Ref. Ares(2026)7395251 - 27/07/2026

ePowerMove

Project deliverable D4.1

Demonstration and Evaluation plan

Funded by
the European Union

DELIVERABLE ADMINISTRATIVE INFORMATION

Deliverable Administration					
Grant Agreement	101192753	Project name	ePowerMove		
Deliverable no.	D4.1	Deliverable Name	Demonstration and Evaluation plan		
Status	Final	Due	M12	Date	27/07/2026
Editors/Lead authors	Andrew Winder, Anaïs Baudrier (ERTICO), Haibo Chen (UNIVLEEDS)				
Co-authors	Aki Lumiaho (VTT), Pekka Koponen (FVH), Jarkko Kuntanen (UTU), Dominik Schallauer (ATECH), Alejandro Santis (KLAG), Lenos Hadjidemetriou (UCY)				
Peer reviewers	Evan Bernardi (EME), Alican Yılmaz (BEE), Yancho Todorov (VTT)				
Dissemination level	PU - Public				

Quality Control				
	Version	Date	Submitted	Comments
Document history	V0.1	08/09/2025	A. Baudrier	
	V0.2	20/10/2025	A. Winder	
	V0.3	07/11/2025	A. Winder	
	V0.4	17/11/2025	H. Chen	Impact Assessment Framework
	V0.5	23/01/2026	P. Koponen, A. Lumiaho	
	V0.6	12/02/2026	D. Schallauer, A. Winder, J. Kuntanen	
	V0.7	29/06/2026	A. Winder	

	V0.8	17/07/2026	A. Winder, A. Santis, D. Schallauer, L. Hadjidemetriou, H. Chen, Y. Todorov	Version for peer review
	V0.9	23/07/2026	A. Winder	Pre-final
	V1.0	27/07/2026	A. Winder, Y. Todorov	Final submission

Legal Disclaimer

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor CINEA can be held responsible for them.

Copyright © ePowerMove Consortium, 2026.

TABLE OF CONTENTS

Deliverable Administrative Information I

TABLE OF CONTENTS IV

EXECUTIVE SUMMARY 8

List of abbreviations and acronyms 10

1 INTRODUCTION 12

1.1 Project introduction 12

1.2 Overview of this deliverable 12

1.3 Intended audience 13

1.4 Structure of the deliverable and links with other work packages/deliverables 13

1.5 Deviations 13

2 Project Innovation and Impact 15

3 Overview of the Pilot Sites 17

3.1 Helsinki (FI) 17

3.2 Klagenfurt (AT) 18

3.3 Nicosia (CY) 20

3.4 Summary of pilot sites 22

4 Methodology and Research Questions 26

4.1 Reference Methodologies 26

4.1.1 CONVERGE 26

4.1.2 FESTA 27

4.2 Proposed ePowerMove approach 28

4.3 Research questions and Key Performance Indicators 29

4.3.1 Research questions related to project objectives 29

4.3.2 KPIs from the project's impact areas 31

5 Verification Plan 33

5.1 EV chargers, including bidirectional charging 33

5.2 Smart multi-level platform for synergy with the Grid 34

5.3 Smart integration with Renewable Energy Systems 35

5.4 Interoperable user-centric applications with analytical and predictive capability 36
5.4.1 Application combining the needs of the users and the electricity network capabilities 36
5.4.2 Users' free choice of eMSP with the same innovative charging features provided by CPO 37
6 Validation Plan 38
7 Demonstration Plan 41
7.1 Milestones 41
7.2 Demonstration timescale 42
7.3 Monitoring 44
7.3.1 Monitoring platform 44
7.3.2 Dashboard design and visualisation 45
7.4 Risks 51
8 Impact Assessment Framework 53
8.1 Impact assessment approach 53
8.2 Objectives 53
8.3 Key impact dimensions 54
8.4 Procedures of the assessment 55
8.5 Data, monitoring and governance 55
8.5.1 Key Performance Indicators 56
8.5.2 Data collection 56
8.5.3 Assumptions, limitations, and data quality 56
8.5.4 Monitoring and feedback mechanisms 57
8.5.5 Policy recommendations and strategic use of results 57
8.5.6 Timeline and responsibilities 57
8.6 Technical impact assessment 57
8.6.1 Key technical impact areas 58
8.6.2 Assessment approach 59
8.6.3 Expected outcomes 59
8.7 Environmental impact assessment 59
8.7.1 Key environmental impact areas 60
8.7.2 Assessment approach 61
8.7.3 Expected outcomes 61
8.8 Socio-economic impact assessment 61
8.8.1 Key Socio-economic impact areas 61

8.8.2 Assessment approach 63
8.8.3 Expected outcomes 63
8.9 Economies of scale assessment 63
8.9.1 Key economies of scale impact areas 63
8.9.2 Assessment approach 64
8.9.3 Expected outcomes 65
8.10 Integration and synthesis of impacts (proliferation modelling) 65
8.10.1 Key areas of integrated impact synthesis 65
8.10.2 Assessment approach 67
8.10.3 Expected outcomes 67
8.11 Summary 67
9 Conclusions 68
10 References 69

List of figures

Figure 1: Aerial view of Helsinki pilot area 17

Figure 2: Schematic of chargers in Helsinki pilot. 18

Figure 3: Aerial view of Klagenfurt pilot site 19

Figure 4: Klagenfurt site planning view 19

Figure 5: Nicosia pilot area 20

Figure 6: EV chargers configuration at Nicosia pilot site 21

Figure 7: Steps that should typically be considered when conducting an FOT 28

Figure 8: Initial draft of the “Overview” page of the dashboard 47

List of tables

Table 1: The three pilot sites’ innovation areas and related innovative solutions of related focus areas 22

Table 2: Summary table of pilot demonstration sites 23

Table 3: Partner roles at pilot sites 24

Table 4: ePowerMove high-level objectives 29

Table 5: ePowerMove high-level objectives 31

Table 6: Validation KPIs and measurements 38

Table 7: Milestones for the demonstrations 41

Table 8: Demonstration stages and timings per pilot site 42

Table 9: Demonstration risks 51

EXECUTIVE SUMMARY

The ePowerMove project supports mass adoption of electric vehicles (EVs) by designing flexible, scalable, and interoperable **bi-directional smart and slow charging solutions** that adapt to diverse regional power systems and evolve with technology and policy.

Demonstrations will take place from late 2026 / early 2027 for about one year in three pilot locations: **Helsinki** (Finland), **Klagenfurt** (Austria) and **Nicosia** (Cyprus). These cover three geographically diverse regions in terms of climate (Nordic, Alpine and Mediterranean) as well as different use cases. The Helsinki demonstration targets mainly residents and visitors of a residential development. The Klagenfurt pilot focuses mainly on visitors and tourists to the city centre, including multimodal users (e.g. to/from trains or buses) and car sharing. In Nicosia, the demonstration is aimed at staff, students, employees and residents of the University of Cyprus campus.

This deliverable contributes mainly to Work Package (WP) 4 of ePowerMove, “Large-scale demonstration and impact assessment”, which will set up and run these real-world demonstrations of the project’s charging solutions and the whole energy management system. This also includes data consolidation, analysis and impact evaluation.

It describes the specifications for implementing the demonstration trials in the three pilot areas and sets the framework for pilot execution and analysis.

The project includes five **innovation areas**: Non-intrusive EV chargers; Low-cost EV chargers; Smart multi-level platform for synergy with the Grid; Smart integration with Renewable Energy Systems (RES); and Interoperable user-centric apps with analytical and predictive capability. These will be achieved by the development and demonstration of ten Technology Elements as well as four Non-Technical Innovations.

This deliverable focuses on the **technical elements** that will be demonstrated, providing the testing and measurement approach to be able to determine their functioning, performance and contribution to the five expected project impact areas. These are Improved user accessibility; Smart low-cost, low-power, V2G-enabled charging; Synergy with the grid and global energy-usage optimisation; Piloting and validating solutions and technologies; and Accelerated mass deployment rollout.

The **verification plan** focuses on the different technical solutions to be deployed, i.e.:

- EV chargers, including bidirectional charging;
- Smart multi-level platform for synergy with the Grid;
- Smart integration with Renewable Energy Systems;
- Interoperable user-centric apps with analytical and predictive capability.

Validation of the technical solutions will be covered in the deliverable D2.4 Technical validation of the solutions (due Month 24: December 2026), however this deliverable lists the Key Performance Indicators that relate to validation of technical solutions and the required data.

The **demonstrations** in the three pilot sites will be set up by the end of 2026 and start in January 2027, lasting one year until December 2027. The monitoring of the demonstrations will be via a cloud-based platform for data consolidation and analysis. This will allow the pilot site owners to upload operating data via API calls.

Monitoring will be supported through a dedicated data consolidation and dashboard framework, enabling continuous, harmonised monitoring of the three pilot sites throughout the demonstration period, supporting both operational oversight and subsequent evaluation activities.

The monitoring framework will cover multiple categories of data, including operational charging data, system and infrastructure performance indicators, contextual and aggregated system-level indicators relevant to grid interaction and flexibility provision, user-related responses derived from surveys and app usage statistics, and vehicle data.

The planned approach for **assessing the impacts** of ePowerMove's bidirectional charging and smart energy management solutions builds on validated results from earlier work packages and draws on established methodologies from FESTA and CONVERGE. The plan defines a structured framework for evaluating technical, environmental, socio-economic, and scalability dimensions.

The assessment will combine direct measurements from pilot deployments with modelling, scenario-based simulations, and scaling exercises to estimate both immediate and long-term system-level effects. Key performance indicators (KPIs) have been identified to capture the most relevant outcomes, while assumptions, limitations, and data quality considerations ensure the robustness and transparency of the planned analyses.

By integrating data collection, analysis, monitoring, and feedback mechanisms, the impact assessment plan provides a coherent methodology to support decision-making, policy guidance, and strategic planning. The plan also establishes responsibilities, timelines, and procedures to ensure systematic and consistent execution across all pilot sites.

Overall, the ePowerMove impact assessment plan provides a clear roadmap to evaluate the added value, scalability, and sustainability of the project's solutions, supporting evidence-based recommendations for stakeholders and informing the potential replication and expansion of bidirectional charging and V2G technologies.

LIST OF ABBREVIATIONS AND ACRONYMS

Acronym	Meaning
A	Amps
AC	Alternating Current
API	Application Programming Interface
AT	Austria (refers to Klagenfurt pilot)
BESS	Battery Energy Storage System
BI	Business Intelligence
CINEA	European Climate, Infrastructure and Environment Executive Agency
CPO	Charge Point Operator
CY	Cyprus (refers to Nicosia pilot)
DoA	Description of Action (ePowerMove Grant Agreement)
DSO	Distribution System Operator
eMSP	E-Mobility Service Provider
EU	European Union
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment unit
FI	Finland (refers to Helsinki pilot)
FOT	Field Operational Test
GIS	Geographical Information System
ICE	Internal Combustion Engine
IN	Innovation
KPI	Key Performance Indicator
kW	Kilowatt
kWh	Kilowatt-hour

Acronym	Meaning
MoS	Measure of Success
NTI	Non-Technical Innovation
OBD	On-Board Diagnostics
OCPI	Open Charge Point Interface
OCPP	Open Charge Point Protocol
PV	Photovoltaic
R&D	Research and Development
RES	Renewable Energy Systems
SoC	State of Charge
SSO	Single Sign-On
SUS	System Usability Scale
TE	Technology Element
UTAUT	Unified Theory of Acceptance and Use of Technology
V	Volts
V2G	Vehicle-to-Grid
V2X	Vehicle-to-Everything

1 INTRODUCTION

1.1 Project introduction

The ePowerMove project supports mass adoption of electric vehicles (EVs) by designing flexible, scalable, and interoperable bi-directional smart and slow charging solutions that adapt to diverse regional power systems and evolve with technology and policy. These will reduce infrastructure costs while being less intrusive. The combination of advanced charging technologies and intelligent grid energy control to enhance system efficiency will optimise energy usage and support a greater share of renewable energy. Social innovation, affordability, and user acceptability are also key to the work in ePowerMove, to ensure that solutions meet needs across diverse socio-cultural and economic contexts.

From the end of 2026, the project will demonstrate its innovative non-intrusive, efficient and slow-charging solutions in three pilot locations, each addressing a critical aspect of EV charging and integration:

- **Helsinki**, Finland (FI): focus on reducing infrastructure costs and enhancing user experience.
- **Klagenfurt**, Austria (AT): will explore new business models to drive sustainable e-mobility, including e-car sharing on a cross-border basis (Austria – Slovenia).
- **Nicosia**, Cyprus (CY): will optimise grid compatibility and energy flow management.

Key elements of ePowerMove are:

- To ensure the seamless integration of slow, smart and bidirectional (Vehicle-to-Grid – V2G) charging into the energy system, making EVs a valuable asset in sustainable energy management.
- Developing advanced user-centric applications, ensuring friendly and efficient access to charging infrastructure.
- Developing scalable planning and mass deployment business and usage models.

For more information on the project, see https://epowermove.eu

1.2 Overview of this deliverable

Work Package (WP) 4 of ePowerMove, “Large-scale demonstration and impact assessment” has the objective to set up and run real-world demonstrations of the project’s charging solutions and the whole energy management system in three cities: Helsinki, Klagenfurt and Nicosia, for a period of one year. It will also carry out data consolidation, analysis and impact evaluation.

The demonstrations include engagement to foster user interest and usage of the facilities. The data consolidation part includes the creation of a tool to collect, process and integrate the data, and ensuring that the data is shared within the consortium, with sister projects (if any), and that it is able to be incorporated into wider data platforms. WP4 will also perform technical evaluation and business impact analysis, quantify the improved user acceptability of mass deployment, and assess how ePowerMove improves both private and commercial mobility. The impact assessment in WP4 covers environmental and economic impacts of the ePowerMove innovation, including the identification of potential economies of scale.

This deliverable, which is the result of Task 4.1, describes the specifications for implementing the demonstration trials in the three pilot areas. It sets the framework for pilot execution and analysis.

1.3 Intended audience

The principal intended audience is internal, i.e. the ePowerMove partners involved in the demonstrations, particularly in WP4. It mainly guides subsequent tasks in WP4, i.e.:

- Task 4.2: Site setups and demonstrations running
- Task 4.3: Data consolidation and dashboard
- Task 4.4: Technical evaluation, business impact analysis, and user acceptance
- Task 4.5: Environmental and economic impacts, and economies of scale.

It will also contribute to other WPs, including the charging solutions and apps in WP2, the system design and integration in WP3 and rollout acceleration in WP5.

This report is public, hence it is available for use by other projects and is potentially valuable for ongoing and future e-mobility projects such as those funded under the 2ZERO Partnership at EU level (in particular the V2X Cluster of projects dealing with EV charging), as well as for national and other research and deployment projects.

1.4 Structure of the deliverable and links with other work packages/deliverables

Following this introduction, the deliverable highlights the innovation and expected impact areas of the project, as these are the elements that will need to be evaluated. An overview of the pilot sites is then given, looking at the commonalities and differences between what is planned in Helsinki, Klagenfurt and Nicosia. A comparative summary table for the three sites is given.

The methodology behind this plan is described, starting from well-established reference methodologies created by previous EU-funded projects.

The ePowerMove Verification Plan is described, covering EV chargers, the Smart multi-level platform for synergy with the Grid, Smart integration with Renewable Energy Systems (RES), and Interoperable user-centric apps.

This is followed by the Validation Plan, including Key Performance Indicators (KPIs), data sources, validation per product, and risks.

The Demonstration Plan then includes the timing for the planning and execution of the demonstrations, as well as monitoring and risks.

The final core chapter is the Impact Assessment Framework, where the methodology and objectives of this framework are outlined, their impact dimensions, assessment procedures, data aspects, governance and KPIs. The impact assessment will cover technical, environmental, socio-economic and economies of scale aspects, as well as proliferation modelling.

