Deliverable 4.5

D4.5: Training material and assessment

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Project Executive Summary

SCALE (Smart Charging Alignment for Europe) is a three-year Horizon Europe project that aims at preparing EU cities for mass deployment of electric vehicles and the accompanying smart charging infrastructure.

Charging electric vehicles (EVs) predominantly occurs in residential areas and business districts, as well as on public streets. This arrangement presents significant opportunities for smart charging and vehicle-to-everything (V2X) functionalities. By making charging more accessible and user-friendly, it can drive greater adoption of EVs. Additionally, this setup encourages the use of locally produced renewable energy, thereby enhancing the use of sustainable power sources and reducing reliance on the grid.

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Deliverable executive summary

This Deliverable falls under the SCALE Project Work Package 4 “Monitoring, evaluation and impact assessment” and specifically under the Task 4.6: Training of users and researchers in system use and conducting pilots.

Deliverable D4.5 of the SCALE project focuses on the development, implementation, and evaluation of a comprehensive training program to prepare diverse stakeholders for engaging with innovative electromobility and Vehicle-to-Everything (V2X) technologies. The training program was designed to address knowledge gaps, enhance user competence, and promote sustainable adoption of smart charging systems across SCALE’s pilot sites. This initiative is a critical step in ensuring the successful deployment and scalability of these cutting-edge solutions.

The training materials were meticulously crafted to cater to the unique needs of multiple user groups, including electric vehicle (EV) drivers, fleet operators, municipal stakeholders, and researchers. A modular approach was implemented, offering tailored content that covered a range of topics, from basic principles of smart charging to advanced functionalities like bidirectional charging, safety protocols, and energy optimization. The program also integrated practical exercises, case studies, and interactive tools to provide hands-on learning experiences and foster real-world applicability.

Key outcomes of the training program include significant improvements in participants’ preparedness, knowledge, and confidence before executing the trials. Evaluation results, from 20 users among pilot sites, demonstrate high levels of satisfaction, with particular appreciation for the focus on operational safety, behavioral adaptation, and accessibility. The program successfully addressed technical, operational, and policy-related dimensions, equipping participants with the tools and knowledge to effectively engage with V2X and smart charging systems.

In addition to fostering technical competence, the training program emphasized inclusivity and social sustainability. By providing tailored resources for diverse participants, including vulnerable groups, the initiative ensured broad accessibility and equitable participation. This aligns with SCALE’s broader goals of promoting sustainable and user-centric electromobility solutions.

The successes of the training program have greatly strengthened the prospects of SCALE’s pilot implementations and future scalability. Learnings from these can inform other aspects of the program, such as increasing the use of guided simulations and interactive parts of the training. This deliverable greatly advances the overall goals of the project, which are to foster a resilient, efficient, and socially inclusive smart charging ecosystem, through the promotion of user engagement, technical skills, and sustainable practices.

In summary, Deliverable D4.5 represents a pivotal component of the SCALE project, driving knowledge enhancement and stakeholder preparedness. Through its structured and inclusive approach, the training program supports the seamless integration of electromobility innovations, paving the way for sustainable, scalable, and impactful adoption of V2X and smart charging technologies across Europe.

Key words

Training course, training program, awareness, pilots.

Document aim

The primary aim of Deliverable D4.5 is to develop and implement a robust training program that equips stakeholders with the knowledge, skills, and confidence to effectively engage with the SCALE project's innovative electromobility and Vehicle-to-Everything (V2X) systems. By addressing key knowledge gaps and preparing end-users, researchers, and technical staff for real-world pilot deployments, the training program seeks to ensure the seamless integration and operation of smart charging technologies. This effort supports the project's overarching objectives of reducing grid reliance, optimizing energy efficiency, and fostering the large-scale adoption of sustainable electromobility solutions.

A significant focus of this deliverable is to create tailored, modular training materials that are adaptable to the needs of diverse participants, including electric vehicle (EV) drivers, fleet operators, municipal authorities, and vulnerable groups. The training covers essential topics such as smart charging basics, advanced functionalities like bidirectional energy flow, safety protocols, and sustainable energy practices. By integrating practical exercises, real-world case studies, and interactive digital tools, the program ensures participants are not only informed but also empowered to contribute to the success of SCALE's pilot implementations and to the long-term transformation of urban mobility systems.

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List of abbreviations and acronyms

Acronym	Meaning
CPO	Charge Point Operator
EMSP	eMobility Service Provider
EV	Electric Vehicle
LCV	Light Commercial Vehicles
OCPP	Open Charge Point Protocol
V2G	Vehicle-to-Grid
V2X	Vehicle to Everything

1 Introduction

1.1 Purpose and scope of the SCALE training

The adoption of electric vehicles (EVs) and Vehicle-to-Everything (V2X) technologies accelerates. A central challenge to the successful roll-out of V2X systems lies in the adoption and proper use of these advanced technologies by end-users, operators, and researchers involved in the pilot projects. To facilitate this process, it is essential to ensure that these stakeholders are properly trained to use the systems effectively, address potential errors, and understand the benefits of V2X and smart charging technologies. Deliverable 4.6 of the SCALE project addresses this need by developing a comprehensive training program tailored to diverse user groups, ensuring they are well-prepared to interact with and assess the project's cutting-edge solutions before pilot implementations.

The primary goal of this deliverable is to design and implement targeted training that fosters knowledge enhancement, behavioral adaptation, and user awareness of system functionalities, preparing the targeted user groups for their participation in the real-life pilot cases. By aligning training objectives with project goals, this initiative aims to empower end-users and researchers to fully understand the operational and safety aspects of V2X systems, including their components, modules, and subsystems, allowing them to engage with the smart charging systems and V2X technologies effectively. This will enhance their ability to use the systems effectively and responsibly in real-world demonstrations. The goal is not only to raise awareness but also to change user behavior, increase system acceptance, and ensure safe and efficient usage.

The training program is structured to address key aspects such as system benefits, innovations, functionalities, and potential challenges during usage. To ensure inclusivity and accessibility, the training content will be modular and available both in-person and online. Each module will focus on specific topics, such as understanding the benefits of the new systems, learning about user interfaces, and recognizing and mitigating erroneous behaviors. This modular approach enables users to acquire knowledge progressively while catering to varying levels of expertise and interests.

SCALE's pilot cases are a crucial part of the project, offering practical testbeds for the system's real-world applications. These cases are divided into four key innovation clusters, each targeting a different segment of the market where V2X and smart charging are or will become essential:

1. **Home**: Focused on private households, where EV owners will use V2X technologies for both charging and energy management. Key actors include individual users, homeowners, and smart home infrastructure providers.
2. **Business/Office:** Targeting commercial settings where fleets of electric vehicles are used, and businesses are looking to optimize energy use, reduce costs, and promote sustainability. Participants include business owners, fleet operators, and facility managers.
3. **Light and Heavy Duty**: Focusing on transportation sectors with light-duty vehicles (such as delivery fleets) and heavy-duty vehicles (such as electric trucks). Actors in these pilot cases include logistics companies, fleet managers, and truck operators.
4. **Public**: This cluster includes public charging infrastructure, where city municipalities, utility companies, and public service operators are involved in deploying smart charging solutions for the broader public. Key actors include local authorities, public infrastructure providers, and utility companies.

The training content has been sketched to be tailored to each of these pilot cases, addressing specific needs and use scenarios for specific actor groups that will participate in each pilot case. Training will cover a range of topics, such as understanding the benefits of V2X systems, using the various components of technology (from vehicles to charging stations), and ensuring safe and efficient operations. Special attention will be given to possible erroneous behaviors and how to mitigate them, as well as safety protocols to ensure secure system usage. The training will be available both in-person and online, allowing flexibility for the diverse actors involved across the different pilot sites.

Finally, the aim of the training and preparation is to make sure that all the actors of the SCALE project are sufficiently prepared to utilize the system for its proper deployment and to learn from the pilot cases. The training will strengthen knowledge, awareness and the hands-on engagement so as to enable the successful implementation of the V2X solutions' wide scale deployment and the future of smart, connected mobility.

Evaluating how effective the training program is for the participants is an important part of this Work Package. The assessment for the training has been done by a mixed group of at least 20 male and female participants drawn from all demonstration locations. This feedback allowed the evaluation of the quality of the content, delivery and the overall user experience. The analysis of these results will assess the changes that need to be applied on the following versions of the trainings and will also meet the general goals of the SCALE project regarding system effectiveness and stakeholder participation.

To summarize, Deliverable 4.6 is concerned with the creation of a systematic, constructive, and effective training program in line with the goals of the SCALE project towards the advancement of V2X technologies. In particular, participants will be ensured of not only receiving appropriate information on the systems, but also being provided the necessary assistance in making sure that the advantages of these systems will be maximally achieved.

1.2 Structure of the deliverable

This deliverable has been divided into several sections, each of which provides an overview of the SCALE training approach, including its purpose and how it was carried out. It starts with an introductory section (Section 1) which outlines the reason and the extent of the training and its alignment with other work packages and project deliverables. Section 2 analyzes the availability of training in electromobility and V2X, their relative merits, challenges, and future prospects.

In Section 3, the SCALE specific training objectives are outlined in depth, including the users and stakeholders to be trained, as well as the training aims. The training needs analysis is presented in Section 4, which discusses knowledge gaps in the target audience and details the training needs.

The tools and methods for training are covered in Section 5, while Section 6 outlines the organization and structure of the courses for SCALE trainings with their delivery procedures. Afterwards, Section 7 addresses the evaluation and feedback, including how the training is measured for effectiveness and the outcomes from the users and evaluators.

Finally, Section 8 draws our attention to the concluding remarks of this project as well as the most important discoveries. In Section 9, the reader can find the cited literature. Finally, Annex A contains detailed information on the training content, including target users, project scope, use cases for smart charging, and safety training. The structure is designed to guide the reader from an overview of the training's objectives and methodologies to a detailed analysis of its impact and outcomes.

1.3 WP4 flow and connection to other work packages/deliverables

The work carried out in WP4 is closely intertwined with the efforts in WP3. Once the pilot infrastructure was established and fully operational, our focus shifted to developing comprehensive training materials. These materials were meticulously crafted to educate users on the optimal use of the infrastructures, with a keen awareness of the unique characteristics present at each pilot site.

Initially, the core objectives revolved around ensuring that the infrastructure met all technical and operational standards. After achieving this, we prioritized user training to enhance both efficiency and safety. The training content was tailored to address the specific needs and challenges of each location, ensuring that users could leverage the infrastructure effectively.

By aligning the training program with the specificities of each pilot site, we aimed to foster a deeper understanding and competence among users, ultimately driving better engagement and maximizing the benefits of the infrastructure across all locations. This integration of WP3 and WP4 efforts underscores our commitment to holistic project development, ensuring that each phase seamlessly supports the next for optimal outcomes.

2 State of the Art for training schemes related to electromobility and V2X

2.1 Introduction

For a variety of stakeholders, training programs specifically designed for electric mobility (e-mobility) and vehicle-to-everything (V2X) technologies are becoming increasingly important as these technologies gain traction. With the help of these applications, users, researchers, and business experts should be able to handle the rapidly changing e-mobility systems and technology landscape. Aspects of electromobility such vehicle operation, system integration, user behavior, and safety procedures are all covered in training programs. Furthermore, V2X, which facilitates communication between automobiles and other automobiles or infrastructure, necessitates specific training because of its intricacy and revolutionary influence on energy distribution, traffic control, and car features.

The sections below present some indicative training schemes related to the aforementioned topics.

2.2 Electromobility Training Schemes

A number of training initiatives have been established internationally to meet the increasing need for qualified workers in the electric vehicle industry. These schemes are mainly aimed at teaching consumers how to use EVs, charging systems and how to combine using electric cars with renewable energy sources. Some examples are the following.

1. **The European Commission's E-Mobility Training Program**[1]

The European Commission has also sponsored several training initiatives to enhance e-mobility and human capacity to manage the implications of electric transportation systems. Programs such as the e-Mobility Training Programme (2020) has educated individuals who are involved in the automotive, public and energy sectors. Topics include installation and maintenance of charging points, smart charging, and how to incorporate electric vehicles into the power network.

2. **The E-Mobility Professional Qualification (EMIQ)**[2]

The EMIQ project, which is a collaborative effort across multiple EU member states, has created a qualification system that can help support the growth of the e-mobility sector. The scheme offers modular courses for technicians, engineers and fleet managers on electric vehicle technology, charging infrastructure and grid integration.

3. **The Clean Energy Ministerial (CEM) EV Training Programs**[3]

The Clean Energy Ministerial initiative has provided global training on EVs to improve the knowledge of the public and private sectors on the use of electric vehicles. These programs are designed to inform the public about the environmental advantages of electric vehicles and how to promote their use. The CEM is a leading advocate for EV-related training for fleet managers, operators, and energy providers.

[1] European Commission. (2020). "Electric Mobility Training Programme." Retrieved from https://ec.europa.eu/.
[2] European Commission. (2020). "E-Mobility Professional Qualification (EMIQ)." Retrieved from https://www.emiq.eu/.
[3] Clean Energy Ministerial. (2021). "Electric Vehicle Training Programs." Retrieved from https://www.cleanenergyministerial.org/.

