the system. Comprehensive feedback from Energie Graz employees was gathered and analyzed, identifying areas for improvement and ensuring the system better met user needs. Insights from this feedback highlighted key enhancements, enabling the project to move closer to its operational goals.
The findings from the 2024 testing phase were incorporated into structured user surveys, which validated the system's usability and identified any remaining functionality gaps. These surveys provided valuable data to ensure the charging system aligned closely with user expectations and operational requirements.

In summary, the co-creation group test validated key functionalities and provided a strong foundation for further optimization. The continued development in 2024 and integration of user feedback significantly enhanced the system's capabilities, ensuring a more user-centric approach.

Task 5.3: System tutorial and beta-test of prototype

A comprehensive user manual, along with a detailed tutorial video, has been created to ensure the successful operation of the charging robot during testing. These resources are designed to serve as quick and accessible references for users, enabling them to refresh their knowledge and address any uncertainties, even after periods of inactivity. By allowing users to independently revisit the instructions at any time, the video and manual reinforce familiarity with the robot's functions, empowering users to engage confidently with the technology.
Furthermore, these resources are particularly valuable as the user base expands, as they reduce the need for one-on-one training sessions. This enables new users to quickly familiarize themselves with the

system. The conclusion drawn from this initiative is that the video and manual significantly lower the barriers to using the new system, making it simpler for users to understand, engage with, and adopt the technology independently.

Following the test phase, a qualitative survey was carried out among the participants. The purpose of the survey was to collect feedback on the system's strengths and weaknesses. It also examined technical challenges and gathered suggestions for potential improvements. Furthermore, the survey aimed to understand participants' perspectives on research initiatives undertaken by Energie Graz. The survey results are summarized as follows:

The charging robot was primarily praised by test users for its comfort and convenience. A standout feature was the elimination of the need to manually connect a charging cable, which is particularly advantageous in adverse weather conditions such as rain or winter. Users appreciated not having to exit their vehicle, saving time and avoiding dirt on their hands or clothing. Many regarded the automated connection as a significant improvement over traditional charging stations, as the entire process was simpler and less strenuous. The operation of the charging robot was described by most as relatively simple and intuitive. After a brief introduction or with the help of instructional videos, users found it easy to understand the navigation and guiding button. However, some required multiple attempts to find the correct vehicle position or initially struggled to use the navigation correctly. Technical issues were occasionally reported, including navigation connection failures, faulty status displays, or system blockages. Some users had to reposition their vehicles to start charging, while others encountered problems with the robot's flap. Nevertheless, the manufacturer Volterio was often able to resolve issues quickly via telephone support. Test participants suggested improvements such as a more stable connection, greater flexibility in the connection process through a larger range, and faster navigation. Additional suggestions included an app for remote monitoring of the charging process, an underbody camera, or an improved display for vehicle positioning. Regarding the impact on transitioning to an electric vehicle, the charging robot alone was not a decisive factor for most. Many respondents were already convinced of electromobility regardless of the system. However, some participants indicated that widespread availability of the system would increase their willingness to adopt electric vehicles, as it significantly simplifies the charging process. Compared to conventional charging stations, the majority preferred the charging robot, citing its comfort, time savings, and weather independence. However, some expressed concerns about relying on the system’s functionality for their decision. Most respondents appreciated that Energie Graz is testing new technologies like the charging robot and contributing to the advancement of electromobility. However, some emphasized that the company should continue to focus on its core business. Overall, the charging robot is seen as an innovative and forward-looking system, albeit with room for improvement in certain areas.

Task 5.4 Recommondation for future development

The initial plan was to use a SWOT analysis for all the preparation and work leading up to the workshops and for the assessment of customer needs. However, based on the collective experience and market analysis of fleet management systems and booking applications based on similar or even identical approaches, it was concluded that a SWOT analysis would not be the right tool to create a basis for customer needs. Therefore, the new focus was put on the extensive stakeholder involvement as described in Task 2.3.

Task 5.5 – Derivation of demand – profiles and hand-over to linked project "UserGRIDs"
Continuous evaluation of the system functionality through the entire project further enables the collection of a broad range of data from integrated subsystems. Based on gathered data from the charging management system, dynamic charge demand profiles of observed vehicles will be derived. These profiles serve as the basis for charge demand projections of future electric vehicle fleets and will be handed over and linked to the task interface of project "UserGRIDs". Therein, derived charge demand profiles from real world fleet operation will be used as input for charge demand estimations. Results from project "UserGRIDs" will be discussed regarding transferability to the present project.