1.5 Deviations

This deliverable was submitted six and a half months later than planned to take account of evolutions and progress in the three pilot sites and because at the time of the initial draft at the end of 2025, several aspects of the demonstrations in the three sites were not yet confirmed. In particular, the location of the Klagenfurt pilot site was moved from an out-of-town park-and-ride site to a city centre location (Contract Amendment including this change was approved at the end of March 2026). Also, work in WP3 – System Design and

Integration for Smart Synergy with the Grid – further defined the V2G configuration and architecture design at the three pilot sites, as reported in D3.1 – Design and development of a Grid-Charging RES (Renewable Energy System) – in March 2026.

As this document is primarily a guide for the next stages of WP4 (with the demonstrations due to start in December 2026 / January 2027), this delay has not affected subsequent tasks in this work package or elsewhere in the project.

2 PROJECT INNOVATION AND IMPACT

The innovation (IN) areas of ePowerMove are as follows:

- IN-1: Non-intrusive EV chargers
- IN-2: Low-cost EV chargers
- IN-3: Smart multi-level platform for synergy with the Grid
- IN-4: Smart integration with Renewable Energy Systems (RES)
- IN-5: Interoperable user-centric apps with analytical and predictive capability.

These are planned to be achieved through the development and demonstration of the following Technology Elements (TE):

- TE-1.1: Less physically and visually intrusive AC EV charger (relates to IN-1)
- TE-2.1.1 & 2.2.1: EV Supply Equipment for low-cost and fast installation in built urban environments (relates to IN-2)
- TE-2.1.2 & 2.2.2: Optimised AC EV charger design for built urban environments (relates to IN-2)
- TE-3.1: A multi-level synergetic framework with seamless data-exchange to co-manage Grid, RES and EV charging (relates to IN-3)
- TE-3.2: Forecasting load flow analysis tool to schedule charging limitations for grid-friendly integration (relates to IN-3)
- TE-3.3: Real-time and cost-effective flexibility controller to relieve grid congestion (relates to IN-3)
- TE-4.1: A smart integration system of rooftop solar panels and EV charging as an energy community (relates to IN-4)
- TE-4.2: Controller for optimised scheduling of resources/charging to reduce electricity cost and for real - time activation of flexibility according to DSO requests (relates to IN-4)
- TE-5.1: An application combining the needs of the users and the electricity network capabilities (relates to IN-5)
- TE-5.2: Users' free choice of eMSP with the same innovative charging features provided by CPO (relates to IN-5).

In addition, there are four Non-Technical Innovations (NTI):

- NTI-1: Improved usability of the charger and mobile applications for special needs' group based on accessibility and Universal Design
- NTI-2: Social inclusivity of physical and digital designs
- NTI-3: Enhanced user acceptability of EV chargers amongst all community clusters through co-design
- NTI-4: Social Innovation.

Innovation is managed in Task 7.3 of the project, with the process initially reported in ePowerMove deliverable D7.2: Innovation plan and process.

This Plan focuses on the technical elements that will be demonstrated in the three pilots, providing the testing and measurement approach in order to be able to determine their functioning, performance and contribution to the following expected impact areas:

- **Improved user accessibility**: Impact by increasing EU-wide access to user-centric interoperable public chargers; seamless integration of innovative charging solutions with the grid energy management system; higher user acceptance across Europe.

- **Smart low-cost, low-power, V2G-enabled charging**: Impact via interoperable, efficient, low-power smart and bi-directional on-street charging, leading to increased appeal of EVs; and increased uptake of on-street charging by the cities, leading to increased EV adoption rate.
- **Synergy with the grid and global energy-usage optimisation**: Impact through affordable and accessible energy across diverse communities, improving EU competitiveness; decreasing GHG emissions and promoting sustainability.
- **Piloting and validating solutions and technologies**: Impact in terms of improved user acceptability, lower charging costs for end users, and visibility and proof of working solutions.
- **Accelerated mass deployment rollout**: Impact in terms of improved legislative framework (informing lawmakers on the current legislative strides for the mass market deployment at EU level along with the proposed recommendations and solutions). Also enabling prediction and power supply planning on a larger scale.

3 OVERVIEW OF THE PILOT SITES

The technology elements will be deployed and demonstrated in three pilot sites (Helsinki, Klagenfurt and Nicosia). The approaches in these three pilots are all different but all target to validate and assess low-cost, slow, bi-directional, non-intrusive, and interoperable EV charging on-street environment.

The principal focus areas of these pilot sites differ, with Helsinki focusing on low-cost charging infrastructure deployment and people-friendly mobile applications, Klagenfurt focusing on business model development and Nicosia focusing on integration with the electrical grid. Therefore, several of the Technology Elements listed above are deployed only in one of the pilot sites.

The main target user groups also differ from each other. Helsinki targets mainly residents and visitors of a residential development close to the city centre. In Klagenfurt, the focus is mainly on visitors and tourists to the city centre, including multimodal users (site is adjacent to the main railway and bus stations) and car sharing. In Nicosia, the intended users are university staff, students, employees and residents of the University of Cyprus campus.

3.1 Helsinki (FI)

The Helsinki pilot will demonstrate mass adoption of low-cost, non-intrusive, bidirectional, AC charging equipment, suited for Nordic conditions both in terms of usability in all weather conditions and fitting to the street environment in a non-discriminatory and non-obstructing way.

The pilot is situated in the urban area of Ruoholahti, located in the southwestern sector of Helsinki's central area. Currently, there are more than 1200 parking spots in this area, which are managed by Ruoholahden Pysäköinti. 40 of these parking locations are designated for the Helsinki pilot. The parking spots include both kerb-side parking for public use and separate parking lots, with designated parking spots for the residents who have leased a parking spot. All the leasable parking spots currently have the possibility of slow charging with 3.6 kW household plug.

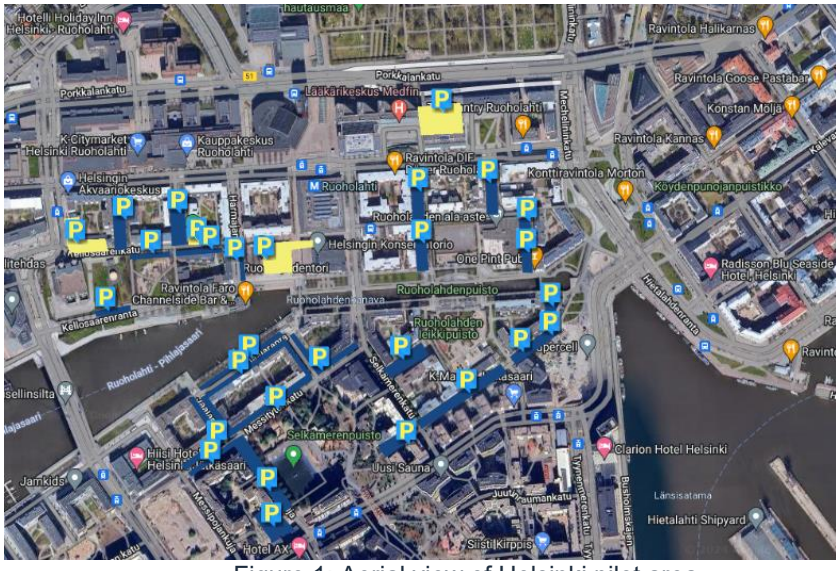


Figure 1: Aerial view of Helsinki pilot area

The Helsinki pilot features:

- Bi-directional kerb-side chargers and software developed by UTU and IGL

- Charging power of 11 kW and Type 2 connectors
- Minimised footprint of the chargers on the walkway to enable winter maintenance
- Vehicle-EVSE cable connected to the charger on the street side
- 8 of the chargers will be UTU's new design, from WP2. The remainder will be updated UTU Max chargers (same electronics but different enclosure).

The chargers in the Helsinki pilot shall be dual output, Type 2 connector equipped AC chargers, with 11 kW (3 x 16A) maximum bidirectional power per output (22 kW in total per charger). The chargers shall support bidirectional AC charging with compatible vehicles. The identification method(s) and user interface details shall be decided during the project, utilising the information collected in WP1.

The chargers will be installed at the on-street locations using known installation best practises to meet the city of Helsinki's electrical installation, cabling and safety requirements. Feeding cables shall be located 700mm below ground level. On the pilot site, existing cabling infrastructure will be used as much as possible. Feeding cables to charging stations are chained. Actual charging stations are to be based with 500-700mm deep concrete or metal base parts that keep charging stations rigidly straight in all weather conditions (note in Helsinki, the ground usually gets frozen during the winter months). Innovation will be sought to find ways to avoid the need for (heavy) lifting equipment in installation and finding ways to make connector interfaces and installation procedures as standard as possible. Figure 2 shows principles of charger station installation architecture in the Helsinki pilot.

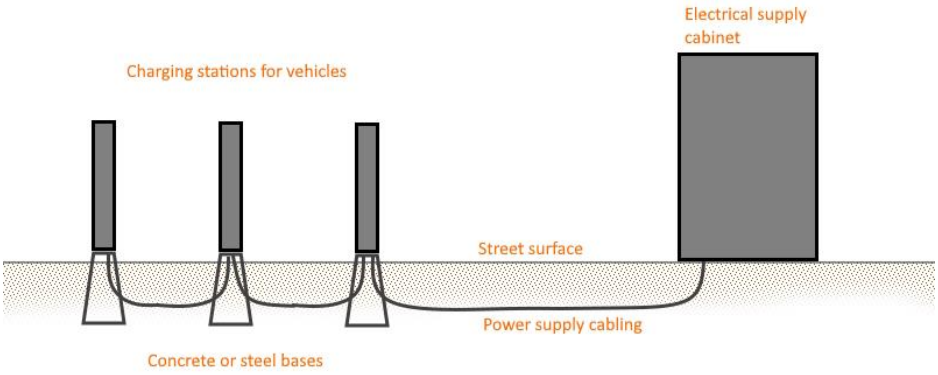


Figure 2: Schematic of chargers in Helsinki pilot.

The planned installation method requires the chargers to be connected in parallel and thus requires the sizing of the feeding cable according to the maximum combined power of all the charging points on a single drop line. The final specifications of the maximum number of chargers and the sizing of the cabling are done during the project.

3.2 Klagenfurt (AT)

The pilot location in Klagenfurt is situated at the city's central railway station and targets local mobility and energy challenges at this major transport hub.

The station hosts Klagenfurt's largest taxi stand, where the shift to electric mobility is underway, yet no EV charging infrastructure is currently available. Nearby, the central bus depot of the public transport operator KMG employs over 200 bus drivers who commute to the site, creating a need for charging facilities. KMG's

fleet and company cars are also being electrified, further increasing demand. An EV car-sharing service based at the station is planned to grow alongside the Koralmbahn expansion.

For the pilot site, 6 public AC charging stations will be installed (4 double chargers and 2 single chargers), providing a total of 10 charging points, including 1 accessible point and 2 dedicated car-sharing points. These will be developed with integrated bidirectional V2G solutions, a pioneering initiative for Austria. To comprehensively test low-power smart, bi-directional use cases, the car-sharing operator Avant Car, will integrate V2G-capable vehicles into their fleet for relevant charging operations. Scientific monitoring by partner University of Ljubljana (UL) will compare the grid stability advantages of V2G capability with non-V2G charging. The regional DSO, KNG, plays a central role in coordinating vehicle-grid interaction. Avant Car, alongside local partners, will expand its backend system for project analysis and operate the charging infrastructure during the demonstration period.



Figure 3: Aerial view of Klagenfurt pilot site

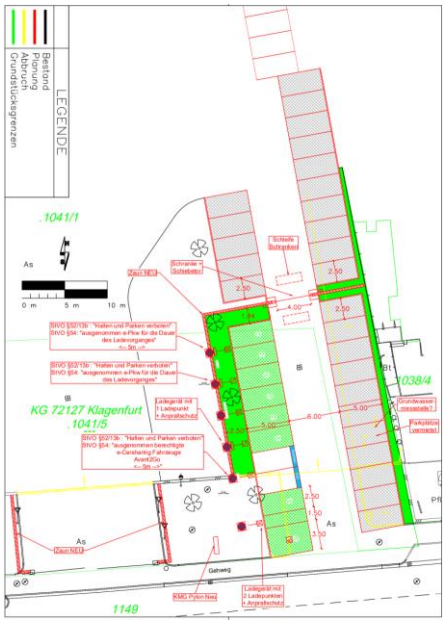


Figure 4: Klagenfurt site planning view

A key focus of the project is to understand how V2G charging affects different user groups at the pilot site in order to improve related business models and support efficient large-scale deployment.

A multi-level DSO flexibility analysis tool – using grid, consumption, feed-in, and user behaviour data and equipped with integrated load-flow simulation – will be deployed to ensure grid-friendly use of V2G by providing constraints to the charging infrastructure at the pilot site. Under current Austrian regulations, DSOs must guarantee full supply and feed-in capacity for all customers, including EV charging and PV. However, there are no legal provisions for flexible grid access contracts or an established flexibility market. As a result, low-voltage grids must be designed to handle simultaneous EV charging and renewable feed-in peaks, with associated costs reflected in grid tariffs.

Based on identified needs, roles, and communication pathways between DSOs, CPOs and fleet operators, the tool must process large volumes of data: GIS-based grid data, feed-in and consumption data from MDM and SAP, weather forecasts, and behavioural data from the charging infrastructure within the ePowerMove project. The data architecture, together with the load-flow simulation, will identify grid bottleneck periods using big-data predictions and provide interoperable conditions for charging point operators, enabling V2G functions based on common communication protocols. The impact of this operating mode will be analysed in terms of RES feed-in absorption and grid support during high-demand periods.

The goal of this multi-level flexibility approach is to move from conventional grid planning to a smarter, more flexible system that improves utilisation of existing grid capacity and reduces the need for grid reinforcement. The insights gained can support broader grid-scale expansion, increasing RES hosting capacity through coordinated V2G slow-charging strategies and highlighting the need for flexible grid access contracts and market mechanisms.

Additionally, the car-sharing operator Avant Car will upgrade its user app to include V2G services for demonstration at the pilot site. Future business models will be analysed and evaluated based on the new V2G-enabled AC slow-charging stations, following a holistic approach that accounts for increasingly challenging morning and evening peak demand periods.

3.3 Nicosia (CY)

The Nicosia pilot aims to showcase a groundbreaking synergetic framework capable of intelligently co-managing the distribution grid and bi-directional EV charging infrastructure. Its objectives include avoiding grid congestion, reducing electricity charging costs, and enhancing RES utilisation. The pilot is situated in the UCY campus area in Nicosia (Figure 5), covering 600 000 m^2 and serving approximately 10 000 individuals (e.g., employees, students, residents) daily. During the project implementation period, an estimated 150-200 EV users will be accommodated, with projections indicating a rise to 1500 by 2035, aligned with demographic trends and the county's EV penetration targets.



Figure 5: Nicosia pilot area

The pilot will deploy 8 bidirectional AC 11 kW (Type 2) double kerb-side chargers (16 charging points), designed to integrate seamlessly into the environment without obstructing bike lanes or pedestrian walkways. The charging stations will be installed across two main parking areas and will be accessible to the public, students, and employees. The chargers will accommodate a range of usage patterns, including several-hour charging while attending classes or working on campus, as well as overnight charging for those residing nearby.

These chargers will comply with standard protocols, ensuring interoperability as well as real-time monitoring and control within the new synergetic framework. A key challenge of this pilot is the coordinated management of bidirectional EV charging together with the campus photovoltaic and battery energy storage installations (currently 400 kW of PV in place, with an additional 5 MW of PV and 2.35 MWh of storage under deployment).

This integration will be essential to alleviating grid congestion, maximising RES penetration, and reducing charging costs.

A new multi-level synergetic framework will be developed through seamless data-exchange between platforms and different entities, such as DSO, prosumer (campus owner), charging points, charging owners, and EV owners, with the ultimate goal of reducing charging costs, maximising RES utilisation, and preventing grid congestion. This enables the DSO to schedule operational envelopes for each prosumer/charging point to proactively prevent congestion and to coordinate flexibility activation in real time from bidirectional chargers and distributed resources. Prosumers and EV CPOs are then empowered to optimally manage their resources to reduce electricity cost while respecting EV owners' preferences and grid restrictions and to effectively activate flexibility. The system-wide architecture and configuration is currently designed to ensure necessary data exchange between different entities and components for this framework.