2.3 V2X Training Schemes

V2X tools are turning into a key part of today's transport systems, special training for users, builders and stake holders is very important to make sure things work well. V2X talk, which lets cars connect with road setups, other cars and even the power grid, needs a good grasp of how things fit together and keeping data safe. Here are some examples:

1. **V2X Communication Training by SAE International**[4]

SAE Global, a top group in travel rules, gives many certificate plans that focus on V2X talk tech. The SAE J2735 rule for data talk in V2X is key to these learning plans which aims to boost know-how of linked car systems like car-to-car (V2V), car-to-road tools (V2I) and car-to-power grid (V2G) systems.

2. **V2X Awareness and Development Program by the European Union Agency for Cybersecurity (ENISA)**[5]

The ENISA plan gives lessons on the safety effects of V2X talk, looking at how data privacy, network strength, and cyber safe must be taken care in linked vehicle systems. The plan hopes to ready workers to manage V2X systems safe and rightly; touching on problems about hacking, data leaks, and the safe swap of info between vehicles and things like roads.

3. **The V2X Solutions Masterclass (UITP)**[6]

The World Group of Public Transport (UITP) has the V2X Solutions Class, that gives lessons on mixing V2X tools in public transport systems. The lesson plan includes stuff like clever traffic control, live chatting, and building digital setups that help self-driving cars and smart city uses.

4. **The ERTICO V2X Academy**[7]

ERTICO offers a dedicated **V2X Academy**, where public and private sector stakeholders, including fleet operators, local authorities, and researchers, are trained in the deployment and management of V2X technologies. The academy covers V2X system integration, traffic safety, and data management for connected vehicles, addressing both technical and regulatory aspects.

2.4 Challenges and Future Directions

While many training programs have emerged globally, several challenges remain in achieving widespread adoption of V2X and electromobility. These challenges include the need for standardized training curriculums, regional disparities in technology access, and the rapid evolution of both V2X and EV technologies. As a result, future training programs should integrate the latest research findings and emerging trends in the mobility sector, with a focus on continuous professional development and upskilling.

The evolving nature of electromobility and V2X systems also demands an interdisciplinary approach to training, involving not only technical experts but also policymakers, business professionals, and end-users who need to understand the social and environmental impacts of these technologies. Further collaboration

[4] SAE International. (2021). "V2X Communication Training." Retrieved from https://www.sae.org/.
[5] ENISA. (2021). "V2X Security and Development Program." Retrieved from https://www.enisa.europa.eu/.
[6] UITP. (2021). "V2X Solutions Masterclass." Retrieved from https://www.uitp.org/.
[7] ERTICO – ITS Europe. (2021). "V2X Academy." Retrieved from https://ertico.com/.

between public institutions, industry stakeholders, and academic entities will be crucial in developing a comprehensive, future-proof training landscape for electromobility and V2X.

3 Training Objectives for SCALE

3.1 Understanding SCALE's target user groups and stakeholders

The primary goal of SCALE training is to equip end-users, researchers, and stakeholders with the necessary knowledge, skills, and awareness to effectively use and manage these innovative systems in real-life pilot settings. A guiding document for understanding this is the Stakeholder analysis Smart Charging system (https://scale-horizon.eu/?jet_download=5732). The training is designed to foster understanding of both the technical aspects and practical benefits of the SCALE ecosystem, ultimately ensuring successful deployment and operation across diverse use cases.

3.2 Understanding SCALE's Target User Groups and Stakeholders

The SCALE project involves multiple user groups and stakeholders with distinct roles, responsibilities, and levels of engagement in the pilot implementations. Training objectives must, therefore, be tailored to these varying needs:

1. **End-Users**

The core focus of the training is on end-users, specifically those who will directly interact with SCALE systems at different sites. These include:

- **Electric Vehicle (EV) Drivers**: Individuals using V2G-enabled vehicles, who will benefit from understanding how to charge, discharge, and manage energy flows between their vehicles and the grid, home, or business.
- **Business and Facility Managers**: Users at commercial and industrial sites, including car dealerships, office buildings, and depots, who will manage EV fleets, charging stations, and energy consumption within the context of their operations.
- **Public and Municipal Stakeholders**: Municipalities and public parking operators responsible for managing charging infrastructure and overseeing the integration of V2X services to alleviate grid stress, reduce peak loads, and optimize local energy usage.

2. **Researchers and Technical Personnel**

Researchers and technical staff play a critical role in monitoring, testing, and evaluating the system's performance during the pilot phase. The training will equip them with the technical expertise required to:

- Understand the operational workings of the SCALE technologies, including V2X communication protocols, smart charging, and local energy management.
- Troubleshoot technical issues, identify erroneous behaviors in system interactions, and perform data analysis to evaluate system performance and scalability.
- Conduct rigorous evaluations to assess the impact of the technologies on grid stability, energy efficiency, and operational costs.

3. **Project Stakeholders**

The SCALE project involves various external stakeholders who will support and oversee the implementation of the system in specific regions. These include:

- **Policy Makers and Regulatory Bodies**: Authorities responsible for setting the standards and regulations for electromobility, smart grids, and energy management systems. Training will raise awareness of regulatory implications and the potential for future policy developments in the field.
- **Energy Providers and Utilities**: Electricity providers, grid operators, and energy managers who need to understand the integration of V2X technologies with the power grid. Their role is essential in facilitating grid balancing, reducing grid reinforcement costs, and maximizing renewable energy usage.

3.3 Training Goals for SCALE

The instructional design will be aligned with our goals to first improve and then maintain the knowledge, awareness, and behavior of our myriad user groups.

1. Knowledge Enhancement

- Enhance comprehension of the technologies associated with electromobility, especially the concepts of V2X and V2G, among every demographic of users.
- Render detailed understanding of the constituent parts of the SCALE system, its functions, and its interplay among various functions, with particular attention to the user interface and the user experience.

2. Awareness of Benefits and Innovation

Advocating for the adoption of smart charging and V2X technologies brings a host of benefits, including these three big ones:

- They help lower costs related to EV charging.
- They help balance energy supply and demand.
- They help fully integrate EVs into the electric grid.

Increase the recognition of the environmental and financial advantages of employing renewable energy sources along with electric vehicle charging.

3. Behavioral Changes and Adoption

- Motivate the embrace of novel charging behaviors in electric vehicle users, which should include scheduling their off-peak charging and knowing how to use their vehicles' batteries to back up the electrical system.
- Assist business managers and fleet operators in the seamless implementation and management of new technologies within their daily operations, guaranteeing that they can extract the utmost potential from the SCALE system.

4. Safety and Operational Guidelines

- Keep all users, from end-users to technical personnel, well-informed about safety protocols, emergency procedures, and the just-right handling of charging systems and V2X communication to preclude accidents or operational disruptions.

3.4 Key Knowledge, Awareness, and Behavioural Goals for End-Users in SCALE

The SCALE project aims to ensure that end-users are not only knowledgeable about the new electromobility technologies but also capable of safely and efficiently interacting with the system to maximize its potential. The training for end-users is designed to equip them with the necessary skills, understanding, and behaviors to effectively use the system, thereby contributing to the success of the project. The primary objectives revolve around enhancing user knowledge, raising awareness of the system's advantages, and encouraging positive behavioral changes.

Firstly, users must gain a solid understanding of key concepts, particularly the operation of Vehicle-to-Everything (V2X) and Vehicle-to-Grid (V2G) technologies. This includes understanding how electric vehicles (EVs) can interact with the grid and building energy systems. Users will learn how their vehicles can both consume and provide energy to the grid, including how this process benefits the grid and supports the integration of renewable energy. This knowledge will empower users to take an active role in managing their vehicle's energy usage, ensuring they maximize the system's benefits.

In addition to the technical understanding, the training will provide users with the necessary information on how to interact with the system's components, such as the charging points and user interface. Understanding how to schedule and manage charging sessions, how to use bidirectional chargers for V2G functionalities, and how to monitor the charging status are all integral aspects of the user experience. This knowledge will allow users to utilize the system to its full potential, ensuring that they can charge their vehicles efficiently while reducing costs and supporting the stability of the grid.

Safety is another critical component of the training. Users will be educated on safety protocols related to charging and vehicle interactions with the grid, ensuring they can safely manage the system without risk of malfunction or accidents. Training will also focus on identifying and responding to potential issues, such as detecting malfunctions or errors in the charging process. This proactive approach to system usage ensures that users are prepared to handle any situation that may arise, improving the overall reliability and safety of the system.

Awareness of the environmental and economic benefits of the SCALE system is another important goal. Users will be educated on how their actions can contribute to a more sustainable energy system, such as through the use of renewable energy, reducing grid dependency, and lowering their electricity bills. This understanding will help them see the broader impact of their participation in the project, making them more likely to adopt sustainable charging practices and participate in V2G activities.

The training will also foster positive behavioral changes. One key objective is to encourage users to adopt smart charging practices, such as scheduling their charging during off-peak hours to reduce energy costs and alleviate stress on the grid. Additionally, the training will guide users on how to actively participate in V2G functionality, enabling them to discharge energy back into the grid or building when needed. This active participation is vital for the system's success, as it helps to stabilize the grid and balance energy demand and supply.

Finally, users will be encouraged to provide feedback on their experiences with the system. This feedback will be instrumental in refining and improving the system, ensuring that the needs of the users are met while addressing any challenges or concerns. By fostering a feedback culture, the project ensures that the system evolves and improves, driven by the experiences of its users.

3.5 Role of Training in Ensuring Successful Pilot Implementations in SCALE

Training helps user take part, which is key for the success of pilot plans. For any new tech or system to be used, it's vital for end-users to not just know its technical parts but also feel pushed to use it all the time. Good training shows users the perks of the system, like lower costs, energy cuts, and good effects on nature., which makes them want to join in more. For instance, users will find out how to use smart charging tools that help cut down their power bills or how being part of V2G can help keep grid strong. This feeling of belonging and knowing boosts more steady and eager involvement with the system; this is key for data gathering, study, and overall success of the pilot phase.

The training improves the necessary technical understanding and acquaintance with the operational skills for the end-users of the SCALE systems. This is because some of the modern technologies employed in the pilot sites, such as V2G and smart charging, require that users be socialized to new interfaces and operational practices. Without proper knowledge, users cannot know how to interface with bidirectional charging systems or optimize their charging schedules to decrease the effectiveness of the pilot. Training familiarizes users with the system's functionalities so they can easily interface with the technology and realize full utilization of its capabilities. Smooth, seamless operation of the system is ensured with maximum utilization in terms of performance by the pilots.

Besides, the role of training has to be continuously pursued so that the users manage the Issue of Safety. V2X systems introduce a level of complexity with the interaction of electric vehicles, grid systems, and building energy management systems. Training would prepare users to identify any potential safety concerns and respond to emergencies, reducing the risk of system failures or hazardous situations. Safety is even more important in the pilot implementations as users are exposed to technologies which may be rather new to them. Proper training means that all parties will know what to do and how to behave with respect to safety considerations to protect users and integrity of the systems.

Training is also encouraging user engagement in various ways important for the success of a pilot project. The acceptance of any new technology or system would involve the knowledge of end-users on its technical functionalities and a positive attitude for constant use. It is at this very place that an effective training program will enlighten users about benefits like cost reduction, energy saving, and other environmental benefits through the use of the system. For instance, they will learn how to exploit smart charging features that enable them to reduce their electricity bills or, on the other hand, how their contribution to V2G can contribute to grid stability. A sense of ownership and understanding developed this way fosters more consistent and proactive engagement with the system, which is crucial for data collection, analysis, and overall success in the pilot phase.

The other important role of training is ensuring that the system is scalable and expandable. The SCALE project represents scaling-up in deploying V2G and smart charging solutions beyond the pilot phase. Well-trained users in piloting will give useful insights and feedback which could be used to refine and improve the system before full-scale implementation. In addition, the trained users will be ambassadors of the technology among other potential users. This kind of promotion, driven by users, identifies the best practices and areas for improvement, accelerating the transition to larger-scale deployment.

This again makes sure that there is common understanding of the systems and procedures among all stakeholders, from researchers to technicians to local staff involved in the pilot. In a project like SCALE, where several stakeholders are involved in different sectors, such as energy providers, fleet operators, technology developers, alignment is a necessity to avoid miscommunication at any level and to ensure smooth operations. Training also increases the capacity of researchers and pilot managers to monitor system performance and user behaviors for easy addressing of challenges.

4 Training needs analysis

The success of the SCALE project will strongly depend on how its stakeholders will be able to engage with the new electromobility systems and technologies introduced. An effective training program should be underpinned by a comprehensive Training Needs Analysis that meets the needs of these diverse groups. The analysis therefore helps in not only finding knowledge gaps but also in adapting this content so all stakeholders will indeed be properly primed for accomplishing the proposed project objectives successfully.

4.1 Identification of Knowledge Gaps and Training Requirements

The identification of certain critical knowledge gaps that exist among stakeholders marks the first step in the Training Needs Analysis process. These gaps are primarily associated with advanced electromobility technologies such as V2X systems, Vehicle-to-Grid solutions, and smart charging infrastructures within the SCALE project. Most stakeholders, particularly end-users not necessarily conversant with these technologies, need basic education on the principles of such systems. For example, there is a lack of understanding on the part of end-users about how bidirectional charging works, how vehicles can be integrated into grid systems, and how they can optimize energy usage for cost savings.

Furthermore, the safety issues that concern the operability of such systems must be addressed. In particular, V2G technologies pose new safety challenges due to the complicated interactions between electric vehicles, the grid, and energy storage systems. Training will be required so that users can identify potential hazards and safely manage overload or faulty connection situations.