Summary of data evaluation of test vehicles

Four electric cars have been equipped with data tracking technology to provide information about driving distances and energy consumption in real-life usage. This information will be used for testing the automated charging system as well as for improvement of vehicle- and charging management, dynamic cost systems. The technical data of the four cars are listed below.

Car No. 1, 2, 3:

Propulsion technology:	battery – electric, front-wheel drive
Energy consumption (WLTP):	17.4 kWh/100km
Maximal power:	80 kW
Maximal torque:	225 Nm
Battery capacity:	51 kWh

Based on the public available database "EV-Database", https://ev-database.org/car/1164/, averaged energy consumption data are provided. These values represent a basis for evaluation and discussion of the measurement results.

Average energy consumption:	10.9 – 23.6 kWh/100km
City-winter:	16.8 kWh/100km
Highway-winter:	23,6 kWh/100km
Combined-winter:	19.6 kWh/100km
City-summer:	10.9 kWh/100km
Highway-summer:	18.2 kWh/100km
Combined-summer:	14.2 kWh/100km

Car No. 4:

Propulsion technology:	battery – electric, rear-wheel drive
Energy consumption (WLTP):	16.5 kWh/100km

Maximal power:	150 kW
Maximal torque:	310 Nm
Battery capacity:	77 kWh

From the EV-Database (https://ev-database.org/car/1314/, the following information has been extracted for Car No. 4:

Average energy consumption:	12.8 – 26.1 kWh/100km
City-winter:	18.8 kWh/100km
Highway-winter:	26,1 kWh/100km
Combined-winter:	22.0 kWh/100km
City-summer:	12.8 kWh/100km
Highway-summer:	20.5 kWh/100km
Combined-summer:	16.4 kWh/100km

Methodology

Data is gathered from specific data tracking systems, provided by project partner Ilogs. Covered data include date and time (start- and end time) of the trips, driven distances as well as state of charge (SoC) of the battery at start and end of trip. Based on the SoC-levels and the corresponding driving distances, the average energy consumption of that trip (day) is calculated by use of the following equations:

Equation 1: SOC [kWh]

$$SOC\ [kWh] = net\ battery\ capacity\ [kWh] * (\frac{SOC\ [\%]}{100})$$

Equation 2: Energy consumption [kWh]

$$Energy\ consumption\ [kWh] = SoC\ start\ [kWh] - LSoC\ end\ [kWh]$$

Equation 3: Average energy consumption [kWh/100km]

$$Average\ energy\ cons. \left[\frac{kWh}{100km}\right] = \frac{Energy\ consumption\ [kWh] * 100}{km\ status\ at\ start\ [km] - km\ status\ at\ end\ [km]}$$

Results

Data evaluation is conducted for tracked trips in 2023 and 2024. Days with small driving distances (< 5 km per day) and consequentially small energy consumption have been deleted, because the tolerances of data tracking system and environmental influences (e.g., temperature) lead to implausible results.

For Car No. 1, 67 days have been recorded in 2023 and 81 days in 2024, resulting in total 148 days.
For Car No. 2, 82 days have been recorded in 2023 and 126 days in 2024, resulting in total 208 days.
For Car No. 3, 96 days have been recorded in 2023 and 120 days in 2024, resulting in total 216 days.
For Car No. 4, 129 days have been recorded in 2024, resulting in total 129 days.

Results of Car No.1:

	2023, no short trips < 5 km considered				
	Q1	**Q2**	**Q3**	**Q4**	**Ges.**
Driven distances [km]	0	0	514,1	513,9	1028
Av. energy consumption [kWh/100km]	0	0	28,8	28,7	28,7
	2024, no short trips < 5 km considered				
	Q1	**Q2**	**Q3**	**Q4**	**Ges.**
Driven distances [km]	72,2	740,9	726,6	0,0	1540
Av. energy consumption [kWh/100km]	30,9	17,3	17,3	0,0	18,1

Results of Car No.2:

	2023, no short trips < 5 km considered				
	Q1	**Q2**	**Q3**	**Q4**	**Ges.**
Driven distances [km]	0	0	1070,2	1557,1	2627
Av. energy consumption [kWh/100km]	0	0	22,5	27,3	25,4
	2024, no short trips < 5 km considered				
	Q1	**Q2**	**Q3**	**Q4**	**Ges.**
Driven distances [km]	1152,5	1654,0	1220,0	0,0	4026,5
Av. energy consumption [kWh/100km]	20,2	16,7	16,8	0,0	17,8

Results of Car No.3:

	2023, no short trips < 5 km considered				
	Q1	**Q2**	**Q3**	**Q4**	**Ges.**
Driven distances [km]	0,0	0,0	998,8	962,6	1961,4
Av. energy consumption [kWh/100km]	0,0	0,0	25,8	35,5	30,8
	2024, no short trips < 5 km considered				
	Q1	**Q2**	**Q3**	**Q4**	**Ges.**
Driven distances [km]	758,7	596,4	743,5	0,0	2098,6
Av. energy consumption [kWh/100km]	19,7	15,5	13,5	0,0	16,3

Results of Car No.4:

	2024, no short trips < 5 km considered				
	Q1	**Q2**	**Q3**	**Q4**	**Ges.**
Fahrleistung in [km]	2293,8	4503,3	5717,0	0,0	12514,1
Durchschnittsverbrauch in [kWh/100km]	19,1	16,9	15,4	0,0	16,6

Figure 3: Results of cars No.1-4

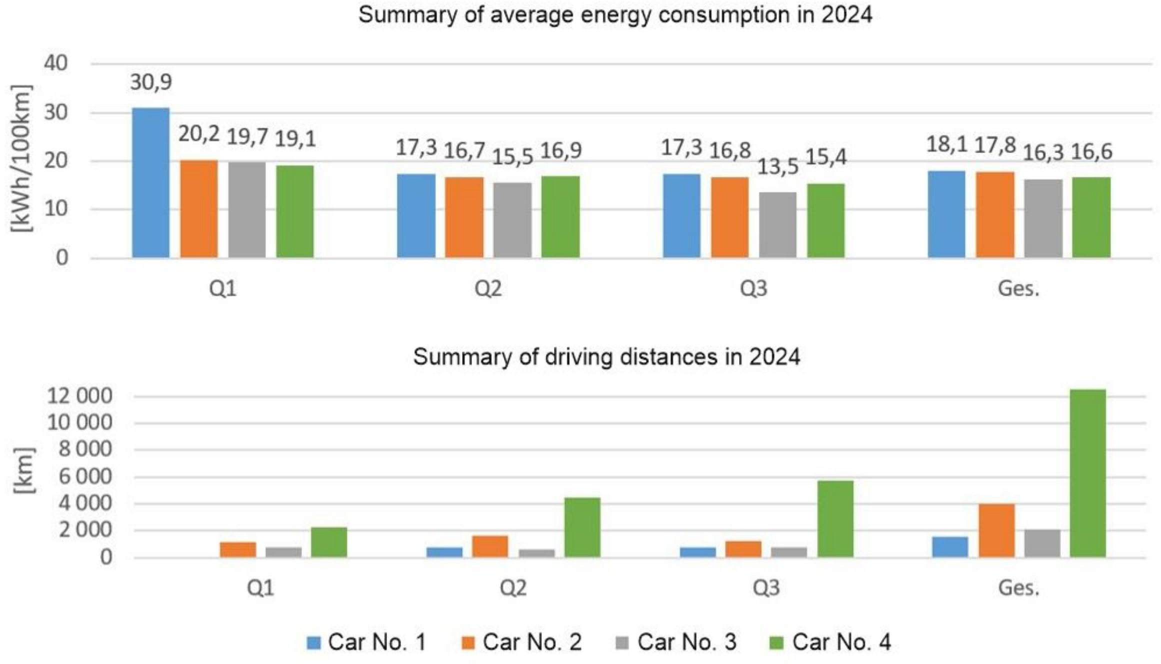

Figure 4: Summaries of data evaluation results

A comparison of the calculated energy consumption shows a pretty well correspondence with the data provided in the EV-Database. In general, it has to be considered, that the cars have been driven in urban regions to a high share, which are characterized by lower energy consumption than highway cycles. Also visible is the influence of varying ambient temperature condition in different seasons. As energy is demanded for heating in winter times, the corresponding energy demand is higher in the cold season. These data are valuable for planning and management of vehicle use and charging infrastructure.