Since bidirectional V2G charging is not yet fully established by vehicle or charger manufacturers, the partners of the Nicosia pilot have held a series of meetings with leading EV charger manufacturers to ensure their support for integrating V2G capabilities into this demonstration in order to mitigate this risk. As a result, AUTEL, through its R&D departments, have committed to providing technical support for enabling such functionalities. Integration will be facilitated through Modbus TCP, operating in parallel with the OCPP protocol, ensuring interoperability with the synergetic framework and enabling their chargers to provide V2G operation.

In total, 16 bidirectional AC charging points will be deployed across two parking areas, with 8 charging points installed in each area. Each parking area will be equipped with 4 × AUTEL MaxiCharger AC Ultra units, with each unit providing 2 × 22 kW V2G AC charging points. The topology and configuration of the chargers within the Nicosia pilot are presented in Figure 6.

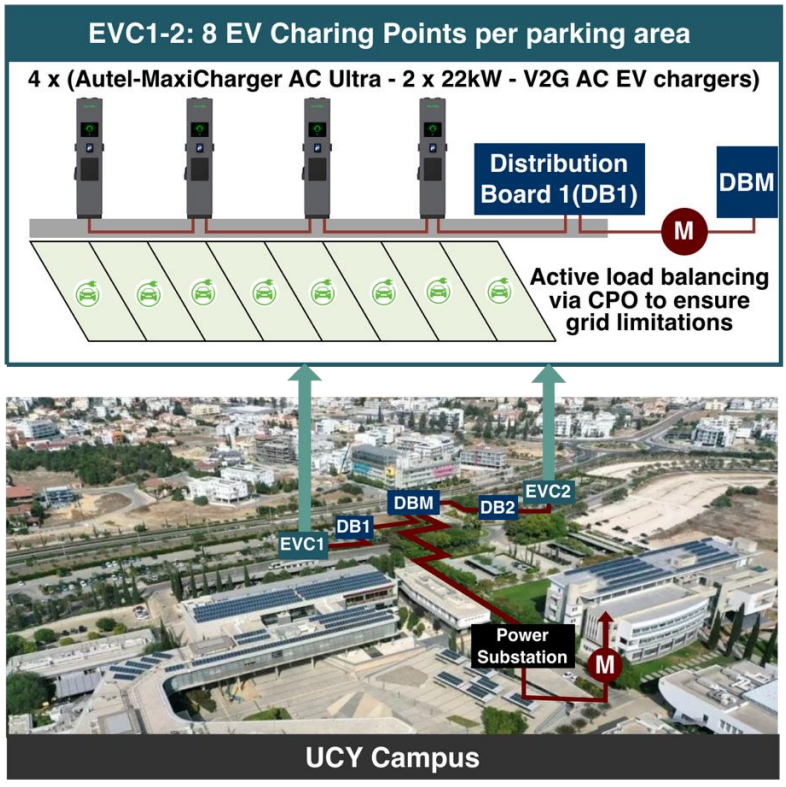


Figure 6: EV chargers configuration at Nicosia pilot site

During the testing and demonstration phase, flexible charging operation and/or V2G operation will be validated through incentivised charging tariffs for individual EV owners, or alternatively by renting V2G-compatible EVs for specified periods. Several real-life use cases will be carried out, focusing on:

- Relieving grid congestion by coordinating EV charging, battery storage, and PV flexibility at the grid level to enable more vehicles to charge.
- Reducing electricity costs and maximising RES utilisation through coordinated management of EV charging, PV generation and battery storage at the prosumer or charging-site level, while respecting EV owner preferences. User interaction and charging preferences will be supported through the platform currently associated with EV Power, which will be managed by a new project partner[1].

In addition, some extreme operating scenarios that may not be achievable under current campus conditions will be investigated using a digital twin of the campus energy infrastructure, allowing safe emulation of future system conditions and testing of operations near their physical limits.

3.4 Summary of pilot sites

Table 1 summarises the Innovation Areas and Solutions, and pilot site system and technology activities.

Table 1: The three pilot sites' innovation areas and related innovative solutions of related focus areas

Innovation Area	Technology Elements	Helsinki (FI)	Klagenfurt (AT)	Nicosia (CY)
IN-1: Non-intrusive EV chargers	TE-1.1: Less physically and visually intrusive AC EV charger	**X**	x	x
IN-2: Low-cost EV chargers	TE-2.1.1 & 2.2.1: EV Supply Equipment for low-cost and fast installation in built urban environments	**X** (TE-2.1.1)	**X** (TE-2.2.1)	
	TE-2.1.2 & 2.2.2: Optimised AC EV charger design for built urban environments	**X** (TE-2.1.2)	**X** (TE-2.2.2)	
IN-3: Smart multi-level platform for synergy with the Grid	TE-3.1: A multi-level synergetic framework with seamless data-exchange to co-manage Grid, RES and EV charging	**X**	**X**	**X**
	TE-3.2: Forecasting load flow analysis tool to schedule charging limitations for grid-friendly integration		**X**	**X**

[1] At the time of submission, the previous partner responsible for this aspect, EV Power, is withdrawing from the project. A replacement partner has been proposed but this is subject to an ongoing Contract Amendment.

Innovation Area	Technology Elements	Helsinki (FI)	Klagenfurt (AT)	Nicosia (CY)
	TE-3.3: Real-time and cost-effective flexibility controller to relieve grid congestion			X
IN-4: Smart integration with Renewable Energy Systems (RES)	TE-4.1: A smart integration system of rooftop solar panels and EV charging as an energy community	X		
	TE-4.2: Controller for optimised scheduling of resources/charging to reduce electricity cost and for real - time activation of flexibility according to DSO requests			X
IN-5: Interoperable user-centric apps with analytical and predictive capability	TE-5.1: An application combining the needs of the users and the electricity network capabilities	X	x	
	TE-5.2: Users' free choice of eMSP with the same innovative charging features provided by CPO	X	X	

Key: **X** – Key element in demonstration. **x** – Included in demonstration.

The following tables give a comparison of the three sites and outline ePowerMove partners' roles in each one.

Table 2: Summary table of pilot demonstration sites

Demo features	Helsinki (FI)	Klagenfurt (AT)	Nicosia (CY)
Number of bi-directional charging stations	20 (double)	6 (2 single / 4 double)[2]	8 (double)
Number of charging points (spaces)	40	10	16
Charger features	2 x 11 kW AC V2G chargers	11 kW AC / all V2G capable according to ISO 15118	8 × AUTEL MaxiCharger AC Ultra units, each providing 2 × 22 kW V2G AC chargers

[2] Currently under review, with regard to costs, as this is more than is planned under the Grant Agreement.

Demo features	Helsinki (FI)	Klagenfurt (AT)	Nicosia (CY)
Type of location	Residential area: public and residents' parking	Central bus depot, adjacent to central railway station	University campus car park
Permitted usage of chargers	Residents of nearby housing companies, customers of Ruoholahden Pysäköinti. Possibility to open for public use	8 charging points: General public 2 charging points: Avant car-sharing	8 chargers: General public 8 chargers: UCY employees
Renewable energy sources	Solar panels (existing panels used)	N/A	Solar panels

Table 3: Partner roles at pilot sites

Role	Helsinki (FI)	Klagenfurt (AT)	Nicosia (CY)
Pilot leader	VTT	ATECH	UCY
Charger manufacturer / supplier	UTU	MET	PAP
Charger installation	UTU	MET, KLAG	UCY, PAP
Charger operator	IGL	AVANT	New partner[3]
Site owner	Ruoholahden Pysäköinti Oy (FVH & VTT coordinate)	KMG (a company of KLAG)	UCY
Provider of related services (app, software, mobility services, etc.)	IGL	AVANT	New partner[2], UCY
Data collection (usage, performance)	FVH / IGL	KNG / AVANT	EAC, New partner[2], UCY
User surveys (feedback)	FVH / VTT	ATECH	
Data analysis	UnivLEEDS, VTT	UnivLEEDS, ATECH	UnivLEEDS, UCY

[3] At the time of submission, the previous partner responsible for this aspect, EV Power, is withdrawing from the project. A replacement partner has been proposed but this is subject to an ongoing Contract Amendment.

Role	Helsinki (FI)	Klagenfurt (AT)	Nicosia (CY)
Impact assessment (WP5)	UnivLEEDS, VTT	UnivLEEDS, ATECH	UnivLEEDS, UCY

4 METHODOLOGY AND RESEARCH QUESTIONS

4.1 Reference Methodologies

The ePowerMove project, involving three test sites to validate, demonstrate and measure impact of the proposed solutions, is concerned not only with the individual site results but also with gaining knowledge from the combination of results. To achieve this, a common evaluation methodology is required, ensuring joined-up planning and communication among the partners involved in the development of solutions and pilot sites as well as a consistent approach to data collection, classification and analysis.

As background to the methodology, this section summarises the main methodologies used in ITS or field test projects, in particular the CONVERGE and the FESTA methodologies.

4.1.1 CONVERGE

CONVERGE[4] was an EU-funded support project in the late 1990s, providing tools for the management, coordination and exploitation of projects under the Transport Telematics Applications Programme (all transport modes). It provided a coordination and expert support platform to exploit key synergy between projects in order to maximise the value, quality and range of programme achievements. CONVERGE also provided technical papers and rapporteurs for several concertation meetings, building and sharing best practice.

According to CONVERGE, “Assessment is the process of determining the performance and/or impacts of a candidate application, usually in comparison to a reference case (existing situation or alternative applications), and usually including an experimental process based on real-life or other trials, often involving users.” In this context, validation can be defined as the process of verifying that an application performs as expected, often based on assessment results.

Within the project, two important documents were provided in order to establish guidelines for project evaluation and validation purposes: “Guidebook for Assessment of Transport Telematics Applications” and “Checklist for Preparing a Validation Plan” (both CONVERGE project, 1998 – see References section). The Guidebook is intended to give more general guidance and recommendations regarding the assessment or validation process, whilst the Checklist provides more detailed advice on how to produce draft and final validation plans.

The “Guidebook for Assessment of Transport Telematics Applications” defined seven key stages which constitute a generic assessment process; CONVERGE focused on transport telematics (ITS) projects, but they can still be used as a role model for other types of project assessment:

1. Definition of user needs

2. Describing the applications

3. Defining assessment objectives: Technical assessment (system performance, reliability); Impact assessment (safety, environment, transport efficiency, user behaviour, modal split etc.); User acceptance

[4] https://cordis.europa.eu/project/id/TR1101

assessment (users' opinions, preferences, willingness to pay); Socio-economic evaluation (benefits and costs of system implementation); Market assessment (demand and supply); and Financial assessment (initial and running costs, rate of return, payback period).

4. Defining expected impacts: “Pre-assessment”

5. Assessment methodology: Selection and definition of indicators; Reference case; Data collection (measurement and/or simulation); Measurement or simulation conditions (“blocking”); Statistical considerations/sampling; Defining the measurement plan; Integrity of measurement and/or simulation.

6. Data analysis

7. Reporting results.

Relevance is given to the way projects contribute to create a “European added value”: in fact, the real “customers” for the results of projects include both the direct participants and a broad audience of potential users, purchasers, manufacturers and operators. For them it is important to know how the various systems and applications perform, how much they cost to buy and to operate, and what impacts they might produce if implemented locally. “Cross-Project Collaborative” studies can facilitate informed decisions on other implementations. In the ePowerMove context, experience sharing approaches, solutions and results within the V2X Cluster[5] of 2ZERO projects brings mutual improvement and greater European added value.

4.1.2 FESTA

The FESTA methodology (Field opErational teSt supporT Action) was developed with the purpose to set-up and conduct Field Operational Tests (FOTs), and to analyse the validation results and perform impact assessment. The most updated version of is the Version 7 of the FESTA Handbook (FOT-Net and CARTRE projects, 2018).

The FESTA Handbook (page 14) describes a “Field Operational Test” (FOT) as “the study undertaken to evaluate a function, or functions, under normal operating conditions in road traffic environments typically encountered by the participants using study design so as to identify real-world effects and benefits”. This means, on a first step, that the impact assessed by any functions or element must be compared with a baseline, or situation existing before introducing the aforementioned functions.

FOTs are large-scale user tests where participants are recruited to try out a system or a function in the study for a period of time. The duration of tests may be from a few months to two years. During this period, several information gathering tools are used such as questionnaires, measurements and observations, to identify how the introduced system or function will change the participants’ driving or travelling behaviour, as well as the effects on other road users or wider impacts on the transport system.

The FESTA methodology is summarised in Figure 8. The V-shape shows the dependencies between the different steps in the left- and right-hand side of the V. Despite being described in a linear way, the steps usually are performed in iteration. The steps can be summarised as the FESTA approach and can be described in three phases, following the FESTA-V:

[5] https://www.epowermove.eu/liaison-en/

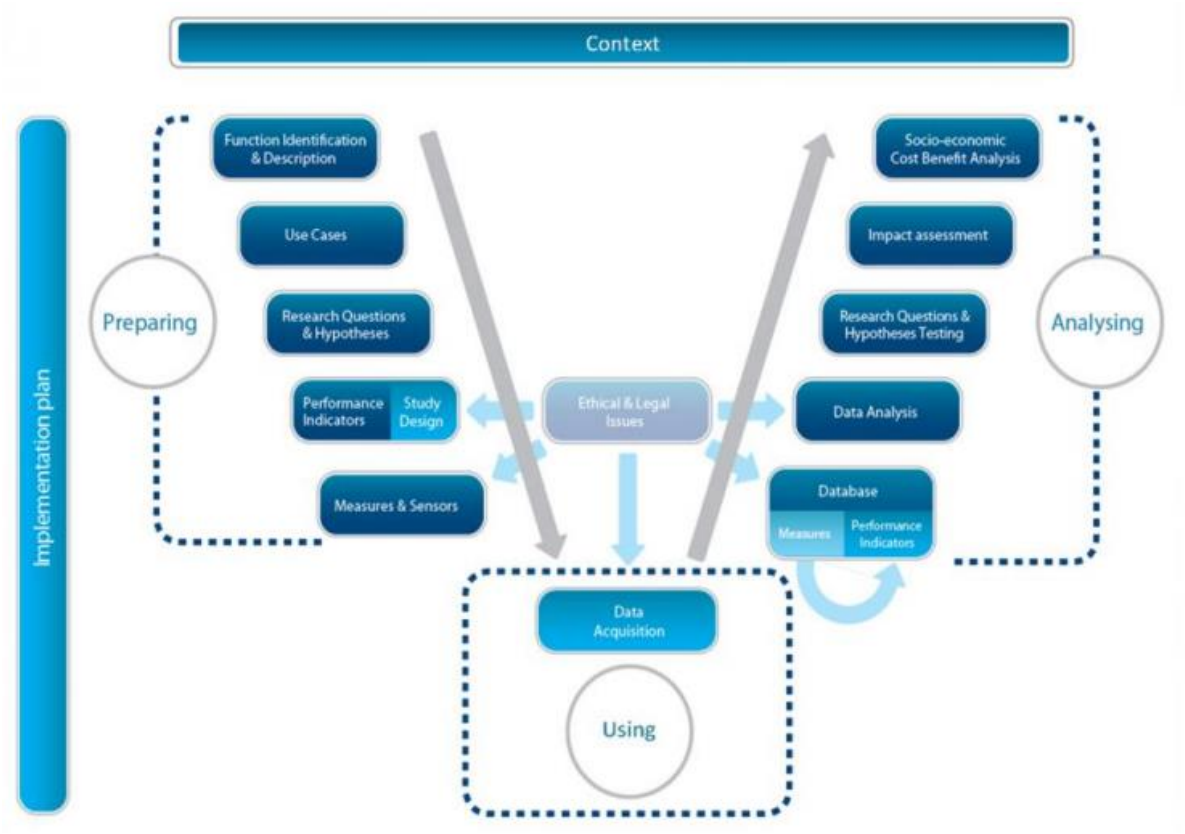


Figure 7: Steps that should typically be considered when conducting an FOT[6]

In ePowerMove, FESTA is adapted to the project's needs, with this deliverable focusing on the left-hand side of the V-diagram (Preparing). The Analysing side will be covered in D4.4: The ePowerMove impact assessment.