The integration of those technologies within currently available infrastructure would probably also constitute another knowledge gap. Many of the sites in question targeted for SCALE, whether office buildings, car depots, or residential areas, might not have been confronted with such implementations related to smart charging systems. Training will be needed to explain how these systems will be integrated with the existing energy management systems or how they will operate in concert with local renewable energy sources, such as solar panels or battery storage systems. Researchers and technical staff will be trained on how to analyze system data and diagnose operational issues, as well as assess the overall performance of the pilot installations.

Beyond these more technical areas, there is also a need to fill knowledge gaps about the business models and operational benefits of the systems, especially with stakeholders who could be scaling the project or looking at adopting the technologies in question, such as fleet operators, property managers, and local municipalities. Training should focus on the economic benefits arising from smart charging: cost reduction by better management of demand charge, energy efficiency, and new revenue streams created by V2G services.

4.2 Analysis of the Target Audience training needs

The SCALE training program is designed for end-users and other stakeholders, such as fleet operators, property managers, local authorities, and technical staff. All these stakeholders have different demands and will therefore need different training content.

The main actors during the pilot phase are the end-users, like employees in serviced offices, car-sharing customers, or private vehicle owners who need a high level of knowledge about the day-to-day use of the technologies. The training content should, for them, be about user-friendly features: how to operate the vehicle charging systems, how to use renewable energy in charging, and how to create safety in operations. This is a group with limited technical know-how; the training should focus on clear instructions and practical demonstrations that allow users to become acquainted with the systems.

Indeed, fleet operators and property managers remain some of the most important stakeholders in the wider diffusion of such technologies. It is not just a question of operational and technical issues but also strategic, economic, and policy considerations that would form the basis of their decisions. These trainings for the same would need to touch on how business operations can involve V2G, how generally to manage fleets of electric vehicles, and assessing the long-run financial implications associated with the eventual adoption of those systems. However, they would also need perspectives on regulatory approaches to electromobility and smart charging, with ongoing technology development.

In the SCALE framework, training content has been uniquely positioned to meet the unique needs and expectations of each target group. To the end-user, the training is simple, interesting, and practical. Benefits related to the technologies and how directly users can benefit through cost savings, convenience, and environmental advantages are the focus of the training materials.

The training will also be provided online, complemented by extra resources and assessments, so that information and guidance can be found when needed. Interactive materials reinforce the knowledge acquired during training sessions, and allow users to review information at their own pace.

5 Training Methods and Tools

The training philosophy of the SCALE training program on EV charging systems is a combination of practical training, written material, and ways of evaluation, so as to enable learners to acquire both theoretical knowledge and skills. The training thus focuses on practical applications of EV charging technologies whereby users will understand how they work, how safety is catered for, and the best ways to implement and manage these technologies.

Practical training constitutes a very important part of training that aims to provide learners with real-life scenarios and step-by-step guides that will help them get acquainted with different charging systems. These exercises will vary from correctly following the charging procedure and troubleshooting charging stations to being aware of the necessary safety measures. Such steps will be practiced by the learners through clear, structured instructions in a real-to-life situation.

Case studies from the SCALE pilot locations supplement this training content with actual EV charging system deployment in the real environment. The case studies will let the learners understand challenges and the solutions implemented for these pilot projects, which is of utmost importance when it comes to practical use and maintenance. It contains various case studies elaborated in both written explanations and images presenting these technologies in real-life application formats for illustrating the context within which learning will take place.

Assessment methods will be integrated into the training at different stages to track user progress and identify that a learner is learning the key concepts. Quizzes will be used to present tests on specific topics, including types of charging technologies, safety procedures, and energy management strategies. Quizzes include multiple-choice, true/false, and short-answer-type questions to test comprehension and recall.

The entire training is hosted on Moodle, which has a flexible, user-friendly interface for the learner. Moodle has features that permit learners to move through the course at their pace, offering multiple opportunities to revisit materials and assessments. Learners can access training modules, take quizzes, and track their performance over time via Moodle. It ensures this training experience is organized, efficient, and geared toward independent learning.

Learners can have straightforward, organized course materials comprising text, pictures, and case studies through Moodle. This course is then organized into distinct modules that take the learners through logical, stepped progressions from understanding the composition of charging equipment to advanced energy management concepts. The platform allows for both asynchronous learning by participants at times convenient for them and synchronous elements, such as scheduled assessments or online discussion forums.

Progress tracking for learners is one of the key benefits with Moodle. This means that participants in training can easily track where they are in the learning process, while trainers can view performance and engagement through easily-accessible reporting functions. The system automatically tracks quiz results, participation in discussion forums, and module completion, thereby enabling trainers to give timely feedback or extra support if needed.

Along with knowledge acquisition, Moodle embeds in itself the mode of assessment through training objectives. Such assessments-quiz, practical tests-provide learners with the opportunity to put into practice what they learn regarding EV charging technologies, from the operation and maintenance of chargers to energy flow management and response to eventualities for safety. These assessments are submitted by the learner and immediate feedback is given to reinforce learning and point out further areas of study. The trainers also provide one-on-one feedback, routing the learner to extra resources based on their quiz results or progress report.

The integration of collaborative features within Moodle, such as discussion forums, can foster learning between peers. Learners can talk over their issues and share thoughts with one another, which helps build a supportive learning community. Instructors can actively participate in such discussions on these forums by offering expert advice or clarifications regarding complex topics, further enhancing the overall learning experience.

Moreover, the fact that Moodle is accessible from any device connected to the internet, including mobile phones and tablets, offers flexibility to participants in terms of time and place. This is important for users who may have irregular schedules or need to revisit specific training content. The accessibility issue is complemented by the intuitive interface, which reduces technical barriers to a minimum and ensures that learners can easily navigate through the course.

6 SCALE training course structure and content

6.1 Introduction

This section outlines the structure and content of the training modules designed to provide a comprehensive understanding of smart charging, electric vehicle (EV) infrastructure, and their functionality in real-world scenarios. The training is structured to cater to different target users, offering clear training objectives and practical insights based on the SCALE project's scope and innovative solutions.

The course content covers several key topics, starting with an introduction to the SCALE project's scope, objectives, and its impact on the smart charging landscape. It delves into the necessary infrastructure for smart charging, the different types of EVs required, and the optimization of energy usage during charging. This foundational knowledge is then followed by detailed modules on the end user's role in interacting with smart chargers, highlighting how to use these devices effectively, from standard operations to advanced functionalities like Vehicle-to-Grid (V2G).

Subsequent modules address various use cases, providing in-depth steps for practical scenarios such as peak shaving, grid optimization, interoperability, and V2L (Vehicle-to-Load) in business contexts. The training explores the integration of solar charging, load management, and V2G peak shaving in public charging settings, ensuring users understand the broader implications of these technologies on grid efficiency and energy management.

Safety training is also integrated into the modules, emphasizing proper charging procedures, handling bidirectional charging safely, and managing electrical risks effectively. Each module is designed to guide users through real-life applications, ensuring they not only understand the theoretical aspects but are also prepared to apply this knowledge in their everyday interactions with smart charging systems.

6.2 Training course content

The content of the SCALE training courses is detailed in Annex A and can also be accessed on Moodle via the following link https://hit-projects.gr/Scale_elearning/course/view.php?id=2 .

To access the SCALE courses on Moodle, users have to create an account. This is done by clicking the option "Create New Account" on the Moodle platform. After that, users will be asked to enter their name, email address, and password. Then a confirmation message will be sent via an email that contains the verification link. Users need to sign in, followed by logging in using the registered email and password. Next, after logging in, navigate to the offerings about SCALE and enroll into the relevant modules to get started.

6.3 Implementation and Execution of Training

In essence, the general aim of training courses is that users gain good knowledge and proper skills on system operation before its charging. All these training courses are foreseen after installation events at every pilot site. It shall also include training of the users on various components of the system and their functions for safe and efficient operation. These courses are tailor-made to deal with challenges users may experience while using it, with practical solutions to be implied for smooth operations. By the end of the training, users should feel confident and competent in using the technologies, minimizing risks and maximizing the potential of the system. This preparation is essential to lay the foundation for successful testing and long-term use of the technologies.

7 Evaluation and Feedback from Users

7.1 Evaluation methodology

Monitoring of the effectiveness of the SCALE training programs is a continuous process through which there is a systematic mechanism for review and solicitation of feedback. An in-depth online evaluation after each training aims to ensure courses meet users' and stakeholders' needs. In particular, post-training assessments include more than 20 participants who can give rich insights on their learning process. They are selected in view of the target audience to ensure that the responses from participants would vary and be representative of the entire training.

The evaluation of the SCALE training program has been especially designed to obtain valid and useful information from the trainees regarding the efficacy of the training. The methodology focused on measuring perceptions and understanding before and after the training, relevance, usability, and quality of the training materials and delivery platform.

Feedback for this evaluation involved a post-training survey that employed quantitative and qualitative questions. Participation from the many user groups needed to complete this survey was contacted after they have had a chance to engage in the training content. Such a feedback mechanism allowed this team to quantify the immediate effectiveness of the training program on their knowledge and readiness to perform these pilot tasks under the SCALE project.

It utilized specific questions in order to deduce a number of critical variables about the whole training experience, including the respondents' overall feeling, perceived helpfulness, relevance of the class content, and how effective the online training facility was. As a matter of fact, supported on a Likert scale, responses to which, from "1-No, not at all," to "5-Yes, very much" are quite aptly quantitive in nature in representing the participation.

The key evaluation questions were as follows:

1. **How would you rate the training overall?**
   - This question aimed to capture the overall satisfaction level of the participants.
2. **How prepared did you feel to execute the pilot tasks before the training?**
   - This allowed the evaluation team to understand the participants' initial level of preparedness before engaging with the training content.
3. **How prepared did you feel to execute the pilot tasks after the training?**
   - The goal of this question was to assess the perceived improvement in participants' preparedness as a result of completing the training.
4. **Was the course content useful and aligned with the training objectives?**
   - This question focused on whether the course content met the learning goals set out at the start of the training.
5. **Did the training meet your expectations?**
   - This question provided insights into how well the training program aligned with the participants' prior expectations.
6. **Was the training platform easy to use and understand?**
   - This question measured the usability and accessibility of the training platform, which is critical for ensuring smooth user engagement.
7. **Was the training material relevant to your role and/or position?**
   - This question helped to determine whether the training content was applicable and meaningful for the participants’ specific roles within the SCALE project.

The feedback collected from these evaluation questions was then analyzed to identify trends, areas for improvement, and key strengths of the training program. By combining these insights with other sources of data, such as participant engagement levels and platform usage statistics, the evaluation results are presented at the following section.

7.2 Evaluation results

The analysis of the collected feedback from more than 20 participants from all pilot sites revealed several key insights into the effectiveness of the SCALE training. Overall, the participants expressed a high level of satisfaction with the course content, training platform, and the degree to which the program prepared them for their pilot tasks. The following points summarize the main findings:

1. Overall Satisfaction and Preparedness

Respondents rated the training positively, indicating that they found it both informative and engaging (Chart 1). Many participants reported a noticeable increase in their sense of preparedness before and after completing the training, suggesting that the course was successful in closing initial knowledge gaps related to their pilot tasks (Chart 2). The majority of ratings fell within the 4 range ("Agree"), underscoring a consistently positive learning experience.