The project UserGRIDs targeted to the development and demonstration of digital energy services to reduce greenhouse gas emissions on a research campus: (https://greenenergylab.at/projects/nutzungszentrierte-planung-und-regelung-komplexer-nachhaltiger-quartiers-energiesysteme/) In the concept, key role plays digital planning and management of both energy provision and energy usage. The concept includes different types of sustainable electric provision technologies, as e.g., photovoltaic, geothermal and excess heat, as well as intelligent energy storage and use. In this context, there are several intersections with the Project AC/DC – especially in view of the energy consumption side. In this context, the holistic energy management system developed in UserGRIDs might consider the automated charging technology of AC/DC to optimize energy consumption. This can include fleet charging management optimization in a way that electric cars are charged in times when renewable energy sources are on a high output level, e.g., charging during days with photovoltaic energy. In addition, future bi-directional charging technologies of electric cars can be integrated into holistic energy management, whereby cars can play a relevant role as electric energy storage systems, not only as consumer. This opportunity has great potential to reduce electric grid load, and increase efficiency of the renewable energy system.

4.6 Work Package 6: Roadmap and project dissemination

Task 6.1: Potential use cases and target groups
As result of the analysis, tenants were identified as main target group, whereas it could affect both tenants and owners at new constructed buildings as well as already existent apartment buildings with access to a parking area mainly in the urban area. Beside them, housing developers for new constructions and property managements play an important role concerning such innovative solutions for parking areas belonging to their own properties. With those target groups identified, it becomes clear, which use cases come into the focus of the business plan and correlate well with them. Smart and autonomous charging solutions could generate a massive benefit as well for housing developers and management as for the end users themself. Through the software solutions it will be possible to charge docked vehicles in the most efficient way in consideration of the needs of the end users.

Task 6.2: Business Plan development
The project's outcomes reflect substantial progress and strategic development across multiple areas, ultimately creating a comprehensive solution for electric vehicle charging in residential and commercial settings. Key results are presented in terms of market understanding, product development, and strategic partnerships, showcasing the combined efforts of Energie Graz and ilogs to bring a viable charging infrastructure solution to the market.
The market analysis provided critical insights into the current barriers and opportunities in the EV charging sector. For residents in apartment complexes, the primary challenges included limited existing infrastructure, high installation costs, and regulatory hurdles, particularly in older buildings. Similarly, fleet operators faced issues with cost control, charging downtime, and managing the required electrical capacity for simultaneous charging. Addressing these insights allowed the team to tailor solutions that meet the specific needs of both individual and corporate users.
Product Development was conducted with a user-centric approach, focusing on the intelligent "Quality Charging" software designed to balance demand and charging availability. This system integrates real-time energy data, user-specific charging needs, and renewable energy inputs, enabling both optimal battery health and cost-efficient charging. By incorporating feedback from potential users, the product evolved to include features such as prioritized and demand-based charging, peak load management, and compatibility with various charging schedules, making it adaptable to multiple user profiles. This adaptability enhances user satisfaction and optimizes energy use, demonstrating the software's versatility across diverse charging scenarios.
Strategic Partnerships were essential to the project's success, as collaboration with key stakeholders—wallbox manufacturers, housing associations, and utility companies—enabled a holistic solution. Partnerships with CPMS (Charging Point Management Systems) providers, local electricians, and installation experts ensured that the product could meet technical, operational, and regulatory requirements seamlessly. The collaboration with Energie Graz allowed ilogs to leverage existing networks and market insights, expediting the development of a scalable solution ready for market entry by 2025.
In conclusion, the project effectively addressed the critical challenges in EV charging for residential and fleet users. Through a well-planned combination of software development, market insights, and strategic

partnerships, the team has laid a robust foundation for a sustainable, user-friendly, and economically viable charging solution. This positions both Energie Graz and ilogs to capitalize on the growing demand for EV infrastructure, setting a strong precedent for future expansions and market growth in the e-mobility sector.