4.2 Proposed ePowerMove approach

In line with guidance from CONVERGE and FESTA, as well as good practice from other relevant projects studied, the approach of ePowerMove centres around the following:

- Develop Research Questions (see below). These are based on projects objectives and the Measures of Success (MoS) from the Grant Agreement / DoA. They are the questions which the evaluation process should seek to answer.
- Define the steps for the Verification phase (Chapter 5), which focuses on the key technologies.
- For Validation phase (Chapter 6), define the data needs for measuring the Key Performance Indicators (KPIs) described in the DoA.
- Plan the demonstrations, including what data to collect and how (Chapter 7). This includes milestones, the timetable, the monitoring process and platform, and risks.

[6] Source: FESTA Handbook

- Determine the Impact Assessment framework (Chapter 8). This includes environmental and socio-economic impacts, scalability and replication, and a decision-support framework for policymakers, public authorities and energy stakeholders.

4.3 Research questions and Key Performance Indicators

The proposed research questions focus on three of the five project objectives (the ones relevant to the demonstrations in WP4) as well as KPIs taken from the relevant expected impacts (project's contribution to topic outcomes). These elements are from the project's Description of Action (DoA), within the ePowerMove / EC Grant Agreement.

4.3.1 Research questions related to project objectives

The project comprises five high-level objectives, as follows:

Table 4: ePowerMove high-level objectives

Objective nº	**Description of objective** (from DoA)	**Relevant WP(s)**	**Included in this deliverable for research questions**
O1	Co-designing with the community clusters to enhance user acceptability, accessibility, and fulfil real user requirements in the three different socio-cultural contexts while maintaining a strong connection to social innovation	1, 2	No
O2	Large-scale demonstration of low-cost, non-intrusive, efficient, interoperable charging solutions for different categories of EVs in urban areas	1, 2, 4	Yes
O3	Seamless integration and fluid operation of smart and bi-directional charging solutions for sustainable energy usage and integration	3, 4	Yes
O4	Development and demonstration of advanced user-centric applications for friendly access and use	1, 2, 3, 4	Yes
O5	Development of innovative models for planning and mass deployment across Europe	5, 6	No

For the three objectives covered in this chapter (O2, O3 and O4, due to their relevance to WP4), the proposed measures of success (from the DoA) and research questions are as follows:

O2: Large-scale demonstration

Requirements (summary from DoA):

- Develop innovative charging solutions compatible with L, M1, and N1 EVs, while considering user-centric principles.

- Solutions will be slow, conductive AC charging to maintain optimal levels of charging cost and efficiency.
- Deliver hardware and methods to reduce the associated labour and installation costs.
- Enhanced integration and hardware in chargers will reduce manufacturing costs.
- Design is physically and visually less intrusive.
- Chargers' performance and interoperability will undergo initial evaluation in a controlled setting, followed by a large-scale demonstration in the pilot sites. Over 40 units will be deployed for both opportunistic and overnight charging at publicly accessible locations.

Measures of success (summary from DoA):

- MoS7: Reduction of AC charger kerbside installation costs by at least 50%.
- MoS8: Reduction of AC charger manufacturing costs by at least 20%.
- MoS9: Demonstration of innovative low-cost, slow charging solutions with more than 40 chargers.

Proposed research questions:

1. How the new charger designs will impact manufacturing, installation and operational costs?
2. What is the expected percentage cost saving under mass production compared to current charger models?
3. How do users rate their overall experience of new charger designs compared to proprietary chargers? (FI only, where the new design will be installed).

O3: Seamless integration and fluid operation of smart and bi-directional charging solutions

Requirements (summary from DoA):

- Enhance power supply grid efficiency and overcome barriers to widespread bi-directional charging adoption.
- Develop Grid-level controller (GridRelief) and consumer-level controller (OptimDER) to manage grid congestion and maximise local RES utilisation, reducing the charging costs.
- Digital twin models will predict aggregated EV charging flexibility, facilitating grid impact assessment of project solutions at larger-scale distribution grids.
- Collaborating with DSOs, the project will propose business models to monetise the controllable discharges, ensuring benefits are shared across the entire value chain, including end users.
- Gather data for mass deployment of bi-directional, interoperable chargers and vehicles.
- Issues related to meeting grid codes, validating vehicles for discharging, and controlling discharging effectively will be addressed in close collaboration with vehicle OEMs and DSOs.

Measures of success (summary from DoA):

- MoS10: Smart and bi-directional charging solutions validated in 3 pilots.
- MoS11: Reduce electricity cost for EV charging by 7/12% under net-billing/variable-pricing approaches compared to uncontrollable prosumer operation without flexibility.
- MoS12: Reduction of peak loading conditions and reverse power flow congestion by 20% (and reduce by 10% the RES curtailed energy) compared to conventional grid operation with uncontrollable EV charging.

Proposed research questions:

4. What is the overall cost for a regular user in each pilot site (over a period of time) compared to the pre-existing average standard rates in these cities?

5. What is the actual and potential reduction in peak loading conditions at each pilot site?

O4: Development and demonstration of advanced user-centric applications for friendly access and use

Requirements (summary from DoA):

- Integrate various user-centric features into the chargers' mobile applications. These features include innovative smart and bi-directional charging controls, user-friendly interfaces for locating and pre-allocating chargers, transparent indications of charging and discharging costs, simplified initiation of charging procedures, and monitoring charging and battery health states.
- Ensure interoperability of mobile applications, enabling seamless EV use across Europe without being locked into a single eMSP.

Measures of success (summary from DoA):

- MoS15: New software-based services validated in 3 pilots and 2 replicator use cases in cities that are in the planning phase.
- MoS16: High users' satisfaction (4 / 5) with applications by gathering their feedback on usability and effectiveness of the applications.

Proposed research question:

6. What is the usage level and user satisfaction (scale of 1 to 5) for apps and other software services demonstrated?

4.3.2 KPIs from the project's impact areas

The project comprises seven main impact-related Outcomes related to the Call topic:

Table 5: ePowerMove high-level objectives

Impact Outcome	**Description of outcome** (from DoA)	**Relevant to the demonstrations in WP4**
OUT-1	Development & demonstration of innovative, interoperable, efficient, low-power smart and bi-directional on-street charging, increasing awareness and removing barriers to EV user acceptability in densely populated areas. User acceptability should be quantifiably improved from technological, investment costs & costs of charging.	Yes
OUT-2	The proposed innovative solutions should be conductive to optimise efficiency and reduce costs, but ideally should not be visually and physically intrusive, or these aspects should be kept to a minimum level, given the high level of expected deployment that would create problems for pedestrians and other road users.	Yes
OUT-3	Development of an analytical methodology including representative models to ensure an efficient planning for the mass deployment and integration of public (and where applicable private) EV charging	Yes

Impact Outcome	Description of outcome (from DoA)	Relevant to the demonstrations in WP4
	infrastructure, satisfying user needs and making it compatible as much as possible with existing low voltage grid and power system capabilities.	
OUT-4	Quantifiable improvement of related business models and gaps for users compared to current State of the Art, additionally also including considerations for less densely populated areas.	No, as related to WP5
OUT-5	Development of socio-cultural databases at city, regional and national level comprising daily charging habits, practices, and ideas of different community clusters (including individuals with special needs) and their integration into charging and planning tools, to support the determination of the most efficient and most accepted charging solutions. These developments should interact with the work of Sustainable Transport Forum.	No, as related to WP1
OUT-6	The identification and analysis of potential regulatory aspects and barriers for relevant standardisation activities via common, interoperable and open standards, protocols and digital services.	No, as related to WP5
OUT-7	Deployment of multilevel systemic architecture and solutions for smart and bidirectional charging power management that will increase RES penetration as well as enhance the grid capacities and power system resilience by alleviating grid congestions and levelling off the load curve.	Yes

For the four outcomes covered in this chapter (OUT-1, OUT-2, OUT-3 and OUT-7, due to their relevance to WP4), the KPIs from the DoA that are relevant to this deliverable (scope: demonstrations in WP4) also contribute to research questions. To avoid repetition, the relevant KPIs are listed in Table 6, under Chapter 6: Validation Plan.

5 VERIFICATION PLAN

The verification steps for each technology are given in this section.

5.1 EV chargers, including bidirectional charging

Owners:

- FI: UTU, IGL
- AT: MET, KNG
- CY: PAP, EAC.

Reference deliverables:

- D2.1 Prototype EV Supply Equipment (lead: UTU, Demonstration, Sensitive, due M20)
- D2.2 Physically and visually less intrusive bidirectional AC charger (lead UTU, Demonstration, Sensitive, due M20)
- D2.3 Novel installation methods (lead: UTU, Report, Sensitive, due M20)
- D2.4 Technical validation of the solutions (lead: VTT, Report, Sensitive, due M24).

For bespoke chargers designed for ePowerMove (FI), the EV charger manufacturer (UTU) will perform the following type approval tests to the chargers, to verify compliance according to IEC61851-1, IEC61439-7 and other relevant specifications[7]):

- Functional tests
- Compatibility tests
- Load tests
- Mechanical endurance tests
- EMC tests and safety tests.

Manufactured charging stations will be unit tested electrically, mechanically and functionally at the manufacturing site.

Bidirectional chargers to include the necessary intelligent components and firmware, ensuring they can support advanced functionalities and communicate with cloud platforms (OCPP) and EVs (ISO 15118-20). Verification steps are:

- Tests with ISO 15118-20 with physical EV simulator
- Definition of APIs between IGL (Task leader) and retailer(s)
- Certificates to communicate with EVs with encrypted ISO 15118-20
- Implementation of APIs between IGL and retailer(s) and between DSO and IGL.

[7] As per ePowerMove Milestone 4: Technical requirements, constraints and needs; and Milestone 5: Bidirectional AC charger requirement specification.

After field installation, commissioning testing will be performed to charging stations on site. After this, system level testing will be performed to verify operational compliance with charging and parking management back-end system.

5.2 Smart multi-level platform for synergy with the Grid

This includes:

- Multi-level synergetic framework with seamless data-exchange to co-manage Grid, RES and EV charging
- Forecasting load flow analysis tool to schedule charging limitations for grid-friendly integration
- Real-time and cost-effective flexibility controller to relieve grid congestion.

Owners:

- UL
- FI: IGL, UTU
- AT: KLAG, KNG, MET, AVANT
- CY: UCY, EAC, PAP, new partner replacing EVP.

Reference deliverables:

- D3.1 Design and development of a Grid-Charging-RES (lead: UL, Report, Sensitive, delivered M15).
- D3.2 ePowerMove Grid and charging/prosumer level management solutions (lead: UCY, Report, Public, due M22).

The verification activities for the smart multi-level platform will confirm that the developed platform is correctly implemented, interoperable with the relevant external systems, and capable of supporting the exchange of information required for grid-, RES- and charging-aware operation.

The verification will focus on the platform layer, ensuring the correct, secure and timely exchange of information between the platform modules and the relevant external actors, including the EMS, EMSP/CPO systems, DSO, chargers, local energy resources and the electricity market.

The verification process will ensure the correct:

a) acquisition of site power limits, grid constraints, electricity prices, RES production, BESS state of charge, prosumer demand, charging demand, charging preferences, EV connection status and EV state of charge;

b) data exchange through the implemented interfaces, APIs and agreed communication protocols, including Modbus and OCPP, where applicable;

c) authentication and authorisation through mechanisms such as API tokens and role-based access control;

d) exchange of inputs and outputs required by the demand forecasting, RES forecasting, load-flow analysis and flexibility-control tools;

e) reception and processing of DSO constraints, congestion-related information and flexibility requests;

f) routing and transmission of control decisions to the relevant charging or energy-management systems; and

g) monitoring of the communication status between platform components and connected systems.

Particular attention will be given to the consistency of exchanged timestamps and units, the compliance with the expected communication frequency, and the correct interpretation of received information by the intended platform component.

Verification will be considered successful when the required inputs are received and interpreted without errors, the relevant information is exchanged through the implemented interfaces within the required time, and commands or decision outputs are transmitted to the intended charging or energy-management component.

The verification activities will be performed through the following stages, depending on the maturity and availability of each component:

a) **Software and simulation verification:** testing of data exchanges and interfaces using synthetic, historical and representative datasets.

b) **Laboratory and integration verification:** end-to-end testing of communication functions using representative hardware or emulated components.

c) **Pilot-site verification:** confirmation of system operation using actual measurements, connected devices and operational conditions.

5.3 Smart integration with Renewable Energy Systems

This covers the Renewable Energy System (RES) -aware optimisation and flexibility control. It includes a smart integration system of rooftop solar panels and EV charging as an energy community and the controller for optimised scheduling of resources/charging to reduce electricity cost and for real-time activation of flexibility, according to DSO requests.

Owner:

- UCY.

Reference deliverables:

- D3.1 Design and development of a Grid-Charging-RES (lead: UL, Report, Sensitive, delivered M15).
- D3.2 ePowerMove Grid and charging/prosumer level management solutions (lead: UCY, Report, Public, due M22).

The verification activities will confirm that the intelligence layer implemented on top of the platform produces feasible, technically valid and grid-aware control decisions. While Section 5.2 focuses on the verification of communication and interoperability, this section focuses on the verification of the decision-making logic behind the generated commands.

Verification will confirm the correct coordination of EV charging, local RES generation and, where applicable, battery storage. The implemented controller will be verified with respect to objectives such as increasing PV utilisation, reducing electricity costs, respecting grid constraints and supporting flexibility activation according to DSO requests.

The verification process will ensure the correct:

a) use of PV generation, PV forecasts, EV charging demand, battery state of charge, site consumption, electricity prices and grid constraints as inputs to the optimisation and control functions;

b) execution of the optimisation algorithm for representative operating scenarios;

c) generation of EV charging schedules, EV station operational envelopes and BESS charging or discharging set-points;

d) adaptation of charging and discharging schedules to changes in renewable generation, demand, electricity prices and DSO requests;

e) compliance of the generated schedules and commands with charger, battery, user, prosumer and site-level constraints;

f) comparison of the generated decisions against relevant baseline operation, where applicable, to assess improvements in RES utilisation, cost reduction and grid-support performance; and

g) monitoring and recording of actual RES generation, charging demand and energy flows to support verification of the intended system behaviour.

Representative scenarios will include periods of high and low PV generation, charging demand exceeding available renewable production, BESS charging and discharging operation, changes in electricity prices, variations in prosumer demand, and the reception of grid constraints.

Verification will be considered successful when the controller produces feasible schedules and technically valid commands, the defined constraints are respected, and the system response follows the intended RES integration, cost-reduction and grid-support objectives. Where applicable, the verification will also confirm that the generated decisions improve the relevant performance indicators compared with baseline or non-optimised operation.

The verification activities, similar to Section 5.2, will be performed through the following stages, depending on the maturity and availability of each component:

a) **Software and simulation verification:** testing of individual algorithms, data exchanges and interfaces using synthetic, historical and representative datasets.

b) **Laboratory and integration verification:** end-to-end testing of optimisation and control functions using representative hardware or emulated components.

c) **Pilot-site verification:** confirmation of system operation using actual measurements, connected devices and operational conditions.

5.4 Interoperable user-centric applications with analytical and predictive capability

5.4.1 Application combining the needs of the users and the electricity network capabilities

Owner:

- FI: IGL.

A human-centric mobile application (app) is being developed with an intuitive HMI for seamless charging station discovery, price comparison and reservation capabilities. It will include user inputs for features such as flexible bidirectional charging. Other features will include charge session management, clear pricing, payment options, real-time data flow, accurate billing and troubleshooting.