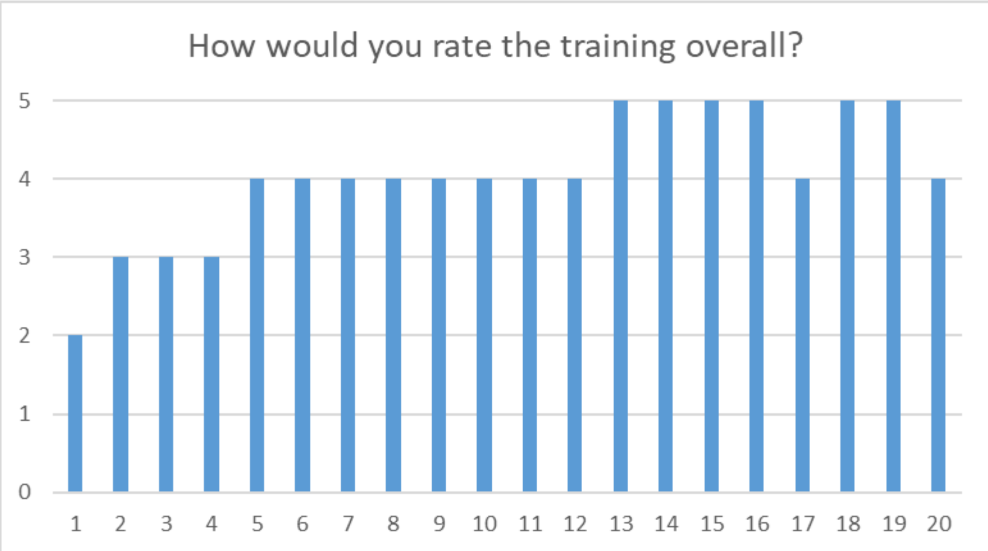

Chart 1: Overall training score

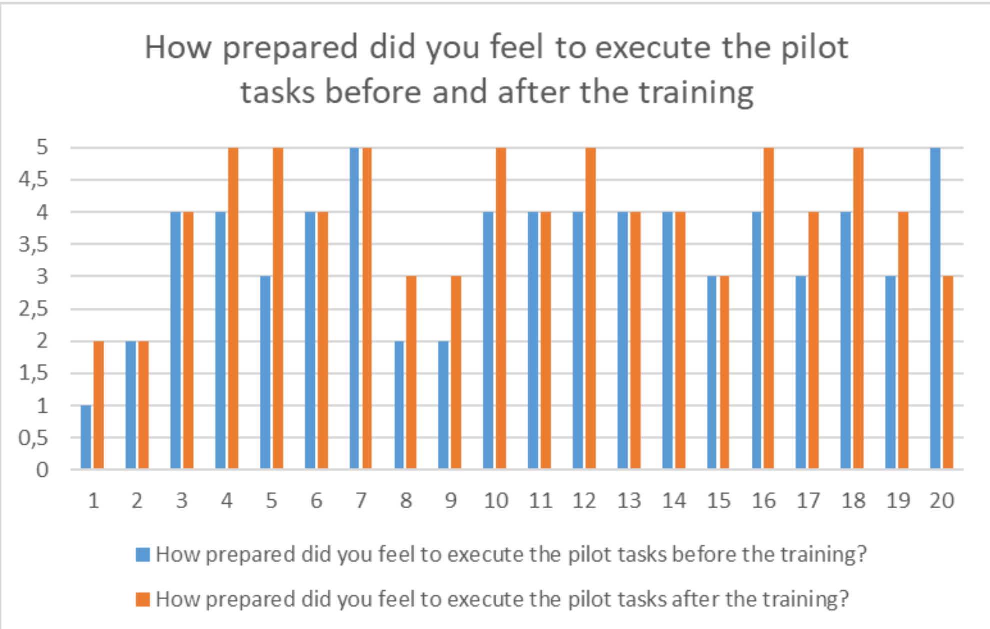

Chart 2: Before and after training preparedness for the task

2. Alignment with Training Objectives

The course content was largely perceived as useful and as being aligned with the stated training objectives (Chart 3). The training addressed the essential components of the SCALE project, including practical guidelines for EV charging, V2X technologies, and safety procedures. This alignment between the content and the objectives was cited as a factor that enhanced learning effectiveness and clarity.

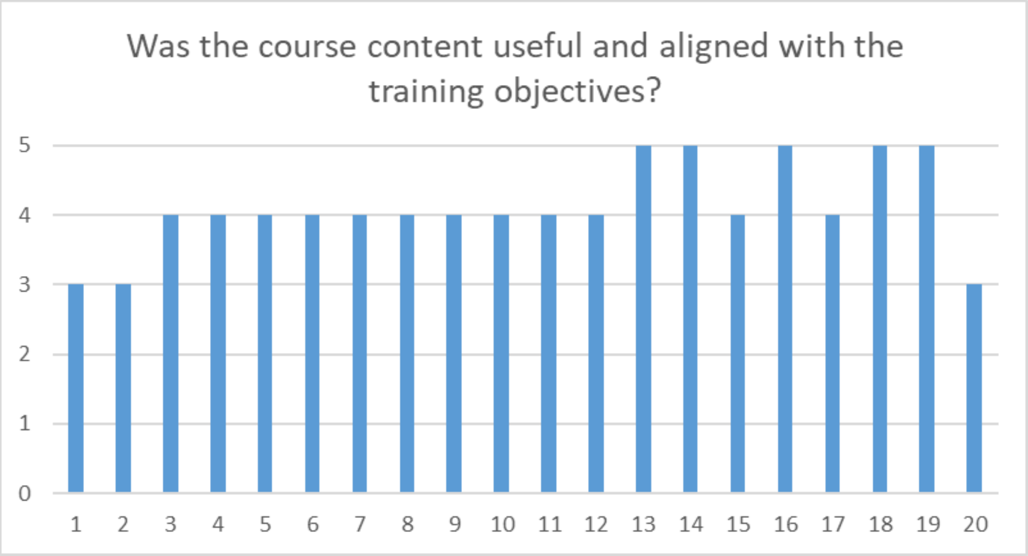

Chart 3: Usefulness and alignment to objectives

3. Meeting Expectations

When comparing actual learning outcomes to their initial expectations, participants generally agreed that the training met or exceeded what they anticipated (Chart 4). The modules provided sufficient depth on critical topics, and that the structured approach (from foundational knowledge to advanced scenarios) helped them internalize the concepts more effectively.

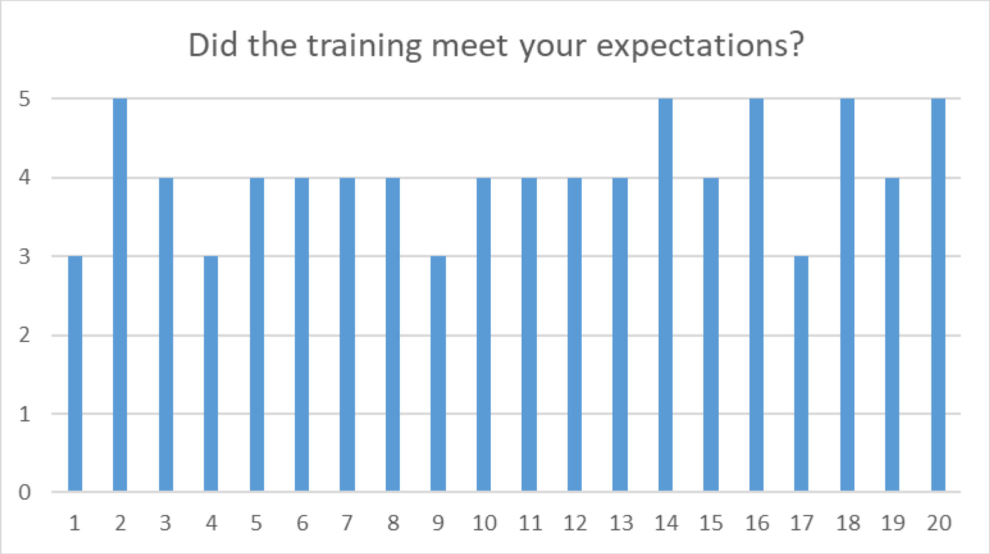

Chart 4: Meeting expectations

4. Usability of the Training Platform

The Moodle platform received positive feedback regarding ease of use and navigability (Chart 5). Most participants found the interface intuitive and straightforward, reporting minimal technical difficulties. They appreciated the ability to complete modules at their own pace and revisit content as needed, which contributed to a flexible learning environment suited to diverse schedules and learning paces.

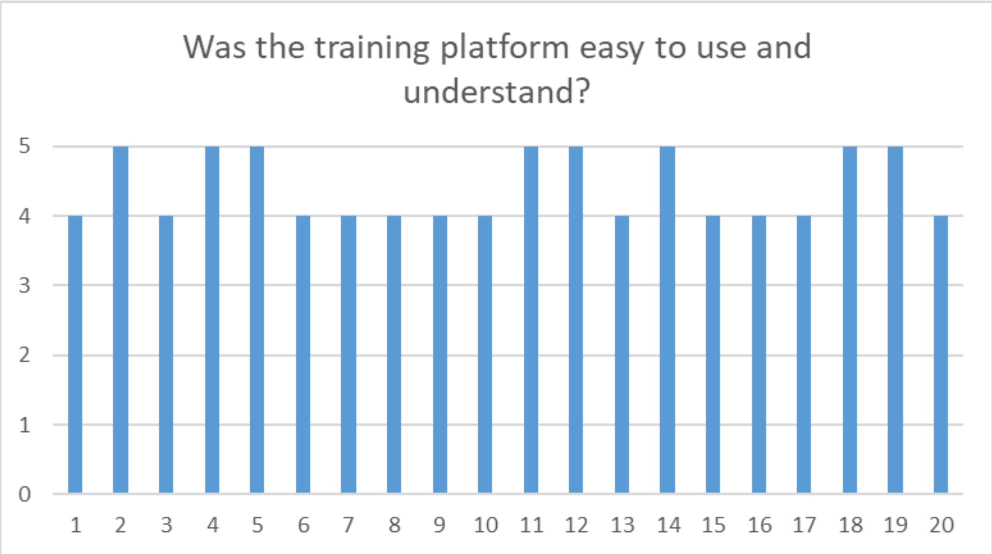

Chart 5: Usability and navigability of the platform

5. Relevance to Roles and Responsibilities

A large portion of participants deemed the material highly relevant to their roles within the SCALE project (Chart 6). The real-world scenarios, case studies, and pilot-focused content resonated well with stakeholders who have direct responsibilities tied to electric vehicle and charging infrastructure deployment.

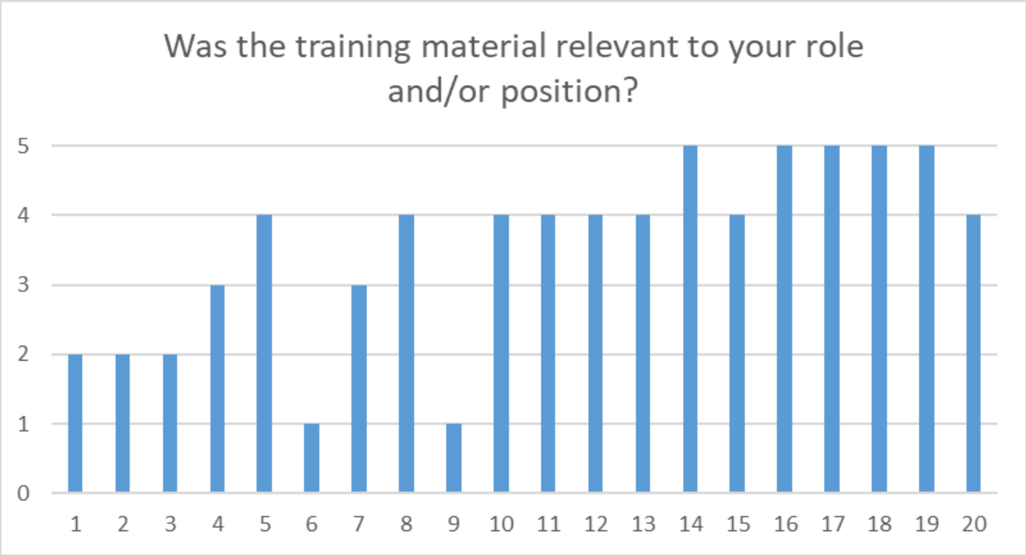

Chart 6: Relevance to participants responsibilities

Despite the overall positive reception, a few areas for enhancement were identified. Additional hands-on or demonstration-based learning—such as supplementary videos or interactive visual aids—could further enrich the training experience. Additionally, more frequent quizzes or self-assessment tools could exist, to reinforce retention of complex technical information.

In conclusion, the evaluation results indicate that the SCALE training program has been largely successful in delivering relevant, high-quality content that adequately prepares participants for their pilot tasks.

8 Conclusions

Deliverable D4.5 of the SCALE project has accomplished the design and delivery of the wide training plan for users, researchers, and stakeholders on the effective use of state-of-the-art electromobility and V2X technologies. The various participants are trained in the acquisition of knowledge and competencies concerning the interaction with innovative smart charging systems and the V2X infrastructure in pilot sites. It has brought marked improvements in readiness, engagement, and user acceptance through the addressing of technical, behavioral, and safety dimensions of such technologies.

The training tools were developed in a modular approach so that it would be easy to provide customized training according to the needs of different users, such as EV drivers, fleet operators, municipal stakeholders, and technical staff. The core of the training approach was practical exercises, case studies, and digital resources to ensure that the participants received theoretical as well as hands-on experience. Topics ranged from basic knowledge on the principles of smart charging to more sophisticated functionalities, including bidirectional charging, safety features, and optimization of charging schemes according to energy needs and financial efficiency. This flexible and easily accessible learning environment, provided through the use of interactive tools such as Moodle, supported participants' absorption and application of new knowledge in a better way.

Evaluation of the training program revealed high levels of participant satisfaction, with marked improvements in preparedness and confidence post-training. End-users reported better understanding of system functionalities, including how to optimize charging behavior for environmental and economic benefits.

Researchers and technical staff highlighted the program's utility in deepening their technical expertise, particularly in areas such as system performance analysis, troubleshooting, and safety management. The integration of behavioral insights and user-centric design elements into the training has been especially effective in encouraging sustainable practices and proactive engagement with the technologies.

One of the training program's key achievements has been its emphasis on addressing knowledge gaps and fostering inclusivity. Participants from diverse backgrounds, including those from vulnerable groups, were provided with tailored materials that ensured accessibility and relevance. This approach not only promoted equitable learning but also aligned with the project's broader goals of social sustainability and community engagement.

In conclusion, the SCALE training program has established a robust foundation for empowering stakeholders to engage with electromobility and V2X technologies effectively. By equipping participants with the tools and knowledge to navigate these innovations, the program contributes significantly to the project's objectives of reducing grid reliance, enhancing energy efficiency, and accelerating the transition to sustainable smart charging ecosystems. Through this structured and inclusive approach, the SCALE project is well-positioned to deliver meaningful impacts, both during the pilot phase and in the broader context of electromobility adoption across Europe.

9 Annex A

Contents

List of figures

1 Target Users

The training program aims to equip users with comprehensive knowledge and practical skills related to smart charging technologies for electric vehicles (EVs). By covering essential topics, this training will empower participants to understand the functionalities, benefits, and safe operation of smart charging systems.