Task 6.3: Future development timeline for mass market adoption

The Volterio charging system has been successfully licensed to on of the world's leading automotive Tier-1 supplier Continental AG. This strong partnership with a global player is essential for the system to be accepted by the automotive OEMs. Continental takes care not only for the vehicle unit inside the car as well as the system integration but also about the charging robot and the final steps of serial development. Continental is also the perfect partner for volume production. Currently the B-sample is developed and a introduction to market is expected for 2026. In parallel several advanced development projects were performed with leading OEMs such as BMW group or Renault.
Furthermore, a slightly modified system with higher charging rates was successfully licensed to the US listed corporate Wabtec Inc., which is a global player for heavy duty applications.
To accompany the efforts for a global standard, Volterio is member in all relevant international standardisation bodies for ACD-U systems.

Task 6.4: Dissemination of project results

The project and its results were communicated with the help of the following dissemination activities:

- **Scientific publications:**
  - Hirz M., Flechl C., Schachner N., Pommer A. (2024): Novel concept for automated charging of professional electric vehicle fleets, Mechatronika 2024 Conference, 4.-6.12.2024 in Brno, Czech Republic, https://mechatronika.fel.cvut.cz/
  - Planned for 2025: 16th International Scientific Conference Management of Technology – Step to Sustainable Production MOTSP 2025 3 – 6 June, 2025 Crikvenica, Croatia, https://motsp.eu/
- **Press releases published on:**
  - fivemedia GmbH: 5min.at (26.06.23)
  - Holding Graz: Holding-graz.at (26.06.23)
  - Kleine Zeitung: Kleinezeitung.at (26.06.23)
  - Grazer: Grazer.at (25.06.23)
  - **Kronen Zeitung (18.05.21)**
- **Project profile „Vorzeigeregion Energie“**
- **Workshops/Events:**
  - 19.07.2021: Thematic field workshop: Social acceptance of climate protection technologies and measures (Green Energy Lab)
  - 28.10.2021: Green Energy Update (Green Energy Lab)
  - 21.04.2022: Project manager meeting (Green Energy Lab)

- 16.05.2023: 12. BEÖ-Board Meeting

Conclusion
The dissemination activities conducted throughout the project facilitated a wide-reaching distribution of results, ensuring that the project's outcomes were communicated effectively to a diverse audience. Through scientific publications, such as the upcoming presentations at the Mechatronika 2024 Conference and the MOTSP 2025 Conference, the project gained visibility within the academic and scientific communities. Additionally, press releases in reputable media outlets, including fivemedia GmbH, Holding Graz, Kleine Zeitung, and Grazer, helped broaden the reach of the project to the general public and industry stakeholders.

The project was also prominently featured in the "Vorzeigeregion Energie" profile, further amplifying its visibility. The organization of workshops and events, including thematic workshops on social acceptance of climate protection technologies and updates at the Green Energy Lab, provided a platform for direct interaction with relevant audiences, fostering engagement and knowledge exchange.

Through these varied dissemination efforts, the project was able to achieve a broad and effective outreach, contributing significantly to its successful promotion and the widespread application of its results.

5 Outlook and recommendations

The AC/DC project was valuable in many ways to expand Volterio’s the product portfolio with a dedicated solution for outdoor usage and public spaces by a seamlessly and flush integrated charging solution. This robot variant helped also to get insights over several years of testing and to eliminated weaknesses. The intensive testing helped to mature several aspects of the system design. The knowledge was already used in several other OEM projects and led to a modified version for heavy duty applications. The revolutionary system and its underlying patent portfolio was successfully licenced to one of the leading US stock listed corporate which is a Tier-1 supplier for heavy duty applications such as electric buses. Negotiations with several other suppliers for the passenger car version are currently taking place with the main focus on Asia. We can conclude that the project was not only from a technical and development standpoint successful but also from a business standpoint and the system is the bases for several upcoming products in different industries. The outdoor charging solution also helps to complete the ecosystem of robots for various applications. Autonomous charging will be a necessity for future autonomous driving vehicles but already contributes today in operating electric fleets for efficiently by optimizing fleet management.

As part of AC/DC, ilogs had the opportunity to deeply engage with the topic of electromobility and identify the significant demand potential for private EV charging in multi-family buildings and company fleets. Through a thorough understanding of the specific needs of both markets, we were able to create a tailored prototype system that optimally balances user-friendliness and technical requirements. The system enables efficient and cost-effective management of charging processes while ensuring fair load distribution among users. In 2025, we plan to bring the system to market maturity with a "friendly customer" and subsequently offer it in Austria. With this market launch, we aim to make a significant contribution to sustainable mobility and make electromobility more accessible to all users.

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