Verification steps are:

- Verifying that the application correctly integrates user requirements (WP1 user needs)

- Verifying that users can easily configure preferences and understand charging outcomes (feedback)
- Validating application performance in a real operational environment (pilot site)
- Verifying interoperability with multiple charging stations and backend systems.
- Confirm real-time data exchange with grid operators (retailer/aggregator)
- Verifying that charging optimisations decisions effectively respect grid limitations and do not cause overloads or underloads.

5.4.2 Users' free choice of eMSP with the same innovative charging features provided by CPO

Owner:

- FI: IGL.

Verification steps are:

- Charger technology integrations with third party eMSP(s)
- OCPI integrations with third party eMSP(s)
- Confirm correct handling of roaming and service switching
- Validating correct charging session reporting and billing accuracy
- Validating and defining contractual arrangements between CPOs and eMSPs.

6 VALIDATION PLAN

Validation of the technical solutions will be covered in D2.4 Technical validation of the solutions (lead: VTT, Report, Sensitive, due M24).

This section gives the project's Key Performance Indicators that relate to validation of technical solutions and the required data. These are shown in the following table.

Table 6: Validation KPIs and measurements

Outcome (OUT) / KPI	KPI description	Unit of measurement	Data requirements
OUT-1: Development & demonstration of innovative, interoperable, efficient, low-power smart and bi-directional on-street charging			
KPI-1.2	A 20% reduction in charging costs with V2G vehicles (decreased charging costs due to compensation from bi-directional charging.	€	Charging costs with and without V2G for a given charge at each site. Pilot locations' average charging cost in public AC chargers.
KPI-1.3	At least 50% improvements of user knowledge and acceptance rate (compared to beginning of project) from technological improvement and reduction in investment costs and charging prices.	Percentage	User surveys. Compare with WP1 surveys at beginning of project (where possible also any public survey data from other V2G/V2X charging projects)
OUT-2: Innovative solutions that are conductive to optimise efficiency and reduce costs, and not be visually and physically intrusive			
KPI-2.1	More than 25% satisfaction increases among residents, and street maintenance workers, compared to the beginning of the project.	Percentage	User surveys. Compare with WP1 surveys at beginning of project
KPI-2.2	4/5 usability satisfactions of drivers with special needs.	Likert scale	User surveys.
KPI-2.3	At least 50% reduction in occupied walkway area, compared to normal public stand-alone charging stations currently found on the market.	Metres	Observation.

Outcome (OUT) / KPI	KPI description	Unit of measurement	Data requirements
KPI-2.4	Zero safety incidents such as collisions and tripping hazards during the pilot period.	Number of accidents or other incidents (classified by type)	Surveys, reports/complaints.
KPI-2.5	4/5 satisfaction by local residents for less visually and physically intrusive charger design.	Likert scale	User surveys.
OUT-3: Analytical methodology including representative models to ensure efficient planning for the mass deployment and integration of EV charging infrastructure, satisfying user needs and compatible with existing low voltage grid and power system capabilities.			
KPI-3.1	4/5 satisfaction with night charging of L, M1 and N1 vehicles and their opportunistic day charging.	Likert scale	User surveys.
KPI-3.3	100% compatibility with existing low voltage grid and power system capabilities.	Percentage	Measurement of level of compatibility / listing of any incompatible elements (dashboard data).
KPI-3.4	At least 50% increase on the number of EVs that can be successfully served by the low voltage distribution grid in a daily based without causing congestion and without requiring additional investments for grid reinforcement	Percentage	Modelling/ reasoned estimation based on baseline of maximum EV served by distribution grid under uncontrollable charging without causing congestion.
OUT-7: Deployment of multilevel systemic architecture and solutions for smart and bidirectional charging power management that will increase RES penetration as well as enhance the grid capacities and power system resilience by alleviating grid congestions and levelling off the load curve.			
KPI-7.1	Avoid 90% of the possible grid limits violation events and reduce peak loading conditions (reverse and forward) by 20% in distribution feeders	Number of events.	Measurement of events (dashboard data). Compare to conventional uncontrollable charging approach.
KPI-7.2	Reduce renewable energy curtailment by at least 10%, increasing RES utilisation,	Number of events.	Measurement of events (dashboard data). Compare to grid/consumer operation without controllable charging.

Outcome (OUT) / KPI	KPI description	Unit of measurement	Data requirements
	through a novel synergetic coordination approach.		
KPI-7.3	7-12% Reduction in overall electricity cost for EV charging under different pricing approaches by co-optimising RES and EV charging utilisation.	€	Electricity costs (dashboard data). Compare to the inflexible consumer operation.

7 DEMONSTRATION PLAN

7.1 Milestones

The following project Milestones relate to the demonstration pilots.

Table 7: Milestones for the demonstrations

MS. n° (from DoA)	Title	Related Work Package	Means of Verification	Lead Partner	Due date and status
6	Bidirectional AC charger prototype(s) ready for installation at pilot site(s)	WP2	Prototypes verified at the laboratory level (at VTT).	VTT	M24 (Dec 2026) – pending
7	Application prototype for bidirectional charging that takes into account energy demand and grid conditions	WP2	Application verified in laboratory test environment, with simulated power flow	UTU	M20 (Aug 2026 – pending)
8	Well defined data-exchange and functional requirements for each grid/charging-level solution	WP3	A table listing the functional requirements, the required input and expected output data for each solution.	UCY	M6 (June 2025) – achieved
9	Solutions validated and ready to be installed in pilot sites	WP3	Full solutions tested in closed environments (at VTT and at UCY).	VTT	M23 (Nov 2026) - pending
10	Site preparation, setups and all installations completed	WP4	Chargers commissioned and tested with real vehicles.	UNIVLEEDS	M23 (Nov 2026) - pending
11	Preliminary data of the demonstrations' first two months collected and analysed.	WP4	Results of the data analysis	UNIVLEEDS	M25 (Jan 2027) - pending

Note that if Milestone 10 is achieved in M23 and Milestone 6 in M24 (as planned), then the demonstrations will most likely start in January 2027, causing a small delay to Milestone 11: if the first two months data are for January and February 2027, then this Milestone should be achieved in March = M27.

7.2 Demonstration timescale

The following table sets out the timing of the pilot demonstrations.

Table 8: Demonstration stages and timings per pilot site

Demo features	Helsinki (FI)	Klagenfurt (AT)	Nicosia (CY)
Type approval testing	AC charging stations will be type approval tested (CE mark criteria) by functional and compatibility tests, load tests, mechanical endurance tests, EMC tests and safety tests. Responsible: UTU Timing: August 2026	AC charging stations will be type approval tested (CE mark criteria) by functional and compatibility tests, load tests, mechanical endurance tests, EMC tests and safety tests. Responsible: MET Timing: May 2026	Commercially available AUTEL AC Ultra units will be used. AUTEL will confirm that the V2G-enabled firmware remains compliant with applicable certification and safety requirements (additional conformity assessment to be performed if needed). Responsible: PAP (and AUTEL) Timing: August 2026
Factory acceptance tests	Manufacturing factory will perform factory acceptance tests for pilot units. Responsible: UTU Timing: August 2026	Manufacturing factory will perform factory acceptance tests for pilot units. Responsible: MET Timing: September 2026	Manufacturing factory acceptance tests will be performed on the pilot units. After activation of the V2G firmware, PAP and UCY will conduct additional tests for the new modes. Responsible: PAP (AUTEL), UCY Timing: September - October 2026.
Equipment / infrastructure preparation	Description: Ground works in parking area, including trenching, cables, etc. Responsible: UTU, FVH Timing: September 2026	All ground works including trenching, laying cables, preparing foundations, setting up parking lot, preparing measurement equipment Responsible: KLAG, KNG, KMG, MET Timing: November 2026	Preparation of the two parking areas, including electrical design, trenching and cabling, charger foundations, installation of distribution boards, meters, communication infrastructure, protection equipment and connection to the campus electrical network and monitoring systems.

Demo features	Helsinki (FI)	Klagenfurt (AT)	Nicosia (CY)
			Responsible: UCY (external electrical contractor) Timing: July – Sep. 2026
Installation	Installing chargers at pilot site: both standard (proprietary) models from UTU and the new UTU design from ePowerMove Responsible: UTU, FVH Timing: September 2026	Installing chargers at pilot site, installing measurement equipment Responsible: MET, KNG Timing: December 2026	Installing 8 double chargers at pilot site Responsible: UCY, PAP Timing: September - October 2026
Commissioning testing of charging	After site installation, commissioning testing will be performed at site. Responsible: UTU Timing: November 2026	After site installation, commissioning testing will be performed at site. Responsible: MET, AVANT Timing: December 2026	On-site commissioning of all charging points, including electrical safety checks, verification of charging operation, charger-to-backend communication, Modbus TCP and OCPP connectivity, metering accuracy, remote monitoring and control. Responsible: UCY, PAP (AUTEL), New project partner[8] (instead of EVP) Timing: October-December 2026
Testing of additional / complementary systems	IGL's eParking management system back-end system tests Responsible: IGL Timing: December 2026	eFrend backend and grid safety analysis Responsible: AVANT, KNG Timing: December 2026	End-to-end integration testing of the chargers with the CPO platform, the ePowerMove synergetic framework, campus PV and battery systems, DSO. Responsible: UCY, EAC, PAP, AUTEL, new project partner (instead of EVP)

[8] At the time of submission, the previous partner responsible for this aspect, EV Power, is withdrawing from the project. A replacement partner has been proposed but this is subject to an ongoing Contract Amendment.

Demo features	Helsinki (FI)	Klagenfurt (AT)	Nicosia (CY)
			Timing: November 2026–January 2027
Start of public demonstration	Timing: January 2027	Timing: January 2027	Timing: January 2027
End of public demonstration	Timing: Beginning of 2028	Timing: Beginning of 2028	Timing: Beginning of 2028

7.3 Monitoring

7.3.1 Monitoring platform

Monitoring will take place via a cloud-based platform for data consolidation and analysis that will be developed by the partner that will replace EV Power (subject to 2026 Contract Amendment), as leader of Task 4.3: Data consolidation and dashboard. This will allow the pilot site owners to upload operating data via API calls. The Task Leader shall collect information regarding data API availability from all three pilot sites.

A time-series database will store periodically uploaded field data, using efficient filtering for data retrieval and analysis. Custom dashboards will be created for each pilot site to display KPIs via graphical interfaces. These will enable data analytics for informed decision-making as well as data export.

Monitoring of the large-scale demonstrations will be supported through a dedicated data consolidation and dashboard framework, developed under Task 4.3. The objective of this framework is to enable continuous, harmonised monitoring of the three pilot sites (Helsinki, Klagenfurt, and Nicosia) throughout the demonstration period, supporting both operational oversight and subsequent evaluation activities.

A **cloud-based data consolidation platform** will be used to collect, store, and manage heterogeneous data streams generated during the pilots. Secure API-based interfaces with appropriate authentication mechanisms will allow pilot owners and system operators to upload operational data in a controlled and standardised manner. The platform will rely on a **time-series-oriented data structure**, enabling efficient handling of periodically uploaded field data and facilitating temporal analysis across different system components and pilot locations.

The monitoring framework will cover multiple categories of data, including:

- Operational charging data (e.g. charging and discharging events, power levels, energy exchanged, utilisation rates);
- System and infrastructure performance indicators (e.g. charger availability, operational status, V2G activation events);
- Contextual and aggregated system-level indicators relevant to grid interaction and flexibility provision, where available;
- User-related responses derived from surveys and app usage statistics, supporting the monitoring of user acceptance and behavioural trends.
- Vehicle data.

Based on the consolidated data, **custom dashboards will be developed for each pilot site**, providing visualisation of key monitoring indicators through intuitive graphical interfaces. These dashboards are

intended to support real-time and near-real-time monitoring of pilot operation, allowing project partners to track system performance, identify anomalies, and inform corrective actions during the demonstration phase, particularly during the initial ramp-up period.

Survey data collected through pre- and post-demonstration questionnaires will not be displayed at an individual level. Instead, selected aggregated indicators (e.g. changes in user acceptance, willingness to use, or perceived usefulness) may be incorporated into the dashboards at pilot or site level, ensuring compliance with ethical and data protection requirements.

Access rights to the platform and dashboards will be defined according to partner roles and responsibilities, ensuring data security and compliance with the project's Data Management Plan. In addition to visualisation, the framework will allow export of consolidated datasets to support in-depth analysis conducted in Tasks 4.4 and 4.5 and in later work packages.

7.3.2 Dashboard design and visualisation

Monitoring of the demonstrations will be supported through a dashboard and data consolidation concept developed under Task 4.3, aiming to provide a consistent "single view" across the three pilot sites. The dashboard is designed to support (i) operational monitoring during the live demonstration period (e.g., deployment status, utilisation, charging/discharging activity, system events) and (ii) structured preparation of datasets for downstream evaluation in Tasks 4.4 and 4.5.

The dashboard design follows a layered structure, organised into five interconnected modules to address different monitoring needs:

- **Overview**: A high-level summary of project-wide KPIs and status.
- **Pilot Sites**: Detailed, real-time operational views for Helsinki, Klagenfurt, and Nicosia.
- **User**: A dedicated interface for tracking acceptance, behaviour, and survey results.
- **Data**: A structured repository for accessing and exporting consolidated datasets.
- **About**: Contextual information regarding the project objectives and consortium.

The "Overview", "Pilot Sites", and "Data" modules can be implemented using **Grafana**[9], connected directly to a high-performance time-series database (e.g., InfluxDB). This ensures that operational KPIs, such as charger status, power flow, and grid frequency, are visualised with **sub-second latency**, providing site managers with immediate situational awareness. The "User" modules can be delivered through a specialised Business Intelligence (BI) platforms (e.g., Tableau, PowerBI). To ensure a seamless user experience, these distinct layers (Grafana and Tableau) can be integrated into a Single Sign-On (SSO) web portal. Stakeholders will log in once to navigate between the real-time operational streams in Grafana and the strategic impact reports in the BI platform.

7.3.2.1 Overview

The Global Overview serves as the entry point for the monitoring framework, providing a consolidated view of the entire ePowerMove project. Its primary objective is to facilitate consortium-wide monitoring and high-level progress reporting by aggregating data from all three pilot sites (Helsinki, Klagenfurt, Nicosia) into a unified portfolio view.

[9] https://grafana.com

Visualisation Strategy:

1. Navigation and Controls (Control Layer):

- Time Horizon Filter: A sidebar control allows users to adjust the aggregation window for all displayed metrics, toggling between "Live" (real-time snapshot), "Past 24 Hours" (daily summary), and "Historical" (cumulative project-to-date values).
- System Status and Data Freshness: A composite status indicator provides immediate confirmation that the central platform is online. Since data frequencies vary by source (ranging from real-time telemetry for charging sessions to daily batches for DSO scheduling), the dashboard displays the "Last Successful Sync" timestamp for each pilot site. This ensures transparency regarding data currency, allowing users to distinguish between live operational streams and periodic batch updates.

2. Headline KPIs (Performance Metrics): The top section features a grid of high-level KPI cards.

- Active Chargers: Total number of online charging points.
- Energy Delivered: Cumulative energy (MWh) transferred to EVs.
- V2G Discharged: Cumulative energy (MWh) exported back to the grid.
- Grid Events: Count of congestion management or frequency support events.
- CO_2 Avoided: Estimated tonnes of CO_2 emissions saved through smart charging optimisation and renewable integration.
- Average User Savings: Average monthly financial benefit (€/month) realised by participants via V2G compensation.
- Active Users: Total number of participants actively connected via the mobile application.
- Average Dwell Time: Average connection duration (hours).

3. Geospatial Portfolio (Central View): The core visual component is an interactive Portfolio Map displaying the geographical distribution of the three pilot sites.