Key objectives include an understanding of the fundamentals of smart charging—emphasizing energy efficiency and grid management—while also ensuring safe operation practices for charging stations and EV batteries. Participants will learn to utilize advanced features for optimal energy management and will be trained on emergency protocols to handle any potential issues.

Furthermore, the training will provide hands-on experience with user interface software and mobile applications for charging management, along with insights into bidirectional charging capabilities, such as Vehicle-to-Everything (V2X) systems. Overall, this program aims to foster responsible EV charging behaviors that minimize costs and enhance sustainability.

1.1 Training Objectives

1. Understanding Smart Charging Basics:
   - Objective: Ensure users understand the concept of smart charging and its benefits, including energy efficiency, reduced costs, and environmental impact.
   - Key Topics:
     - What is smart charging?
     - Differences between standard and smart charging.
     - Advantages for energy consumption and grid management.
2. Safe Operation of EV Charging Stations:
   - Objective: Provide clear guidelines on how to safely use smart chargers and handle equipment without risking injury or damage.
   - Key Topics:
     - How to correctly plug in and unplug the vehicle.
     - Handling charging cables and connectors safely.
     - Identifying any faults or malfunctions in the charging equipment.
     - Emergency procedures for electrical hazards (short circuits, overheating, etc.).
     - Importance of adhering to proper charging station etiquette (e.g., not unplugging other cars).
3. EV Battery and Charging Safety:
   - Objective: Educate users on the safe use and maintenance of their EV's battery during charging.
   - Key Topics:
     - The impact of overcharging or undercharging on battery health.
     - Preventing battery damage from improper use.
4. Using Smart Charging Features:
   - Objective: Familiarize users with advanced features of smart charging systems and their benefits.
   - Key Topics:
     - How to schedule charging times for optimal electricity rates (Time-of-Use pricing).
     - Understanding real-time monitoring and controlling charging remotely via apps.
     - Managing bidirectional charging (V2G, V2B, V2H, V2D, V2P) features, where is applicable.
     - Using the charging management system for efficient energy use.
5. Emergency and Safety Protocols:

- Objective: Ensure users are equipped with knowledge on how to handle emergencies and ensure safety during charging.
- Key Topics:
  - What to do in case of a power outage during charging.
  - Responding to charging station malfunctions or faults.
  - Fire safety and first-aid measures in case of accidents.

6. Optimizing Charging Time and Costs:
   - Objective: Train users to manage their charging schedules to minimize electricity costs and support grid efficiency.
   - Key Topics:
     - Identifying off-peak hours for cheaper rates.
     - Setting up charging times through smart apps.
     - Monitoring energy usage and costs in real-time.
7. User Interface and Software Training:
   - Objective: Provide hands-on experience with the software or mobile app for charging management.
   - Key Topics:
     - Navigation of the app or user interface.
     - Setting preferences for automatic or scheduled charging.
     - Monitoring battery level, charging progress, and historical data.
     - Understanding reports on energy consumption and costs.
8. Bidirectional Charging Training:
   - Objective: Educate users on how to utilize Vehicle-to-Grid (V2G), Vehicle-to-Building (V2B), or Vehicle-to-Home (V2H) capabilities.
   - Key Topics:
     - How to set up bidirectional charging.
     - Managing energy flows between the vehicle and the grid or building.
     - Monitoring the status of energy usage and production.

2 General information

2.1 SCALE project scope and objectives

The SCALE project aims to address the uncertainties associated with the implementation of smart charging, interoperable solutions, and Vehicle-to-Everything (V2X) technologies—covering technical, organizational, economic, social, and policy aspects. Its goal is to help shape a new energy ecosystem that effectively harnesses the flexibility of electric vehicle (EV) batteries. The project is led by a consortium of 29 partners, including prominent European cities, universities, research institutions, charging infrastructure companies, and innovators from the electric vehicle (EV) industry.

The scope of SCALE project is:

- To develop an open system architecture for smart charging & V2X which ensures **interoperability, connectivity, openness of the system and fair market conditions**. An architecture resulting in at least 30 innovations during the project (number of new technologies, products, standards, protocols, software and services being developed).
- To deploy a **user-centric approach**, systematically collecting knowledge, removing existing acceptance barriers and developing solutions in line with 800 users directly involved in SCALE pilots.
- **To reduce the need for grid reinforcement** by a minimum of 50%, leveraging the existing grid better and thereby limiting time-to-market in quality & quantity to ensure a timely transformation.
- To prepare a **mass-market and eco-system for smart charging & V2X** paving the road for Fit-for55 ambitions, ensuring all newly procured chargers are V2X-enabled from 2025 onwards.
- To create the necessary momentum across Europe and maximise exploitation, securing impact beyond the project lifetime through SCALE's V2X Alliance incl. 50 committed members and mobilise a total of at least 150 organisations through the networks of the SCALE partners.

2.2 SCALE project Innovation

Innovation of **smart charging** infrastructures for end users focuses on developing advanced, user-friendly systems to efficiently charge electric vehicles (EVs). These innovations focus on optimizing energy distribution through dynamic load management, which adjusts energy supply based on real-time demand, reducing grid strain and ensuring cost savings. **Vehicle-to-Grid (V2G)** technology allows EVs to send electricity back to the grid, enhancing energy storage and stability. **Mobile applications** offer real-time data on charging status, availability, and energy usage, while the integration of renewable energy sources like solar or wind ensures a sustainable charging process. Additionally, **wireless charging solutions** improve user convenience by eliminating the need for cables. These developments aim to enhance the overall user experience while promoting energy efficiency and sustainability.

2.3 Smart charging required Infrastructure

The infrastructure that is required to exist in order for the smart charging solutions to work properly is the following.

1. Electric Grid Integration

Capacity and Stability: The local power grid must be able support additional load from EV charging without causing instability or outages.

Real-Time Monitoring: There should be integration with energy management systems (EMS) for dynamic load balancing, especially during peak demand times.

2. Charging Stations

Appropriate chargers: DC fast chargers (50 kW or higher) for quick charging and AC chargers (7-22 kW) for slower, home or workplace charging must be installed.

Universal Compatibility: Charging stations should be compatible with various EV models and charging standards (CCS, CHAdeMO, Type 2).

Scalable Network: There should be a modular infrastructure that can expand to accommodate more charging points as EV adoption grows.

3. Smart Grid Capabilities

Bidirectional Charging (V2G): Bidirectional flow of electricity to allow EVs to discharge energy back into the grid or power buildings and homes must be enabled.

Time-of-Use (ToU) Pricing Integration: Smart meters to take advantage of ToU pricing, optimizing when vehicles charge to minimize costs and relieve grid stress must be incorporated.

Demand Response (DR): The grid should allow for dynamic adjustment of charging rates based on its conditions, enabling grid operators to reduce or shift EV charging loads during peak periods.

4. Renewable Energy Integration

Solar and Wind Power: Renewable energy sources, such as solar panels installed on charging station roofs or nearby wind farms, should be incorporated to provide green energy for EV charging.

Microgrids: Microgrids that combine renewable energy sources, battery storage, and smart charging stations for energy independence and resilience should be developed in case of grid failures.

5. Smart Charging Management System:

Software Platform: A centralized cloud-based platform that manages and monitors charging sessions, load balancing, and energy flow in real-time should be available.

User Interface (UI): The users should be provided with access to a mobile app or web-based platform for monitoring charging progress, managing preferences, and scheduling charging times.

Automated Scheduling: Smart algorithms that automatically schedule EV charging based on availability, energy demand, and cost-effective times should be offered.

6. Energy Storage Systems (ESS):

Battery Storage: Large-scale energy storage systems should be integrated to the solution to store excess renewable energy (solar, wind) and supply it during peak charging demand.

Hybrid Systems: A combination of battery storage and grid supply should be utilized to manage charging demands more effectively, especially in areas with intermittent renewable energy.

7. Communication Infrastructure:

5G/LoRaWAN Networks: Fast and reliable communication technologies such as 5G or LoRaWAN should be available for real-time data exchange between EVs, charging stations, and grid operators.

Vehicle-to-Everything (V2X): The infrastructure must support V2X communication for connected EVs to interact with traffic systems, grids, and other vehicles to optimize charging and driving.

8. Physical Space and Design:

Dedicated Charging Zones: Designate and construct parking areas for EV charging in urban, suburban, and rural locations should exists.

Adequate Parking Space: There must be ample space for EVs to park while charging, with consideration for EV fleet and commercial vehicle charging.

Cable Management Systems: Retractable cables or wireless charging should be available to ensure easy access, reduce wear and tear, and maintain safety.

9. Security and Payment Infrastructure:

Authentication and Billing: Radio-frequency identification (RFID) smartphone apps, or contactless payment systems should exist to authenticate users and process transactions.

Data Security: Encryption and secure communication protocols need to be used to protect user data and billing information.

Network Security: Cybersecurity for the charging infrastructure against potential threats or unauthorized access should be ensured.

10. Regulatory Compliance and Standards:

Charging Standards: Regional and international standards for connectors, power delivery, and safety (ISO 15118 for V2G communication, IEC standards for charging equipment) should exist.

Safety Regulations: Electrical safety codes and fire protection measures should be followed for the installation and operation of smart chargers.

Government Incentives and Policies: The infrastructure has to be aligned with local policies and incentives to promote EV adoption and smart charging deployment.

2.4 Vehicle types requirements

The SCALE project encompasses a diverse array of vehicle types, including passenger vehicles from segments A, B, and C, as well as buses and trucks.

Figure 1 We Drive Solar, 00: Bi-directional ecosystem via combined V2G service

Figure 2 Stedin passenger electric vehicle

Figure 3 Renault 5 electric

Figure 4 Stedin e-VAN, C4: Smart charging of light commercial vehicles

Figure 5 VDL e-buses, C2,C3: Highway charging with local generation & storage, VPP with renewable energy generation and second life battery storage

Figure 6 VDL e-trucks, C2,C3: Highway charging with local generation & storage, VPP with renewable energy generation and second life battery storage

2.5 Smart Charging Optimization

By smart charging optimization, we mean the strategies and technologies designed to enhance the efficiency and effectiveness of charging electric vehicles (EVs) and other battery-operated devices. Smart charging optimization aims to balance energy supply and demand, reduce costs, and minimize environmental impact. The main key components of smart charging optimization are mentioned below:

1. **Time-Based Charging**

Charging during off-peak electricity hours can reduce costs and relieve pressure on the grid. Smart chargers can automatically schedule charging for optimal times.

2. **Dynamic Load Management**

This involves adjusting the charging rate based on real-time demand and supply conditions. It helps prevent grid overloads and ensures that charging is efficient.

3. **Renewable Energy Integration**

Smart charging can prioritize the use of renewable energy sources (like solar or wind) for charging when available, further reducing the carbon footprint.

4. **Vehicle-to-Grid (V2G) Technology**

This allows EVs to not only draw power from the grid but also return excess energy back to it, providing grid support during peak demand.

5. **User Preferences and Profiles**

Charging can be tailored based on individual user preferences, such as the specific time they need their vehicle charged, contributing to a personalized charging experience.

6. **Data Analytics**

Utilizing data from charging sessions, grid conditions, and user habits helps optimize charging strategies and improve overall efficiency.

Implementing smart charging optimization can lead to reduced grids investments (to cope against local and national peaks), charging costs, enhanced grid stability, and a more sustainable transportation system.

3 Smart Charging Functionality in use for end users

3.1 Introduction

Smart charging functionality for end users provides several features and benefits that enhance the electric vehicle (EV) charging experience. Moreover, users can have greater control over their EV charging process, leading to reduced costs, increased convenience, and an environmentally friendly charging experience. Below there are some of the main benefits:

1. **Scheduling and Time-of-Use Charging**: Users can set charging times to take advantage of lower electricity rates during off-peak hours, which can result in significant cost savings.
2. **Remote Access and Control**: Many smart chargers come with mobile apps that allow users to start, stop, or schedule charging sessions remotely, providing flexibility to manage charging at their convenience.
3. **Integration with Renewable Energy**: For users with solar panels, smart chargers can be programmed to charge the EV when there's a surplus of solar energy available, maximizing the use of clean energy.
4. **Charging Status Notifications**: Users receive real-time updates on charging status, estimated time to full charge, and alerts when charging is complete, helping to manage time effectively.
5. **Load Management**: Smart charging systems can adjust the energy supply based on grid demand, ensuring that users won't experience any outages while still charging their vehicle efficiently.
6. **User Profiles and Preferences**: Users can customize charging profiles based on their driving habits, such as typical daily mileage and charging needs, allowing for optimized use of energy.
7. **Vehicle-to-Home (V2H) Capability**: Some systems allow users to use the EV battery as a backup power source for home appliances during outages or peak demand times.
8. **Integration with Home Energy Management Systems**: Smart chargers can work in tandem with home energy management systems to optimize overall energy usage, balancing the power needs of the home with EV charging.
9. **Incentive Programs**: Users can access programs that reward them for charging during off-peak times or using renewable energy sources, further lowering their costs.

3.2 How the end user should use smart chargers

Below we present the basic steps a user has to conduct in order to realize smart charging.

1. **Plug-in and Initiate Charging:** The user connects their electric vehicle (EV) to a smart charger, which automatically communicates with the grid and charging network. This seamless connection ensures compatibility and starts the charging process.
2. **Set Preferences via App or Interface:** Most smart charging systems come with a user-friendly app or touchscreen interface Figure 8. The user can set charging preferences such as desired charge level, charging speed, or specific time slots (for example, overnight or during off-peak hours).