- Status Indicators: Each site is represented by a pin colour-coded to its real-time status (e.g., Green for Active/V2G, Blue for Planned/Maintenance).
- Contextual Pop-ups: Hovering over a site pin reveals a summary tooltip (e.g., "Helsinki: 40 Chargers, Status: Active").

4. Aggregated Analytics (Widgets): Two summary charts provide a snapshot of the total system behaviour:

- Real-time Status Distribution: A Pie Chart breaking down the current state of all 61 chargers (Charging, V2G, Idle, Maintenance) to assess overall fleet utilisation.
- Aggregated Flux Trend: A Bi-directional Bar Chart visualising the total power flow over the selected time window, contrasting Total Charging Load (positive bars) against Total V2G Discharge (negative bars) to demonstrate the project's bidirectional capability at scale.

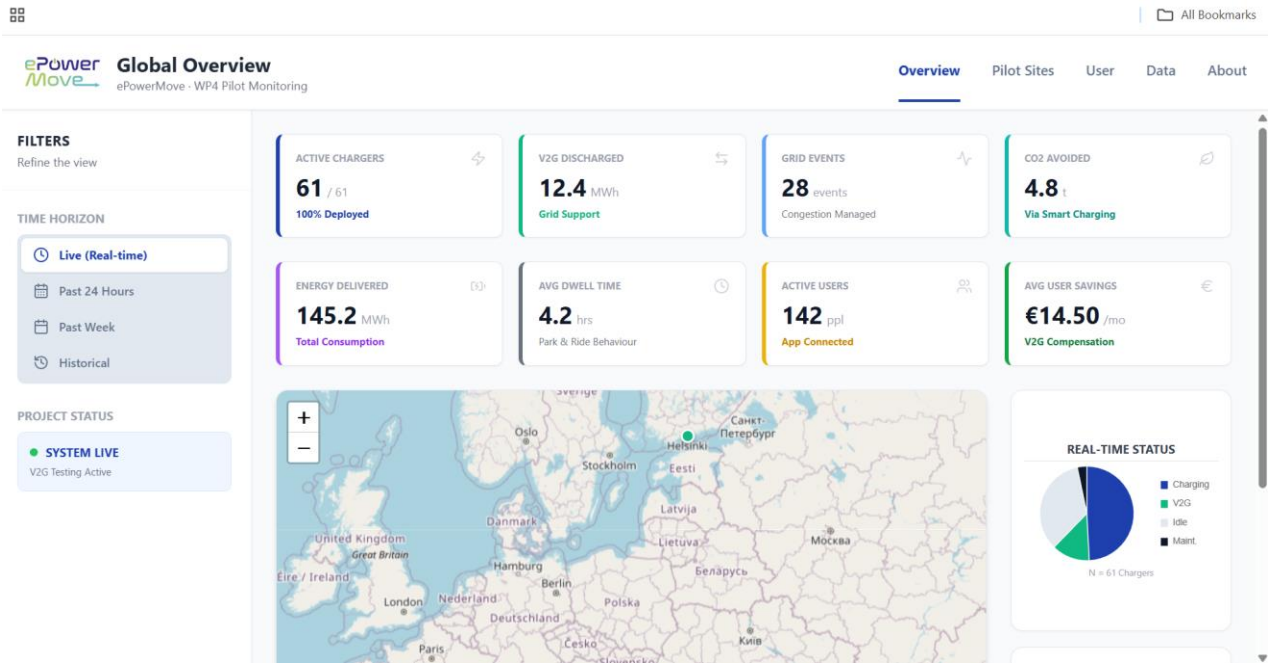


Figure 8: Initial draft of the “Overview” page of the dashboard

7.3.2.2 Pilot Sites

Dedicated site pages provide operational and contextual views tailored to each pilot’s specific demonstration focus. These dashboards serve a dual purpose: providing a real-time operational view for site managers and generating longitudinal performance insights for the evaluation partners.

Visualisation Strategy:

The dashboard layout is structured to provide immediate situational awareness through a hierarchical design: from global navigation to high-level KPIs, down to granular telemetry and domain-specific analytics.

1. Navigation and Controls (Control Layer):

- Site Selector: A tabbed interface at the top level allows users to switch the view between Helsinki, Klagenfurt, and Nicosia.
- Time-Scale Selector: A filter allowing operators to toggle the dashboard context between "Live Monitoring" (real-time stream), "Last 24 Hours" (daily cycle analysis), and "Last 7 Days" (weekly trend analysis).

2. Operational KPIs (Top Layer): Immediately below the navigation, a row of High-Level KPI Cards provides an instant health check of the pilot site. Standard metrics include:

- Charger Uptime: Percentage of infrastructure currently online and available.
- Current Utilisation: Real-time occupancy rate (%) of the charging points.
- Fleet Readiness: Average State of Charge (SoC) of all connected vehicles.
- Net Power Flow: Real-time directional power value (kW), explicitly stating if the site is currently Importing or Exporting.

3. Common Components (Standard View): To ensure consistent monitoring across all sites, the following analytical widgets are standard:

- Geospatial Status: An interactive Map View displaying charger locations with colour-coded status pins: Blue (Charging), Green (V2G Active), Grey (Idle), and Red (Fault).
- Live Telemetry Feed: A dynamic Data Table providing granular session details including Connector ID, Instantaneous Power (kW), Energy Exchanged (kWh), and Battery SoC (%); etc.
- Gross Fleet Activity: Stacked Area Charts visualising the total system throughput by separating Aggregate Charging Load from Aggregate V2G Discharge.
- Net Grid Exchange: Diverging Bar Charts tracking the resultant power flow at the connection point (Positive = Import, Negative = Export).
- Fleet State of Charge (SoC): Histograms showing the distribution of battery levels across the connected fleet (e.g., vehicle count in 0–20%, 20–40% brackets).
- Session Duration Analysis: Bar Charts categorising active sessions by length (e.g., <1h, 1–3h, >6h) to monitor turnover and parking behaviour.
- Contextual Economics: A Line Chart showing real-time electricity spot prices (€/kWh).
- Energy Source Composition: A Donut Chart visualising the real-time energy mix (Renewable vs. Fossil/Grid intensity).
- Operational Alerts: A dedicated Event Log to flag critical notifications (e.g., "Frequency Deviations", "Low Temp Pre-heating").

4. Site-Specific Logic: Besides the common components, custom widgets will be developed to address the unique use cases of each pilot. The specific visualisation requirements for these widgets are to be decided.

Data Needed:

- Standard Telemetry: Meter values (V, A, kW), Transaction events (Start/Stop), Error codes, and Grid Frequency.
- Contextual Data: Spot market prices (e.g., Nord Pool), Carbon Intensity APIs, Local Weather (Temperature), and PV Generation.

7.3.2.3 User

A user-focused tab will visualise indicators derived from the WP4/Task 4.1 survey instruments, covering both Pre-demonstration (T0) and Post-demonstration (T1) phases. The underlying data structure will be pseudonymised, linking T0 and T1 responses via secure User IDs. While the default dashboard view will present aggregated trends (e.g., pilot-level averages) to ensure data protection and anonymity for general viewers, the platform will also support a restricted Analyst View, allowing authorised stakeholders to access or export granular datasets.

Proposed Survey Items:

Acceptance Drivers and Perceived Barriers (derived from Unified Theory of Acceptance and Use of Technology 2 [UTAUT2] by Venkatesh et al (2012)[10]; Perceived Risk Theory by Featherman and Pavlou (2003)[11]; Usability by Brooke (1995)[12].

- Performance Expectancy (UTAUT2)

[10] https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2002388
[11] https://www.sciencedirect.com/science/article/abs/pii/S1071581903001113
[12] https://www.researchgate.net/publication/228593520_SUS_A_quick_and_dirty_usability_scale

- Effort Expectancy (UTAUT2)
- Price Value (UTAUT2)
- Social Influence (UTAUT2)
- Facilitation Conditions (UTAUT2)
- Perceived Risk - Performance
- Perceived Risk - Privacy
- Willingness to Accept (€/month)
- System Usability Scale (SUS) (Post-pilot only)
- Continuous Intention (Post-pilot only)

Visualisation Strategy:

The dashboard layout is structured into three layers:

1. Interactive Slicers (Control Layer):

- Phase Selector: A toggle allowing the user to switch the dashboard view between "Pre-demo", "Post-demo", and "Both".
- Demographic Filters: Dropdown slicers to filter all downstream charts by User Type (Private vs. Fleet), Gender, and Pilot Site.

2. **Dynamic Chart Logic (Main View):** The visualisation widgets adapt based on the Phase Selector:

- If "Both" is selected: The dashboard renders Diverging Stacked Bar Charts to explicitly contrast the shift in sentiment (e.g., Performance Expectancy, Risk, etc.) between T0 and T1.
- If "Pre" or "Post" is selected: The charts automatically switch to standard 100% Stacked Bar Charts, focusing on the detailed distribution of responses (e.g., % of "Strongly Agree") for that specific phase.
- Box Plots will visualise the spread of Willingness to Accept (WTA) thresholds, highlighting outliers and median values.
- Sample Composition: Donut Charts will display the demographic breakdown of the currently filtered dataset.

3. Qualitative Insights: To capture unstructured feedback, the dashboard includes a High-Frequency Topic Cloud to highlight recurring keywords (e.g., "Affordable", "Range Anxiety") and a Driver Verbatims widget to display illustrative quotes and testimonials.

4. KPI Cards: Headline metrics displayed at the top include Total Active Participants, Survey Response Rates, etc.

7.3.2.4 Data (Repository)

The Data tab serves as the central interface for the integration of demonstration data from all pilot sites. Designed for consortium partners and evaluators, this view provides structured access to validated datasets.

Visualisation Strategy:

1. Hierarchical Navigation (Sidebar): Users can expand categories to access specific tables.

- User and Surveys: Longitudinal survey data.
- Mobile Application: Analytics on app usage, push notification logs, etc.

- Operational Telemetry: High-resolution charging session records (CDRs) and 15-minute smart meter values.
- Prosumer and RES: Real-time generation data from local renewable assets (Solar PV) and stationary storage status.
- Grid and Context: External variables influencing the pilots, including Day-ahead Spot Prices and DSO Operational Envelopes (congestion signals).
- Impact and Simulation: Outputs from offline Digital Twin simulations (WP3) and calculated environmental KPIs (WP4).

2. Data Table View (Main Area): Selecting a dataset renders a dynamic Data Table with the following capabilities:

- Granular Inspection: Rows display individual records (e.g., a single charging session or survey response) with all associated attributes.
- Horizontal Scrolling: Tables are enabled with horizontal scroll to accommodate extensive variable lists (e.g., the full suite of UTAUT2 and demographic variables in survey data).
- Export Tools: A persistent toolbar allows authorised users to "Sync" the view with the latest live data or "Export CSV" for external analysis in tools like SPSS or Python.

Data Updates: A timestamp indicator (e.g., "Last Sync: 10 mins ago") informs users of the data currency, distinguishing between real-time streams and daily batch uploads.

Compliance: A persistent footer reinforces the project's data management plan (D7.4), explicitly stating that access is Role-Based (RBAC) and all personal data is pseudonymised in accordance with GDPR.

7.3.2.5 About

About / Context page will present the overall ePowerMove project objectives, the scope and rationale of the large-scale demonstrations, and the role of Task 4.3 within WP4. The page summarises the project’s focus on bi-directional charging, renewable energy integration, and human-centric design, and situates the three pilot sites (Helsinki, Klagenfurt, and Nicosia) within their respective demonstration contexts. In addition, it outlines the purpose of the dashboard itself.

7.3.2.6 Access Control

Access to the monitoring platform and dashboard will be governed by a strict Role-Based Access Control (RBAC) model to ensure data security and compliance with the project’s Data Management Plan (D7.4) and GDPR regulations. The platform is designed to handle distinct data types with varying sensitivity levels.

Owner:

- New partner (replacing EV Power), UnivLEEDS.

Data management principles and ethics will follow the ePowerMove Data Management Reports (to date, D7.4 and D7.5, with future updates being D7.6 and D7.7).

7.4 Risks

The following table lists the main risks related to the demonstrations.

Table 9: Demonstration risks

Risk n° (from DoA)	Risk description	Related Work Package	Risk owners	Probability of occurrence	Severity if it occurs	Mitigation measures
5	Specific software solutions of the synergetic framework not ready on time for integration	WP3	IGL (FI), KNG, AVANT (AT), UCY, new partner (CY)	Medium	Medium	Prioritise the development of tools that are interacting with other solutions of the synergetic framework to minimize the impact during integration
6	Delay on the demonstration availability	WP4	VTT, UTU, FVH (FI), ATECH, KLAG, KNG (AT), UCY, EAC, PAP, new partner (CY)	Medium	Medium	Increase the effort and the alignment with the system integration in WP3 to avoid unexpected delays
7	Poor data quality from demonstrations	WP4	VTT, FVH (FI), ATECH, KNG, AVANT (AT), UCY, EAC, new partner (CY), UNIVLEEDS	Low	High	Carry out a thorough investigation of the data collected in ramp-ups to ensure that all types of data have been examined before the real demonstrations start
New risk (not in DoA)	Unavailability of V2G-compatible EVs	WP4	VTT, FVH (FI), ATECH, AVANT (AT), UCY (CY),	High	High	Sourcing vehicles from other activities for some pilot sites
New risk (not in DoA)	Increased costs for civil engineering works and installation	WP4	UTU, KLAG, UCY	High	High	A significant cost increase has been identified in Klagenfurt and a smaller cost increase in Nicosia. Small increases to be reported as a

Risk n° (from DoA)	Risk description	Related Work Package	Risk owners	Probability of occurrence	Severity if it occurs	Mitigation measures
						deviation by the partner (offsetting with person-months) but bigger ones may need either budget transfers or de-scoping of works.

8 IMPACT ASSESSMENT FRAMEWORK

This chapter presents the impact assessment plan of the ePowerMove project, focusing on the technical, environmental, and socio-economic effects of deploying bidirectional charging and smart grid solutions in real-world pilot environments.

More specifically, the ePowerMove's impact assessment will utilise the data collected during the one-year long real-world demonstrations in three cities, and carry out technical evaluation and business impact analysis, quantify the improved user acceptability of mass deployment, and assess how ePowerMove improves both private and commercial mobility. It will also analyse the environmental and economic impacts of the ePowerMove innovation and identify potential for economies of scale.

8.1 Impact assessment approach

Following the CONVERGE methodology, impacts for ePowerMove are classified into three broad categories:

- **Impacts directly expressed in monetary terms**: these include measurable economic effects such as cost savings from optimised energy use, reduced operational expenses, deferred grid infrastructure investments, or revenues generated through vehicle-to-grid (V2G) energy transactions.
- **Impacts indirectly expressed in monetary terms**: these refer to outcomes that influence financial performance but require estimation or modelling to quantify. Examples include time savings, improved grid reliability, enhanced asset utilisation, or reductions in CO_2 emissions that can be converted into equivalent monetary value through carbon pricing.
- **Impacts expressed in qualitative terms**: these cover non-monetary benefits such as increased user satisfaction, improved perception of e-mobility services, greater energy awareness, or social and environmental acceptance of new technologies. While not easily quantifiable, these impacts are essential for understanding behavioural, societal, and policy-related outcomes.

While validation focuses on the direct measurement and verification of system outputs, technical functionalities, and interoperability under controlled or real-world conditions, the impact assessment extends beyond these immediate results. It involves defining objectives, identifying KPIs, collecting data, analysing outcomes, and conducting modelling, scenario-based simulations, deployment analysis, and scaling-up exercises. These activities are supported by well-defined assumptions and expert value judgments, following the FESTA methodology, to estimate the real-world and long-term effects of the integrated technologies and operational procedures.

8.2 Objectives

The ePowerMove project focuses on optimising energy consumption and promoting sustainable urban mobility through the deployment of affordable, bidirectional electric vehicle (EV) charging solutions. By integrating smart grid technologies, predictive control algorithms, and vehicle-to-grid (V2G) functionalities, ePowerMove enhances overall system efficiency, supports renewable energy integration, and contributes to grid stability. The project also aims to demonstrate how intelligent energy management and user-centred solutions can accelerate the global transition toward sustainable, flexible, and inclusive e-mobility ecosystems. Building on this vision, the primary objectives of the impact assessment are to:

- Quantify the **technical and operational impacts** of ePowerMove solutions, including improvements in grid efficiency, load balancing, and energy utilisation achieved through bidirectional charging and predictive energy management.

- Assess the **environmental benefits**, such as reductions in greenhouse gas (GHG) emissions, increased renewable energy penetration, and improved energy sustainability resulting from V2G-enabled optimisation.
- Evaluate the **socio-economic impacts**, focusing on user acceptance, behavioural changes, market readiness, and economic viability, including cost savings for users and the creation of new business and employment opportunities in the e-mobility value chain.
- Analyse the potential for **scalability and replication**, assessing how the solutions can be expanded cost-effectively across diverse geographic regions and energy systems, and adapted to various business models and deployment scales, while maintaining interoperability and performance standards.
- Provide a **decision-support framework** for policymakers, cities, and energy stakeholders by linking the measured impacts to broader sustainability goals, including EU Green Deal targets, emission reduction pathways, and smart city development strategies.

8.3 Key impact dimensions

The impact assessment evaluates ePowerMove solutions across four main dimensions:

- **Technical impact**:
  The technical dimension in the impact assessment focuses on system-level consequences, benefits, and scaling effects, rather than the component-level performance addressed in the validation stage. It evaluates how deploying ePowerMove solutions impacts energy efficiency, grid stability, and operational scalability within realistic deployment scenarios.
- **Environmental impact**:
  This dimension evaluates how ePowerMove's bidirectional charging and energy management solutions contribute to environmental sustainability. Key indicators include reductions in CO_2 emissions, improved integration of renewable energy sources, decreased energy losses through grid optimisation, and reduced peak-load demand. The assessment also examines how vehicle-to-grid (V2G) operations can facilitate cleaner energy use and contribute to carbon neutrality targets at both local and regional levels.
- **Socio-economic impact**:
  The socio-economic analysis focuses on the wider societal and user-level benefits of ePowerMove solutions. This includes assessing user acceptance, behavioural changes, comfort and convenience, and potential savings for EV owners and fleet operators. It also considers broader economic and social effects such as job creation in the e-mobility sector, impacts on energy communities, and increased resilience of local energy systems. Stakeholder engagement and inclusivity are central elements of this dimension.
- **Economies of scale**:
  This dimension examines the scalability and cost-efficiency potential of ePowerMove technologies as deployment expands. It considers cost reductions from technological learning, standardisation, and increased production, as well as market uptake across different urban and regional contexts. Scenario-based modelling evaluates how system performance and unit costs evolve with scale, providing insights for policy and investment strategies supporting large-scale adoption.

Finally, integrated impact synthesis is necessary because it brings together all impact results into a single, coherent evaluation, enabling clear decisions on the value, scalability, and relevance of ePowerMove beyond individual KPIs. These impacts are mapped against selected key expected outcomes of the ePowerMove project, along with their associated KPIs, ensuring alignment between technical achievements, user benefits, and broader environmental and economic goals.

8.4 Procedures of the assessment

The procedures for the impact assessment of the ePowerMove project follow the logical and iterative structure of the FESTA methodology, adapted to the specific objectives and operational framework of ePowerMove. While the validation process focuses on the direct measurement of technical performance and compliance, the impact assessment extends this analysis to understand system-level consequences, societal relevance, and long-term sustainability. The procedure consists of the following key steps:

Step 1: Definition of objectives and KPIs
Building on the goals and expected outcomes of ePowerMove, specific objectives are formulated for each impact dimension (technical, environmental, socio-economic, and economic). Corresponding Key Performance Indicators (KPIs) are identified, ensuring alignment with the overall project Key Expected Outcomes (KEOs) and European sustainability targets such as CO_2 reduction, renewable energy integration, and energy efficiency.

Step 2: Baseline establishment and data collection
A baseline scenario is established to reflect the current state of energy use, charging behaviour, and grid operation before ePowerMove deployment. Data are then collected from pilot sites, laboratory tests, and user interfaces, complemented by external datasets (e.g., energy prices, emission factors, mobility statistics) to ensure comprehensive assessment coverage.

Step 3: Modelling and scenario simulation
System modelling and scenario-based simulations are performed to estimate impacts beyond direct pilot results. These scenarios capture varying deployment scales, regional conditions, and market environments. Simulation tools are used to predict energy flows, grid responses, and user behaviour under different operational and environmental contexts.

Step 4: Impact quantification and analysis
Following the impact categorisation defined in CONVERGE, the quantitative assessment combines direct measurements with model-based estimations to determine the magnitude of technical, environmental, and socio-economic effects. Using the established KPIs and collected data, the assessment quantifies impacts across all dimensions, integrating both measured and simulated results. This enables a comprehensive evaluation of system-level performance, cost-effectiveness, environmental gains, and user behaviour changes. The analysis synthesizes findings from various test environments and deployment contexts to ensure robustness and scalability of the conclusions.

Step 5: Interpretation and integration of findings
Results from individual dimensions are synthesised to evaluate cross-sectoral implications and trade-offs. For example, technical improvements are linked to environmental gains, while socio-economic indicators provide insights into acceptance and market viability.

Step 6: Feedback and policy recommendation
The outcomes are fed back into project design and stakeholder decision-making. The assessment supports recommendations for scaling, replication, and policy alignment with EU frameworks such as the Green Deal and Fit-for-55.

This procedure ensures that the impact assessment not only quantifies measurable outcomes but also translates them into actionable insights that guide deployment decisions, future investments, and policy development toward sustainable and scalable e-mobility ecosystems.

8.5 Data, monitoring and governance

This section integrates the key elements of indicators, data collection, assumptions, limitations, data quality, monitoring and feedback mechanisms, policy recommendations, and timeline and responsibilities. It provides a structured framework to ensure a coherent, system-level evaluation of the ePowerMove project's impacts

across all dimensions—technical, environmental, socio-economic, and economies of scale. By combining measured pilot data, scenario-based modelling, and expert judgment, this approach ensures that the assessment provides both robust and actionable insights.

8.5.1 Key Performance Indicators

The assessment relies on Key Performance Indicators (KPIs) carefully selected to capture the most relevant outcomes of the ePowerMove project, as defined in the Description of Action (DoA), in particular those defined in the Impact section for the expected outcomes and wider impact areas of ePowerMove. These KPIs provide quantifiable metrics for evaluating system-level performance, environmental benefits, socio-economic impacts, and scalability potential.

- **Technical KPIs**: system-level energy efficiency, load balancing effectiveness, grid stability, operational scalability, and utilisation of predictive energy management algorithms. These indicators allow evaluation of the integrated performance of bidirectional charging and smart energy management under realistic operational conditions.
- **Environmental KPIs**: reductions in CO_2 and other greenhouse gas emissions, increased renewable energy utilisation, improved energy efficiency, and avoidance of losses in the local distribution network. These KPIs help quantify environmental contributions at both the pilot and scaled-up deployment levels.
- **Socio-economic KPIs**: user acceptance, engagement levels, behavioural changes, cost savings for EV owners and operators, market readiness, and perceived value of the solutions. These indicators provide insight into societal adoption, behavioural patterns, and economic viability.
- **Scalability KPIs**: cost reductions due to technological learning, standardisation, replication potential, and interoperability across deployment scales and contexts. These indicators allow evaluation of the broader deployment potential of ePowerMove solutions.

The final set of KPIs may be adapted based on operational realities, availability of reliable data, access to pilot facilities, or other uncertainties encountered during deployment and data collection. This flexibility ensures that the assessment remains practical, feasible, and aligned with project objectives.

8.5.2 Data collection

Data supporting KPI evaluation will be collected from a combination of complementary sources to ensure a comprehensive and representative dataset:

- **Pilot operations**: real-time charging/discharging logs, energy flows, local grid measurements, predictive control outputs, and V2G interactions. These data provide direct evidence of system performance.
- **User feedback**: surveys, questionnaires, interviews, and behavioural logs collected during pilot activities to assess acceptance, usability, and willingness to engage in V2G programs.
- **System and contextual data**: energy prices, emission factors, local renewable generation profiles, electricity demand patterns, and infrastructure characteristics. These contextual data support modelling and scenario analysis.
- **Model inputs**: assumptions for scenario-based simulations and scaling exercises, including future deployment configurations, grid evolution, and user adoption rates.

8.5.3 Assumptions, limitations, and data quality

The impact assessment relies on a number of well-defined assumptions to estimate effects beyond the pilot deployment:

- **Assumptions**: regarding technology performance, user behaviour, grid operations, and future scaling scenarios. These underpin the modelling of long-term impacts.
- **Limitations**: including incomplete pilot coverage, variations in operational conditions, limited duration of trials, or uncertainties in emission factors and cost parameters. These factors are explicitly acknowledged to contextualize the assessment results.
- **Data Quality**: mechanisms to ensure data reliability, traceability, and consistency, including validation of sensor outputs, cross-verification with multiple data sources, and standardised preprocessing and cleaning procedures.

8.5.4 Monitoring and feedback mechanisms

To maintain accuracy and relevance throughout the assessment:

- Pilot progress and data collection are continuously monitored to ensure completeness and reliability.
- Iterative feedback loops are established with stakeholders, including pilot participants, municipalities, energy providers, and technical partners. This allows timely refinement of measurement approaches, data collection protocols, and KPI definitions.
- Observations and emerging insights are used to improve assessment models, adjust scenario assumptions, and refine long-term impact estimations.

8.5.5 Policy recommendations and strategic use of results

The assessment outcomes are designed to provide actionable insights for policymakers, urban planners, energy operators, and industry stakeholders:

- Support informed decision-making on large-scale deployment of bidirectional charging and V2G-enabled solutions.
- Highlight opportunities for regulatory adaptation, incentive design, and integration into existing energy market structures.
- Guide the strategic planning of investment, infrastructure expansion, and scaling strategies based on demonstrable technical, environmental, and socio-economic benefits.

8.5.6 Timeline and responsibilities

A clear schedule for conducting the impact assessment ensures accountability and alignment with overall project milestones:

- **Timeline**: outlines pilot data collection periods, modelling and simulation phases, interim analyses, and final reporting points.
- **Responsibilities**: defines the roles of partners, data owners, analysts, and stakeholders in ensuring timely and accurate data collection, analysis, interpretation, and reporting. Responsibilities also include coordination of feedback loops and integration of lessons learned into policy recommendations.

8.6 Technical impact assessment

The technical impact assessment evaluates how the deployment of ePowerMove's bidirectional charging, predictive energy management, and smart-grid coordination influences system-level performance, operational efficiency, and overall grid reliability. The focus is on quantifying and estimating the technical benefits that arise from optimised charging behaviours, flexibility provision, improved load management, and enhanced integration of distributed energy resources. The assessment examines both direct technical effects

observed in pilot operations and projected system-wide impacts based on modelling, simulations, and scaling scenarios.

8.6.1 Key technical impact areas

1. **Improvements in energy efficiency and load management**:

The assessment quantifies how ePowerMove improves energy efficiency within the local grid by:

- Shifting charging demand away from peak-load periods
- Using predictive controls to optimize charging/discharging windows
- Reducing overall energy losses in distribution networks
- Increasing the efficiency of EV energy utilisation.

Energy efficiency constitutes a key technical KPI and will be evaluated using measured charging profiles, load-flow data, and scenario-based simulations comparing unmanaged charging with smart and bidirectional strategies.

2. **Contribution to grid stability and flexibility provision**:

ePowerMove's bidirectional functionalities enhance the technical stability of the power system by enabling:

- Peak shaving and load-leveling through V2G discharge
- Local balancing and voltage support
- Reduction in short-term power fluctuations
- Provision of flexibility services during grid stress events.

This impact will be assessed using stability indicators, transformer loading data, and modelled flexibility scenarios demonstrating how aggregated EV fleets can support local and regional grid resilience.

3. **Enhanced integration of distributed renewable energy**:

Through coordinated charging and flexibility services, ePowerMove supports the technical integration of renewables by:

- Aligning charging demand with periods of high solar/wind generation
- Reducing renewable curtailment
- Increasing the consumption of locally generated renewable energy
- Supporting stable operation of low-carbon energy communities.

This impact will be evaluated using renewable utilisation metrics from the pilots and simulations showing how higher EV penetration could further enhance renewable hosting capacity.

4. **System reliability, interoperability, and operational robustness**:

The assessment examines how the ePowerMove architecture performs under real-world conditions by analysing:

- Reliability of communication and control systems
- Interoperability between EVs, chargers, aggregators, and DSOs

- Stability of predictive control algorithms under variability
- Occurrence of system faults, delays, or communication failures.

Assessment will be based on pilot operational logs, error reports, performance metrics, and stress-test scenarios that reflect conditions expected at larger deployment scales.

5. **Scalability and deployment performance at larger penetration levels**:

The technical analysis evaluates how ePowerMove performs when deployed across larger EV fleets and wider geographic areas by considering:

- Hosting capacity constraints of local grids
- Behaviour of aggregated V2G resources
- Communication infrastructure requirements
- Technical bottlenecks during high-density deployment.

This impact will be analysed through scenario-based simulations and grid modelling that estimate performance at neighbourhood, district, and city levels.

8.6.2 Assessment approach

The technical impact assessment combines:

- Measured pilot data (charging/discharging profiles, load curves, communication logs, efficiency metrics)
- Modelled projections for larger-scale implementations
- Grid simulations evaluating voltage profiles, transformer loading, and system stability
- Scenario analysis reflecting different EV penetration levels, V2G participation rates, renewable integration levels, and grid conditions.

Together, these analyses provide a comprehensive evaluation of the technical benefits both during pilot operations and under future expansion conditions.

8.6.3 Expected outcomes

The technical impact assessment is expected to demonstrate the extent to which ePowerMove contributes to:

- Improved energy efficiency and more effective load management
- Enhanced stability and flexibility of distribution grids
- Greater renewable energy hosting capacity
- Robust and interoperable operation of integrated mobility–energy systems
- Scalable and reliable deployment across diverse environments.

These outcomes will be aligned with ePowerMove KPIs and integrated into the overall impact assessment framework.

8.7 Environmental impact assessment

The environmental impact assessment evaluates how the deployment of ePowerMove's bidirectional charging and smart energy management solutions contributes to broader sustainability goals. The focus is

on quantifying and estimating the environmental benefits that arise from optimised charging behaviour, improved integration of renewable energy sources, and enhanced grid efficiency. The assessment examines both direct environmental effects, observable in pilot operations, and projected long-term impacts based on modelling and scaling scenarios.

8.7.1 Key environmental impact areas

1. **Reduction in greenhouse gas (GHG) emissions**:

The assessment quantifies the reduction in CO_2 and other greenhouse gas emissions resulting from:

- Shifting EV charging to periods of low carbon intensity
- Enabling V2G discharging during peak-demand periods powered by fossil fuels
- Increasing the share of renewable energy consumed by EV users.

CO_2 reduction constitutes a core KPI for environmental impact and will be evaluated using emission factors, measured energy flows, and scenario-based modelling.

2. **Increased renewable energy integration**:

ePowerMove's predictive controls and bidirectional charging enhance the ability of the grid to:

- Absorb higher shares of intermittent renewable generation
- Mitigate curtailment of solar and wind energy
- Support local energy communities and self-consumption.

The impact will be assessed by measuring renewable energy utilisation levels and modelling how V2G-enabled flexibility could contribute to future renewable growth scenarios.

3. **Improved grid efficiency and reduced energy losses**:

By optimising energy flows and promoting load shifting, ePowerMove reduces:

- Peak demand and associated stress on distribution networks
- Transformer loading and energy losses
- Inefficiencies caused by rapid charging behaviours.

This impact will be assessed using pilot data on load profiles, local grid behaviour, and modelled future deployment scenarios.