Figure 7 EMS (Emobility Solutions) charging station

Figure 8 EMS charging Interface

3. **Monitor Charging in Real Time:** Through the app, users can monitor the charging process, track progress, and see energy consumption. Some systems notify the user when charging is complete or if any issues arise.
4. **Benefit from Time-of-Use Rates:** The system automatically optimizes charging based on grid demand and electricity prices, saving the user money by charging during off-peak hours or when renewable energy is more abundant.

EXAMPLE: When prices are low (often during off-peak hours or times when renewable energy sources are producing more power), the system automatically schedules charging.

5. **Utilize Bidirectional Charging (if available):** If bidirectional charging is supported, the user can select options to return energy to the grid (V2G) or power their home/building (V2B), providing added flexibility and reducing overall energy costs.
6. **Unplug and Drive Away:** Once charging is complete, the user simply unplugs the vehicle and is ready to go. The smart charger records data for future use, ensuring that charging sessions are optimized based on user behavior and energy availability.

4 Use Cases of smart charging (Scenarios)

4.1 Bi-Directional Ecosystem via V2G service (00)

4.1.1 "Use of V2G shared EV by end user" scenario steps

1. EV is charged or discharged by the central management system, optimized according to market conditions (Day-Ahead market, in future also aFRR (automatic Frequency Restoration Reserve) and/or congestion management) but with the boundary condition that it is sufficiently full at the beginning of the reservation period.
2. User unlocks the EV, removes the charging cable, starts the EV and drives it.
3. User returns the EV at the same charger (station based), stops the EV, connects it to charger and locks it.
4. The EV is charged or discharged by the central management system according to market conditions (Day-Ahead market, in future also aFRR and/or congestion management) with the stipulation that It is sufficiently full at the start of the next reservation period.
5. Data is periodically monitored and sent to central management system (EV State of Charge) and data, charger data, charging/discharging power etc.). The CPO (Charge Point Operator) sends the data to the DSO (Distribution System Operator).

Technologies used:

- EV booking app and API
- ISO 15118-20
- OCPP 2.0.1 / 2.1
- OCPI 2.2
- Day Ahead Market driven control, Equigy and GOPACS in development.

Functionalities:

- Charge and discharge battery according to algorithm based on EV booking data
- Communicate EV booking and usage data to central management system
- Communicate SOC and charging management between EV & charger
- Communication between Charger and CPO
- Communication between CPO and central management system
- Communication to/from aFRR balance market and/or congestion management (planned)

Risks and Limitations:

- Having electric vehicles (EVs) that are compatible with ISO 15118 standards for chargers is a prerequisite in this case for the system to work properly. V2G operation with the new Renault 5 is foreseen in spring 2025 and is expected to scale up to 500 V2G shared e-cars by end of 2025.
- Having Renault 5 available fully compatible in 2025.
- Having fully compatibility of CPO to OCPP2.0.1 and OCPI2.2 in the near future (2025)

1.1.1.1. End user training materials for UC00 in Utrecht

In specifics for UC00 in Utrecht there was a more specific training materials that has been used and assessed.

Introduction

The Use Case UC00 in Utrecht has been operational on a large, professional scale throughout the project (about 400 shared e-cars in 2024). Because it is a car sharing system where all smart and V2G charging technology happens ‘under the hood’, it requires little detailed knowledge from the end users. End users just need to disconnect the charger from the car whenever they start using the car and connect again whenever they end the reservation. These are simple procedures which are equal to classic non-smart, smart and V2G charging. While it is a benefit for the users to know that smart and V2G charging happens (resulting in lower prices and benefits for the electricity grid), the underlying technology is transparent to them. Their shared car will just be fully or almost fully charged when they start using it.

For the SCALE UC00, We Drive Solar has developed and operated an instruction platform for the shared e-car users which has been in operation with the shared e-cars in Utrecht until end 2023. Below is a screenshot (in Dutch) from the online information. The information was supported by a helpdesk (telephonic and online) which instructed end-users when necessary and helped solve any problems. User satisfaction on the information and service delivered by WDS was very high.

In 2022, the WDS instruction platform was assessed by a panel of 20 end users (10 male and 10 female). The assessment resulted in a positive evaluation and in number of suggestions for improvement of clarity and information. The instruction platform was then updated incorporating the suggestions from the user panel.

Training specifics

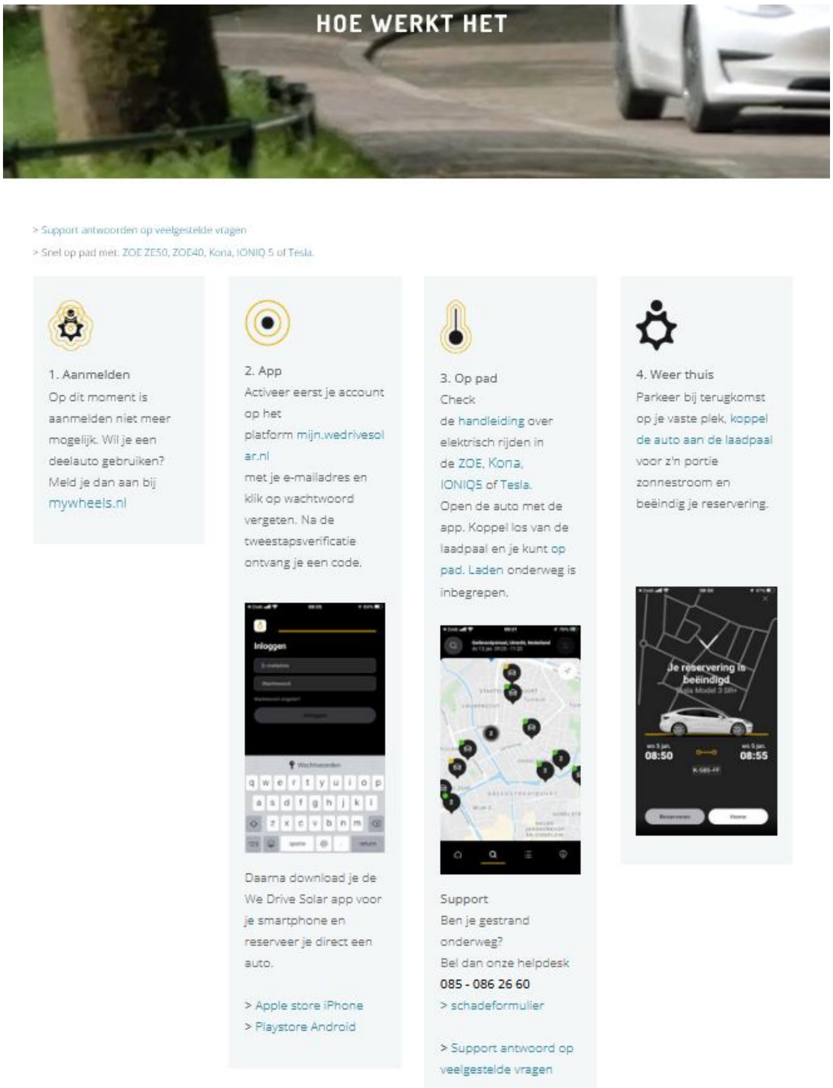

Figure 9 Screenshot from the WDS instruction platform (in Dutch)

From end 2023, Mywheels has taken over the operation of the shared e-cars in UC00. The e-cars are still being charged by the V2G chargers from WDS. MyWheels has adopted their car sharing proposition to a ‘station-based’ model in order to facilitate smart and V2G charging. Below are some images from that current platform which is accessible both online and from the MyWheels reservation app. It includes general instructions, as well as detailed instructions and videos for each EV model in the sharing scheme. Also, this platform is supported by a helpdesk to solve questions and problems and receives satisfaction from the end users.







1. **Key Location**: The car key is located in the dashboard compartment.
2. **Charging and Unplugging**: If the car is connected to a charging station, unplug the charging cable by pressing the charging button on the key.
3. **Unlock and Open**: Keep the key near the car to unlock and open it.
4. **Charging Cable Storage**: Store the charging cable in the trunk.
5. **Start Car**: Press the brake pedal.
6. **Turning On**: Press the start/stop button (to the right of the steering wheel).
7. **Gear Selector**: When starting, keep the gear in N (neutral), but always return to R (reverse) or D (drive) before starting if traction control is integrated.

- **Selector Options**:
  - D = Drive
  - R = Reverse
  - N = Neutral
  - P = Park (use only when stopped and exiting the car)

8. **Driving Off**: Once you release the brake in D, R, or B, the car starts driving. The display will show the mileage and battery consumption. This feature encourages later braking and coasting for efficiency.

Figure 10 Screenshot (in Dutch) of detailed information per EV model of the Mywheels platform in UC00.

The Dutch National Charging Enquiry[8] has researched the user experience with smart charging and V2G in the Netherlands, yearly since 2020. The research also includes research on shared car users in the Netherlands. General results include a high level of satisfaction (81% in 2024) with the service as well as with how the cars are being charged (78% in 2024).

Figure 11 Still from on-line video with detailed instruction in the Mywheels platform (UC00; in Dutch) available for each car model.

[8] https://elaad.nl/wp-content/uploads/2024/09/Nationaal-Laadonderzoek-2024.pdf

4.2 Smart Charging at businesses & offices (B1, B2, B3, B4)

4.2.1 Smart charging at residential/office building scenario steps

1. User arrives and connects the vehicle to the charging station.
2. User connects to the webpage https://evchargingmanagementnew.streamlit.app/ and specifies, ID, outlet, parking duration, desired energy, and maximum charging current.
(The algorithm will calculate the potential co2 and cost savings) Figure 12.

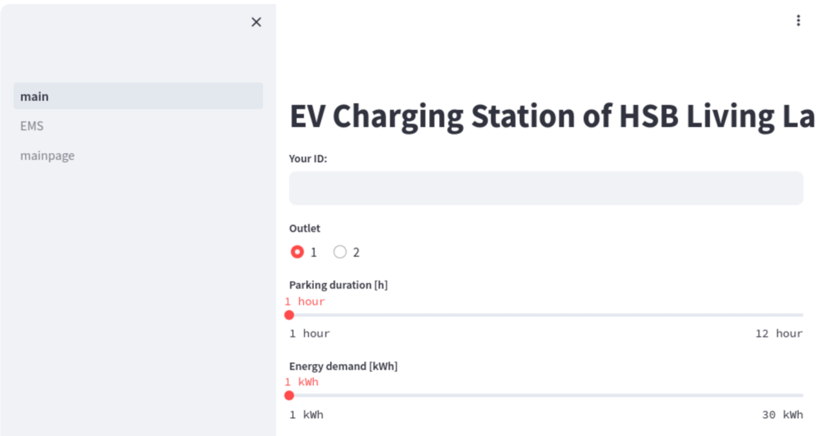

Figure 12 Webpage

4. The user selects his/her preferred charging, e.g. start direct, reduce CO2 or reduce cost
(The data from the charging preferences and charging session is collected by the CPO)
5. The charge session starts and user may depart.

Technologies:

- ISO15118-2
- OCPP1.6

Functionalities:

- Smart charging algorithm to personalize the charging session.
- User-friendly communication interface for easy navigation and operation.
- Multi-tool control for managing the charging session effectively.

Risks and Limitations:

- Communication Interface Failure: If the communication interface goes down, users may enter incorrect values, leading to potential errors in data processing. Consequently, users might avoid using the interface altogether, resulting in decreased efficiency and reliance on manual processes.
- Connected Services Outage: A failure in connected services, such as the database for storing results, can disrupt access to critical data. This may hinder users from retrieving necessary information, impacting decision-making and overall service reliability.
- Availability of Electric Vehicles (EVs): The user may experience limited availability of EVs for participation poses a challenge. This restriction may lead to scheduling conflicts and reduced participation in activities that require multiple vehicles, ultimately affecting user experience and operational efficiency.

4.2.2 V2G charging at residential/office buildings scenario steps

1. User arrives and connects the vehicle to the charging station.
2. User connects to the webpage https://evchargingmanagementnew.streamlit.app/ and specifies, ID, outlet, parking duration, desired energy, and maximum charging current. (The algorithm will calculate the potential co2 and cost savings) Figure 13

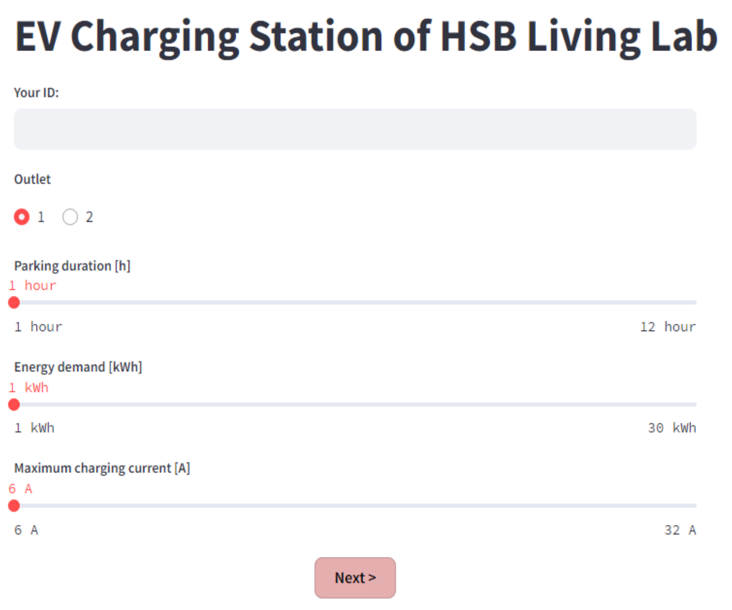

Figure 13 Webpage: Living Lab screenshot

3. The user selects his/her preferred charging, e.g. start direct, reduce CO2 or reduce cost
4. (The data from the charging preferences and charging session is collected by the CPO)
5. The charge session starts and user may depart.

<u>Technologies:</u>

- ISO15118-2 with extension
- MQTT (Message Queuing Telemetry Transport)

<u>Functionalities:</u>

- Smart charging algorithm to personalize the charging session.
- User-friendly communication interface for easy navigation and operation.
- Multi-tool control for managing the charging session effectively.

<u>Risks and Limitations:</u>

- Communication Interface Failure: If the communication interface goes down, users may enter incorrect values, leading to potential errors in data processing. Consequently, users might avoid using the interface altogether, resulting in decreased efficiency and reliance on manual processes.

- Connected Services Outage: A failure in connected services, such as the database for storing results, can disrupt access to critical data. This may hinder users from retrieving necessary information, impacting decision-making and overall service reliability.
- Availability of Electric Vehicles (EVs): The user may experience limited availability of EVs for participation poses a challenge. This restriction may lead to scheduling conflicts and reduced participation in activities that require multiple vehicles, ultimately affecting user experience and operational efficiency.

4.3 Smart Charging of light and heavy duty vehicles (C1, C2, C3, C4)

4.3.1 Peak Shaving Through EV Discharging (V2G) DC scenario steps

The user has to give feedback to enable owners, and energy managers to gather information in order to refine protocols and ensure the system meets energy-saving goals, by following the below procedure:

1. A V2G DC charging station with bi-directional energy transfer is installed at the pilot site, integrated with the building's electrical grid and connected to the grid via AMI.
2. The CPMS (Charge Point Management System), with an embedded EMS, monitors power usage, tracks consumption, and gathers data on building and grid demand, identifying potential bottlenecks.
3. Data is collected on energy usage, especially during peak periods. Based on this data and real-time monitoring, the CPMS predicts peak demand. When peak grid demand or tariffs are detected, the CPMS signals the EV to discharge energy.
4. The CPMS instructs the V2G-compatible EV to discharge a specific amount of energy based on current demand and the vehicle's battery state of charge.
5. The EV discharges energy through the DC charger into the building's grid, reducing grid power use and peak load.
6. As the building's load fluctuates, the CPMS adjusts the EV discharge rate to provide only the necessary energy for peak shaving without over-discharging the battery.
7. The EV's SOC is continuously monitored to prevent depletion below a safe level, ensuring enough charge remains for future use.
8. After peak demand or high tariffs end, the CPMS signals the EV to stop discharging.
9. The EV is scheduled to recharge during off-peak hours using cheaper or renewable energy, with the CPMS ensuring efficient recharging for the next cycle.
10. The CPMS logs data on energy discharged, cost savings, reduced peak demand, and battery health impacts.
11. Detailed reports are generated for site operators, showcasing energy savings from V2G discharging, benefits of peak shaving, and operational insights.
12. The CPMS uses the collected data to improve discharge scheduling, optimizing future discharges for greater efficiency.

<u>Technologies:</u>

- OCPP 1.6/ 2.0.1/2.1

<u>Functionalities:</u>

- Charge and discharge battery according to algorithm

<u>Risks and Limitations:</u>

- The integration of the V2G test case through OCPP 1.6 and the verification of the OCPP flow may experience delays.

- The implementation of OCPP 2.0.1 in chargers may also face delays.
- The implementation of OCPP 2.1 in both the charger and back office might be delayed.
- Acquiring a vehicle that supports discharging over DC could also be postponed
  The in the uncertainty regarding the vehicle's capability to accept the designated charging profile.

4.3.2 Smart Charging for grid cost optimization

The user has to give feedback to enable owners, and energy managers to gather information in order to refine protocols and ensure the system meets energy-saving goals, by following the below procedure:

1. A smart charging station is installed at the pilot site, integrated with the building's electrical grid and connected to the grid via AMI (Advanced Metering Infrastructure).
2. The CPMS, with an embedded EMS, monitors power usage, tracks consumption, and gathers data on building and grid demand, identifying potential bottlenecks.
3. Data is collected on energy usage, especially during peak periods. Based on this data and real-time monitoring, the CPMS predicts peak demand. When peak grid demand or tariffs are detected, the CPMS adjusts the EV charging speed accordingly.
4. The CPMS instructs the EV to reduce or pause charging during peak demand periods, optimizing energy use based on current grid conditions and the vehicle's battery state of charge.
5. As the building’s load fluctuates, the CPMS adjusts the EV charging rate to avoid overloading the grid, ensuring optimal energy consumption during non-peak periods.
6. The EV's SOC (state of charge) is continuously monitored to prevent undercharging, ensuring the vehicle reaches the desired charge level in time for the next use.
7. Once peak demand or high tariffs end, the CPMS resumes or accelerates charging to fully charge the EV during off-peak hours.
8. The EV is scheduled to charge during off-peak hours using cheaper or renewable energy, with the CPMS ensuring efficient recharging for the next cycle.
9. The CPMS logs data on energy usage, cost savings, and the reduction in peak demand achieved through smart charging.
10. Detailed reports are generated for site operators, highlighting energy savings, benefits of peak shaving, and any operational insights.
11. The CPMS uses the collected data to continuously improve charging schedules, optimizing energy efficiency for future charging cycles.

Technologies:

- OCPP 1.6 smart charging on uni/directional chargers

Functionalities:

- Load optimization, involves managing the distribution of electrical load among multiple charging stations to ensure that the available power is utilized efficiently.
- Que optimization, focuses on managing the order in which vehicles are charged at charging station.

Risks and Limitations:

The in the uncertainty regarding the vehicle's capability to accept the designated charging profile.

4.3.3 Interoperability for EV drivers scenario steps

EMSP (eMobility Service Provider) App

Step 1: The EV driver opens the EMSP app Figure 14, which is connected to the CPMS (Charge Point Management System).

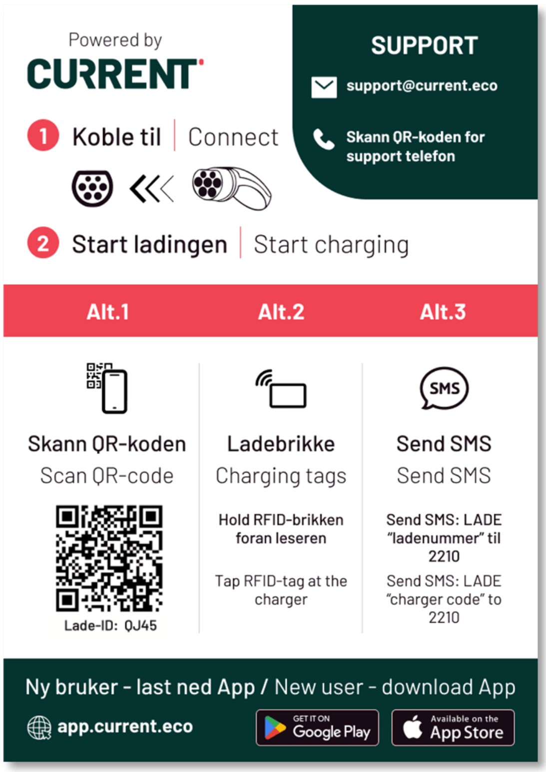

Figure 14 EMSP app

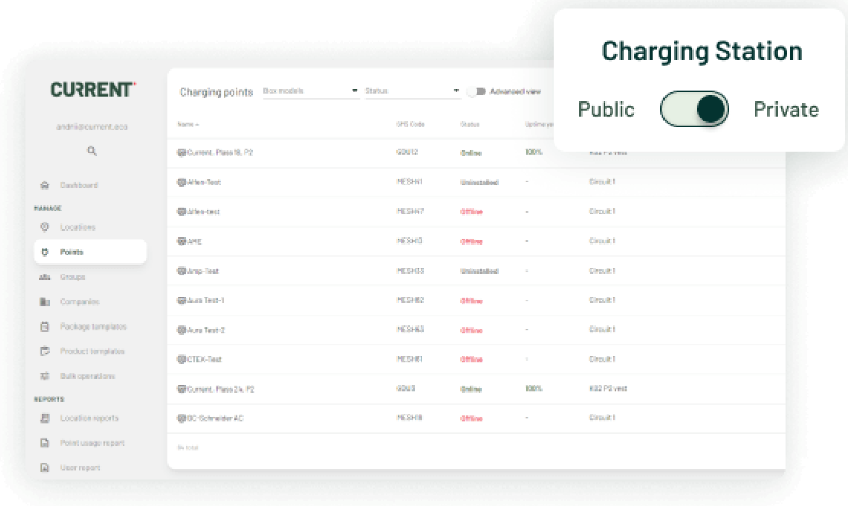

Figure 15 Charge Point Management System

Step 2: The driver selects a nearby charging station from the map or list in the app Figure 16.

Figure 16 Charging station list

Step 3: The driver initiates the charging session by selecting the charging point and confirming the session in the app.

Step 4: The CPMS verifies the driver's account details, including payment method and authorization.

Step 5: Once approved, the CPMS activates the charger, and the EV starts charging.

Step 6: The app provides real-time charging data (e.g. energy usage, session cost, SOC).

Step 7: Upon completion, the driver stops the session through the app, and the CPMS processes the payment and logs the transaction

<u>RFID (radio frequency identification) Card</u>

Step 1: The EV driver swipes their RFID card (Figure 17) of his own at the charging station's reader.

Figure 17 example of RFID card provided by Current

Step 2: The charging station sends the RFID credentials to the CPMS for validation.

Step 3: The CPMS checks the driver's account, verifies payment information, and authorizes the session.

Step 4: Once validated, the CPMS signals the charger to start the session, and charging begins.

Step 5: The driver can monitor the session at the station or through an EMSP app if linked.

Step 6: When the session is completed, the driver swipes the RFID card again to stop charging, and the CPMS finalizes payment and logs the session (Figure18).

Figure18 Payment with RFID card

QR Code

Step 1: The EV driver scans the QR code located on the charging station using their smartphone (Figure 19).

Figure 19 QR code located also on the charging stations

Step 2: The QR code opens a web page or EMSP app where the driver can initiate the session.

Step 3: The driver confirms the charging session and selects a payment method.

Step 4: The CPMS validates the payment and authorizes the session.

Step 5: Once authorized, the CPMS starts the charger, and the EV begins charging.

Step 6: The driver can monitor the session through the web page or app.

Step 7: The session ends when the driver stops charging via the web page or app, and the CPMS processes the payment and logs the transaction.

Web Interface

Step 1: The EV driver accesses the charging station's web interface (Figure 20) via a smartphone or laptop.

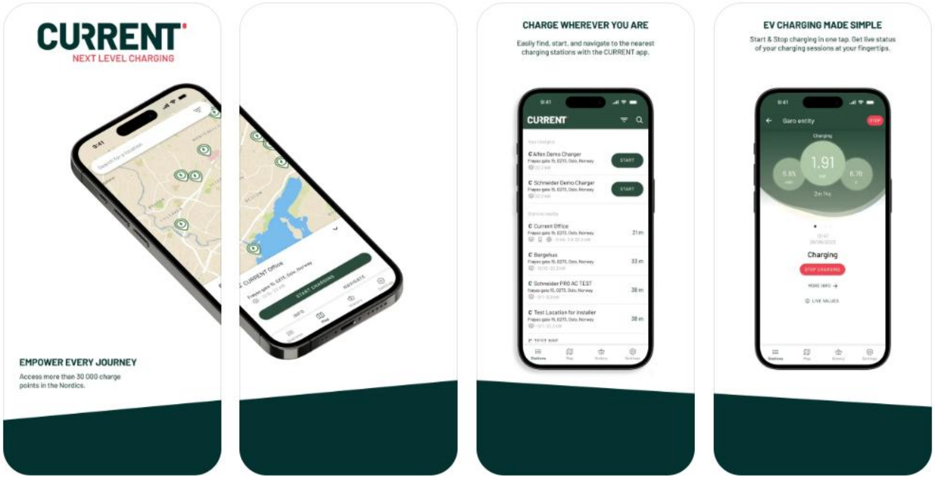

Figure 20 Web interface of charging station

Step 2: The driver selects the charging station and initiates a session by entering credentials or creating an account.

Step 3: The driver confirms payment through the web interface.

Step 4: The CPMS verifies payment and authorizes the charging session.

Step 5: The CPMS activates the charger, and the EV begins charging.

Step 6: The driver can view session data in real-time through the web interface.

Step 7: After charging is complete, the driver stops the session on the web interface, and the CPMS processes the transaction and logs the details.

<u>Roaming</u>

Step 1: The EV driver selects a charging station that supports roaming through their EMSP app or RFID card from another service provider.

Step 2: The CPMS communicates with the roaming platform to verify the driver's credentials and authorization for cross-network charging.

Step 3: The roaming platform authenticates the session with the driver's home EMSP and sends approval to the CPMS.

Step 4: Once authorized, the CPMS activates the charger, and charging begins.

Step 5: The session can be monitored via the home EMSP app or at the station itself.

Step 6: The session ends when the driver stops charging using their RFID card or EMSP app. The CPMS processes payment through the roaming platform, and the transaction is logged.

Payter Apollo Terminal (Credit/Debit Card Payment)

Step 1: The EV driver approaches the charging station equipped with a Payter Apollo terminal (Figure 21).

Figure 21 Payter Apollo Terminal

Step 2: The driver taps their credit or debit card on the Payter terminal to initiate payment.

Step 3: The terminal sends the payment request to the CPMS for processing and authorization.

Step 4: Once payment is authorized, the CPMS starts the charging session.

Step 5: The driver can monitor the session at the station or through any linked EMSP app if available.

Step 6: When the session is complete, the driver stops charging, and the Payter terminal finalizes the transaction. The CPMS logs the payment and session details.

Technologies:

- OCPI 2.2.1
- QR code ad Hoc payment

Functionalities:

- Allowing multiple eMSP to serve customers at same CPO with same price acording to AFIR regulation

Risks and Limitations:

- The integration of new roaming partners remains uncertain, highlighting the need for successful marketing and public awareness efforts.
- The integration of terminals with dynamic QR codes for on-site display needs to be expedited.

4.3.4 Use of V2L by employer on a day to day base scenario steps

End user books a LDV (light duty vehicle)

Figure 22 LCV from STEDIN in charging procedure

1. EV is charged by the central management system, optimized according to market conditions (Day-Ahead market, in future also aFRR (automatic Frequency Restoration Reserve) and/or congestion management) but with the boundary condition that it is sufficiently full at the start of the reservation period.
2. Data is periodically monitored and sent to central management system (EV SOC and data, charger data, energy consumption etc.)
3. User unlocks EV, removes charging cable, starts EV and uses EV.
4. User returns EV at same charger (station based), stops EV, connects it to charger and locks it.
5. EV is charged or discharged by the central management system according to market conditions (Day-Ahead market, in future also aFRR and/or congestion management) but with the boundary condition that It is sufficiently full at the start of the next reservation period.
6. Data is periodically monitored and sent to central management system (EV SOC and data, charger data, charging/discharging power etc.)

Technologies:

- EV booking app
- OEM / Proprietary API
- ISO 15118-20
- OCPP 2.0.1 / 2.1
- OCPI 2.2
- Equigy and/or GOPACS

Functionalities:

- Charge and discharge battery according to algorithm
- Communicate SOC and charging management between EV & charger
- Communication between charger and CPO
- Communication between CPO and central management system
- Communication to/from aFRR balance market and/or congestion management (planned)

Risks and Limitations:

- Main risk is the emergence on the market of fully ISO15118-20 compatible EV's in different segment. At the time of writing, several OEM are developing or launching such EV models.

- Full compatibility of EV to ISO15118, of chargers. (ELaadNL and Stedin collaborate in testing EVs soon expected on the market such as the new Renault transporter.)
- Full compatibility of chargers to OCPP2.0.1. consortium partner WDS has developed a new control unit for chargers that is fully compatible. It is being tested by ElaadNL and OEM.
- Full compatibility of CPO to OCPP2.0.1 and OCPI2.2. CPO is in the process of updating.
- Pilot may be limited in duration due to the expected arrival of compatible EV on the market.

4.4 Smart Public Charging (D1, D2)

4.4.1 Solar Charging scenario steps

This scenario is detailing the control charging sessions by optimizing the generated solar energy into EV's. The current injections and or locally measured solar energy will be measured. Active charging sessions will be controlled based on the available PV energy.

1. Schedule Charging Sessions: Charge the EV during peak solar production hours, usually midday.
2. Prioritize Self-Consumption: Configure the system to use solar energy for charging before drawing from the grid.
3. Monitor Energy Production: Track solar energy generation and usage via connected apps.
4. Adjust Charging Profiles: Set charging rates and times based on energy availability and driving habits.

Technologies:

- Energy management systems (ABB Terra Gateway Pro)
- Smart meters
- PV systems
- Communication protocols (OCPP, Modbus TCP)
- Bi-directional charging

Functionalities:

- Optimizing the use of locally generated energy by interactivly changing current charging sessions. Remote monitoring and control of charging, integration with home energy systems

Risks and Limitations:

- There is a risk that the deployment of hardware may not progress quickly enough.
- Interoperability issues between devices and communication systems continue to persist.
- Grid constraints, such as restrictions on energy injection, may arise.
- Support for EV protocols might not be fully finalized.
- The end-to-end solution may not be suitable for Vehicle-to-Grid (V2G) applications in some instances.
- Even if the chargers for OCPP 2.0.1 are ready, there is a risk that the Charge Point Operator (CPO) may not be able to integrate them into its platform.

4.4.2 Load management scenario steps

This scenario describes the monitoring of the total grid consumption. The control of active charging sessions is happening to prevent the main fuse from failing that may occur due to many cars charging.

The charging cost will be reduced based on the charging scenario's and number of EV's charging.

1. Ensure a smart meter is installed by your utility provider.
2. Use Energy Monitoring Software: Connect to compatible apps for detailed usage insights.

3. Set Up an Energy Management System (EMS): Implement an EMS for comprehensive tracking.
4. Access Real-Time Data: Check your smart meter or app for real-time consumption.
5. Analyze Trends: Review daily and monthly usage patterns.
6. Identify High-Usage Devices: Use software to pinpoint energy-hungry appliances.
7. Set Consumption Goals: Establish targets for reducing peak usage.
8. Configure Alerts: Set up notifications for unusual consumption spikes.
9. Log Findings: Keep a regular record of your consumption.

Technologies:

- Energy management systems (ABB Terra Gateway Pro),
- Smart meters
- PV systems
- Communication protocols (OCPP, Modbus TCP),
- Bi-derctional charging

Functionalities:

- Remote monitoring and control of charging,
- Integration with Terra gateway pro for load balancing,
- Scheduling to optimize charging times based on energy tariffs and availability,
- V2G functionality to feed energy back into the grid

Risks and Limitations:

- There is a risk that the deployment of hardware may not progress quickly enough.
- Interoperability issues between devices and communication systems continue to persist.
- Grid constraints, such as restrictions on energy injection, may arise.
- Support for EV protocols might not be fully finalized.
- The end-to-end solution may not be suitable for Vehicle-to-Grid (V2G) applications in some instances.
- Even if the chargers for OCPP 2.0.1 are ready, there is a risk that the Charge Point Operator (CPO) may not be able to integrate them into its platform.

4.4.3 V2G peak shaving scenario steps

Use batteries of EV's to deliver energy to the pilot site if the current consumption is more than the grid can deliver

1. Monitor Demand: Track pilot site energy consumption.
2. Identify EVs: Determine available EVs for energy delivery.
3. Ensure bi-directional energy flow systems are in place.
4. Calculate Capacity: Assess total battery capacity of participating EVs.
5. Initiate Discharge: Draw energy from EV batteries when grid supply is low.
6. Distribute Energy: Allocate energy based on real-time demand.
7. Monitor Batteries: Check state of charge (SoC) to avoid over-discharging.
8. Adjust Rates: Modify discharge rates as needed.
9. Inform Users: Notify EV owners about battery usage for V2G.

Technologies:

- Energy management systems (ABB Terra Gateway Pro),
- Smart meters,

- PV systems,
- Communication protocols (OCPP, Modbus TCP),
- Bi-directional charging

Functionalities:

- Optimize charging,
- Discharging times based on the user profiles

Risks and Limitations:

- There is a risk that the deployment of hardware may not progress quickly enough.
- Interoperability issues between devices and communication systems continue to persist.
- Grid constraints, such as restrictions on energy injection, may arise.
- Support for EV protocols might not be fully finalized.
- The end-to-end solution may not be suitable for Vehicle-to-Grid (V2G) applications in some instances.
- Even if the chargers for OCPP 2.0.1 are ready, there is a risk that the Charge Point Operator (CPO) may not be able to integrate them into its platform.

5 Safety Training

As the adoption of electric vehicles (EVs) and the new charging technologies continue to rise, understanding the proper use of charging equipment becomes increasingly important for users. This guide provides essential information on familiarizing with charging equipment, ensuring safe charging procedures, and managing energy flow effectively. It covers everything from the components of smart chargers and proper plug-in techniques to monitoring charging processes and handling bidirectional charging safely. By adhering to these guidelines, users can maximize their EV charging experience while minimizing risks and ensuring electrical safety. Whether you're a new EV owner or looking to enhance your knowledge, this guide will equip you with the necessary skills for efficient and safe charging.

Familiarization with Charging Equipment

Before using the charging equipment, you have to understand the components of the smart charger, including the charging cable, connector, and user interface (app or display). Make sure you are aware of the technical details regarding the vehicle’s charging port and ensure compatibility of the vehicle and the charging infrastructure.

Proper Plug-In Procedure

Always inspect the charging cable and connector for visible damage before use. Ensure the vehicle is stationary, the parking brake is engaged, and the power is off before plugging in. Finally, properly align the connector with the vehicle's charging port, avoiding force that could damage the equipment.

Setting Preferences Safely

Review charging options carefully through the respective interface and ensure that only authorized users can access the system. Also, avoid selecting charging speeds that may overload the vehicle's battery. Finally, refer to the vehicle’s manual to understand the maximum charging capacity.

Monitoring Charging

Keep a safe distance from the charger during operation, especially when monitoring through the app or display. There's no need to stand near the equipment. Also, stay alert for notifications from the app that indicate potential issues like overheating, or power interruptions.

Managing Time-of-Use Charging

Understand the risks of overcharging or drawing excessive power during peak times, which could overload local grids, which are the following

- **Monitor Grid Conditions**: Check local utility apps for real-time grid status.
- **Peak Usage Awareness**: Identify peak hours when demand is highest.
- **Educate on Overcharging**: Understand that overcharging can damage batteries and lead to grid overload.
- **Review Local Regulations**: Be aware of local regulations or recommendations on energy consumption.

Ensure the app's settings are correctly optimized to avoid this, by the following the next steps.

- **Enable Smart Charging Features**: Use apps that support smart charging to automate timing.
- **Set Scheduled Charging Times**: Program charging during off-peak hours.
- **Activate Dynamic Load Management**: Allow the app to adjust power draw based on grid capacity.
- **Enable Notifications**: Get alerts about peak times and grid conditions.
- **Review User Settings Regularly**: Periodically check and update app settings for optimal performance.

Handling Bidirectional Charging Safely

The vehicle-to-grid (V2G) and vehicle-to-building (V2B) functions require additional attention to energy flow management, so users should be trained on when and how to safely enable these features. To ensure proper understanding of V2G and V2B Functions, you should do the following:

- **Research V2G and V2B**: Read manuals of vehicle-to-grid and vehicle-to-building technologies.
- **Consult Manufacturer Resources**: Access the vehicle's user manual or manufacturer's website for specific guidance.
- **Attend Workshops/Webinars**: Participate in educational sessions offered by local utilities or EV organizations.

To ensure proper understanding of Energy Flow Management, you should do the following:

- **Understand Energy Flow**: Read and learn how energy flows between the vehicle and grid/building, including potential benefits.
- **Review Safety Protocols**: Familiarize yourself with safety guidelines for enabling V2G/V2B features.
- **Practice with Apps**: Use EV management apps to simulate and understand energy flow scenarios.
- **Check Compatibility**: Ensure your EV and home systems are compatible with V2G/V2B functionalities.
- **Monitor Performance**: Regularly track energy usage and savings to understand the impact of V2G/V2B usage.

Safe Unplugging

Make sure, to always stop the charging process via the app or interface before disconnecting the charger from the vehicle. You have to pull the connector straight out without jerking it and store the charging cable safely to avoid tripping hazards or damage.

Electrical Safety

Never touch the connectors with wet hands or expose the charging port to water. In the event of a power surge, malfunction, or emergency, disconnect the charger from the power supply and follow emergency procedures provided by the manufacturer.

Be aware of the electrical hazards associated with charging equipment:

- Overheating: Charging equipment can overheat if not properly installed or maintained, potentially leading to fires.
- Short Circuits: Damaged cables or connectors can cause short circuits, creating sparks or electrical fires.
- Ground Faults: Water exposure can lead to ground faults, risking electric shock.

Emergency Situations

Make sure you are familiar with the location of emergency disconnects on the charger and vehicle.

Figure 23 Emergency disconnect button on the charger

Know how to react to common issues, such as overheating or software malfunctions.

Overheating

1. **Stop Charging Immediately**
2. **Allow Cooling**
3. **Inspect Equipment**
4. **Check Ventilation**: Ensure the charging station is in a well-ventilated area to prevent heat buildup.
5. **Consult Manufacturer's Guidelines**: Refer to the vehicle's manual for specific recommendations on handling overheating issues.

Software Malfunctions

1. **Restart the System**: Reboot the vehicle's infotainment system or charging station software, if applicable.
2. **Check for Updates**: Ensure the vehicle's software and charging station firmware are up to date, as updates can resolve bugs.
3. **Review User Manual**: Refer to the vehicle's user manual for troubleshooting tips specific to software issues.
4. **Contact Technical Support**: If problems persist, reach out to the manufacturer's technical support for further assistance.
5. **Document Issues**: Keep a record of the issues encountered and any troubleshooting steps taken for future reference.