4. **Contribution to local and regional climate targets**:

The environmental analysis estimates how the deployment of ePowerMove technologies supports:

- Municipal carbon neutrality strategies
- EU Green Deal targets
- Local air-quality improvement measures
- Energy transition and decarbonisation pathways.

Impact will be assessed through alignment with regional climate frameworks and projected emission reductions at different scales (site, city, national).

5. **Reduced reliance on fossil fuel-based flexibility**:

V2G-enabled flexibility can reduce the need for conventional flexibility sources, such as:

- Gas-fired peaker plants
- Diesel backup generators
- Fossil-based balancing services.

This contributes to cleaner balancing of electricity demand and supply. The impact will be modelled through avoided fossil-based flexibility capacity and associated emissions.

8.7.2 Assessment approach

The environmental impact assessment combines:

- Measured data (e.g., charging/discharging cycles, renewable energy use, load-shifting performance)
- Modelled projections for larger-scale deployments
- Scenario simulations reflecting different grid mixes, charging behaviours, and renewable penetration levels
- Emission factor–based calculations for quantifying CO_2 reduction impacts.

Together, these analyses provide a robust evaluation of the environmental benefits both during the pilot and at potential scale.

8.7.3 Expected outcomes

The environmental impact assessment is expected to demonstrate the extent to which ePowerMove contributes to:

- Lower emissions and improved air quality
- Greater renewable energy utilisation
- Enhanced grid sustainability and resilience
- Alignment with regional and EU-level decarbonisation goals.

These outcomes will be mapped to ePowerMove KPIs and integrated into the overall impact assessment framework.

8.8 Socio-economic impact assessment

The socio-economic impact assessment examines the broader societal, behavioural, and economic consequences of deploying ePowerMove's bidirectional charging and smart energy management solutions. Unlike technical validation, which focuses on functional system performance, the socio-economic assessment evaluates how the technology affects users, communities, markets, and social systems. The analysis combines quantitative indicators (e.g., cost savings, economic value creation) with qualitative insights (e.g., perception, acceptance, willingness to participate), following the CONVERGE categorisation of impacts.

8.8.1 Key Socio-economic impact areas

1. **User acceptance and behaviour**:

This dimension assesses how individuals interact with and perceive the ePowerMove solutions, focusing on:

- Assessing willingness to participate in V2G schemes and smart charging programs.
- Evaluating user comfort and convenience, including perceived ease of use of apps, interfaces, and charging services.
- Monitoring behavioural changes, such as charging patterns, energy consumption habits, and engagement with incentives.
- Capturing feedback through surveys, usage logs, and questionnaires to quantify satisfaction and identify barriers to adoption.

Data sources include surveys, interviews, app usage analytics, and pilot participation rates.

2. **Economic benefits and cost analysis**:

- Estimating cost savings for EV owners and fleet operators from optimised charging and energy management.
- Identifying revenue opportunities through participation in V2G energy markets or flexibility services.
- Evaluating the broader economic impact, including reduced operational costs for energy systems, potential business creation, and local economic stimulation.
- Considering indirect monetary impacts, such as efficiency gains, reduced downtime, or improved grid utilisation.

Both direct monetary impacts (measured during pilots) and indirect monetary impacts (estimated through modelling) are included.

3. **Social and community-level impacts**:

The broader social implications of ePowerMove deployments include:

- Assessing job creation in the e-mobility, energy management, and renewable energy sectors.
- Evaluating resilience of local energy communities, including the benefits of decentralised energy storage and flexible demand management.
- Understanding public perception and social acceptance of innovative energy technologies and mobility solutions.
- Considering equity and inclusivity, ensuring benefits are distributed across diverse user groups and communities.

This assessment uses qualitative and mixed-method approaches, integrating stakeholder feedback, local context, and policy considerations.

4. **Policy and regulatory implications**:

Given the evolving regulatory environment for V2G and flexibility markets, the socio-economic assessment also examines:

- Compatibility with existing market structures and tariff schemes
- Consumer protection, data privacy, and cybersecurity considerations
- Barriers or enablers for large-scale adoption
- Alignment with EU Green Deal, Renewable Energy Directive, and local energy regulations
- Policy recommendations to support fair, scalable deployment.

The socio-economic impact assessment integrates both quantitative metrics (e.g., cost savings, participation rates, job creation) and qualitative insights (e.g., user satisfaction, social acceptance) to provide a comprehensive understanding of societal value delivered by the ePowerMove project.

8.8.2 Assessment approach

The socio-economic impact assessment applies a combination of:

- **Quantitative analysis**: cost-benefit modelling, financial calculations, usage statistics, revenue estimations.
- **Qualitative assessment**: user surveys, structured interviews, focus groups, and stakeholder workshops.
- **Scenario-based modelling**: estimation of market potential and scaling impacts under different adoption rates, tariffs, and policy frameworks.
- **Cross-impact analysis**: linking socio-economic outcomes with environmental and technical effects (e.g., cost savings derived from improved grid efficiency).

8.8.3 Expected outcomes

The socio-economic assessment will generate:

- Evidence of user acceptance and behavioural drivers
- Quantified user-level and community-level economic benefits
- Insights into market opportunities and viable business models
- Social impact indicators, including inclusivity, accessibility, and community resilience
- Policy-relevant findings that support the scaling and replication of ePowerMove solutions.

These outcomes will contribute to a holistic understanding of how ePowerMove can create societal value, accelerate e-mobility adoption, and foster sustainable urban energy systems.

8.9 Economies of scale assessment

The economies of scale assessment evaluates how the cost-efficiency, performance, and overall value of ePowerMove solutions evolve as deployment expands across wider geographic areas, larger EV fleets, and diversified market contexts. The focus is on quantifying and estimating the economic benefits that emerge from increased scale, technological learning, standardisation, and aggregation of resources. The assessment examines both direct scaling effects observable in pilot deployments and projected long-term impacts based on modelling and multi-scenario analysis.

8.9.1 Key economies of scale impact areas

1. **Reduction in technology and infrastructure costs**:

As deployment volume increases, capital and operational costs are expected to decrease due to:

- Economies of manufacturing scale for bidirectional chargers
- Lower per-unit installation and integration costs
- Standardised hardware and software architectures
- Reduced communication and platform costs through aggregation.

This impact will be assessed using cost benchmarking, projected learning curves, and scenario modelling of charger deployment at district, city, and regional scales.

2. **Improved cost-effectiveness of V2G and smart charging services**:

Scaling up V2G participation enhances the efficiency and profitability of flexibility services by enabling:

- Greater aggregation of EVs for grid services
- Higher revenue potential per aggregated unit
- Improved utilisation of communication and control systems
- Lower transaction costs per kWh delivered or absorbed.

The assessment will use modelling of aggregated fleet behaviour, flexibility value simulations, and cost–benefit analysis at different participation rates.

3. **Enhanced market competitiveness and business model viability**:

Larger deployment scales enable more viable and competitive business models by:

- Reducing fixed costs across more users
- Enabling subscription-based or dynamic pricing models
- Strengthening commercial attractiveness for fleet operators and energy communities
- Supporting new services such as vehicle-based energy storage and local balancing markets.

This impact will be evaluated through market modelling, cost structure analysis, and assessment of business model scalability across urban and regional contexts.

4. **Increased efficiency through standardisation and interoperability**:

Standardisation and harmonised protocols significantly improve scalability by reducing:

- Integration complexity
- Maintenance and operational costs
- Vendor lock-in and system fragmentation
- Risks associated with heterogeneous technologies.

The impact will be assessed through analysis of interoperability KPIs, platform integration requirements, and the use of common standards across pilot sites and projected larger deployments.

5. **System-level benefits from large-scale adoption**:

Large-scale deployment of ePowerMove solutions generates broader system benefits including:

- Improved grid efficiency due to aggregated load-shifting
- Higher renewable utilisation enabled by large-distributed storage capacity
- Reduced need for traditional grid reinforcement
- Greater certainty for investors and policy makers.

This impact will be assessed using system modelling, long-term projections, and comparative analysis of multiple deployment pathways.

8.9.2 Assessment approach

The economies of scale assessment combines:

- Cost data from pilot installations and operational activities
- Learning curve analysis to estimate cost declines as volumes increase
- Multi-scenario modelling for city-, region-, and EU-level deployment scales

- Business model evaluation across different market conditions
- System-level simulations to quantify aggregated flexibility, avoided infrastructure upgrades, and long-term cost efficiencies.

These methods provide a robust analysis of both current cost trajectories and future scaling potential for ePowerMove technologies and services.

8.9.3 Expected outcomes

The economies of scale assessment is expected to demonstrate:

- Reductions in unit costs for chargers, software, and system integration
- Improved economic viability of flexibility and smart charging services
- Stronger business cases for large-scale public and private deployments
- Increased market attractiveness and competitive advantage for integrated V2G solutions
- Significant long-term economic and system benefits from widespread adoption.

These outcomes will be mapped to ePowerMove KPIs and integrated into the overall impact assessment framework.

8.10 Integration and synthesis of impacts (proliferation modelling)

The integration and synthesis phase combines all assessed technical, environmental, socio-economic, and scaling-related impacts to provide a unified understanding of how ePowerMove performs as a comprehensive system. Rather than evaluating each impact dimension in isolation, this section examines how the different effects interact, reinforce, or counterbalance one another. The synthesis focuses on deriving conclusions about the overall added value, feasibility, and long-term sustainability of deploying ePowerMove solutions at scale. This integrated perspective informs stakeholders, such as policymakers, grid operators, cities, and mobility service providers, on the broader implications of bidirectional charging and smart energy management across operational, economic, social, and environmental domains.

8.10.1 Key areas of integrated impact synthesis

1. **Cross-analysis of technical, environmental, and economic performance**:

The integration process identifies how improvements in one domain produce measurable effects in others. Examples include:

- Technical efficiency gains enabling greater CO_2 reductions
- V2G flexibility reducing both grid reinforcement needs and operational costs
- Improved renewable integration lowering energy prices and emissions simultaneously.

This cross-domain analysis will be conducted using combined datasets, correlated KPIs, and multi-criteria evaluation techniques.

2. **Interactions between user behaviour, system performance, and environmental outcomes:**

User acceptance and behaviour directly influence the achievable technical and environmental benefits. The synthesis evaluates:

- How participation rates affect flexibility values and renewable utilisation

- Behaviour-driven variations in environmental impact (e.g., charging patterns)
- Social acceptance as an enabler for large-scale deployment and economies of scale.

This integration highlights the importance of behavioural factors and socio-economic incentives in achieving the expected impacts.

3. **Combined system-level benefits under different deployment scales**:

Scaling up ePowerMove solutions amplifies both technical and environmental impacts and improves cost-effectiveness. The synthesis assesses:

- How aggregated EV flexibility supports large-scale renewable integration
- How cost declines through scale enhance the economic viability of deployment
- How system performance evolves under local, city-wide, and regional adoption scenarios.

This analysis uses multi-scenario modelling to understand cumulative impacts and systemic benefits at increasing scales.

4. **Alignment with regional, national, and EU sustainability and energy goals**:

This section integrates impact results to assess how ePowerMove contributes to broader policy and climate frameworks, including:

- EU Green Deal decarbonisation pathways
- Local carbon neutrality strategies
- Renewable energy and grid resilience targets
- Smart city and sustainable mobility objectives.

The synthesis evaluates how the combined effects of technical improvements, emission reductions, cost efficiencies, and user participation support strategic energy and mobility transitions.

5. **Identification of synergies, trade-offs, and enabling conditions**:

The integration identifies:

- Synergies, such as:
  - V2G improving both grid stability and climate performance
  - Higher renewable utilisation reducing costs and emissions simultaneously
  - Standardisation supporting both interoperability and economies of scale.
- Trade-offs, such as:
  - Increased system complexity requiring robust user engagement
  - Initial investment costs before scalability benefits are realised.
- Enablers, such as:
  - Clear regulatory frameworks
  - Interoperable standards
  - Strong user-centric service designs.

This ensures that decision-makers understand not only the benefits but also the conditions required to realise them.

8.10.2 Assessment approach

The integration and synthesis assessment combines:

- Cross-dimensional KPI analysis
- Multi-criteria assessment frameworks
- Scenario-based modelling outputs
- Stakeholder feedback (cities, DSOs, fleet operators, users)
- Comparative analysis of pilot data and projected future deployment contexts.

These methods allow a holistic interpretation of impacts and ensure consistency across technical, environmental, socio-economic, and scaling results.

8.10.3 Expected outcomes

The integrated and synthesised analysis is expected to demonstrate:

- The combined added value of ePowerMove across all impact categories
- How technical efficiencies translate into environmental and economic gains
- The conditions under which the greatest benefits are achieved
- The readiness of the ePowerMove solutions for large-scale replication
- Clear evidence to support decision-making for future deployment strategies.

These outcomes will be fully aligned with ePowerMove's KPIs, expected results, and contribution to broader EU-level sustainability and mobility objectives.

8.11 Summary

This chapter outlines the planned approach for assessing the impacts of ePowerMove's bidirectional charging and smart energy management solutions. Building on validated results from earlier work packages and drawing on established methodologies from FESTA and CONVERGE, the plan defines a structured framework for evaluating technical, environmental, socio-economic, and scalability dimensions.

The assessment will combine direct measurements from pilot deployments with modelling, scenario-based simulations, and scaling exercises to estimate both immediate and long-term system-level effects. Key performance indicators (KPIs) have been identified to capture the most relevant outcomes, while assumptions, limitations, and data quality considerations ensure the robustness and transparency of the planned analyses.

By integrating data collection, analysis, monitoring, and feedback mechanisms, the impact assessment plan provides a coherent methodology to support decision-making, policy guidance, and strategic planning. The plan also establishes responsibilities, timelines, and procedures to ensure systematic and consistent execution across all pilot sites.

Overall, the ePowerMove impact assessment plan provides a clear roadmap to evaluate the added value, scalability, and sustainability of the project's solutions, supporting evidence-based recommendations for stakeholders and informing the potential replication and expansion of bidirectional charging and V2G technologies.

9 CONCLUSIONS

This deliverable, although public, primarily serves as an internal plan that covers the verification, validation, demonstration planning and impact assessment of the technical developments within the three ePowerMove pilot sites.

The methodology developed for this plan was inspired by the projects FESTA and CONVERGE, as well as other recent projects in which different consortium members have been involved, notably MODALES and eCharge4Drivers. As with those projects, we define verification as verifying whether the outcome works and complies with the specification or requirements. Validation is the assessment of whether the outcome does the job for which it was created. Impact Assessment looks at whether the outcome has the expected impact, higher or lower.

Following this plan, ePowerMove will conduct:

Task 4.2: Site setups and demonstrations running:

- Has been running since M11 (November 2025), but the demonstrations will start in January 2026.
- This will result in D4.2: Pilot site descriptions and demonstrations (lead: UCY, Demonstration, Sensitive, due M34).

Task 4.3: Data consolidation and dashboard:

- Due to start in M18 (June 2026), but will be slightly delayed due to the departure of the task leader and their replacement by a new partner (subject to a Contract Amendment).
- This will result in D4.3: Data consolidation and dashboard design (new partner leading this dataset, Public, due M36).

Task 4.4: Technical evaluation, business impact analysis, and user acceptance, and **Task 4.5: Environmental and economic impacts, and economies of scale:**

- Both to start in M27 (March 2027).
- These two tasks will result in D4.4: The ePowerMove impact assessment (lead: UNIVLEEDS, Report, Public, due M38).

This work, in particular Tasks 4.4 and 4.5, will then feed into **WP5** on **Rollout Acceleration**, starting in M19 (July 2026).

10 REFERENCES

1. Brooke, J. (1995). SUS: A quick and dirty usability scale. ResearchGate, https://www.researchgate.net/publication/228593520_SUS_A_quick_and_dirty_usability_scale
2. CONVERGE project [Maltby, D. et al]. (1998). Checklist for Preparing a Validation Plan: Updated version; project deliverable D2.4.1.
3. CONVERGE project [Zhang, X. et al]. (1998). Guidebook for Assessment of Transport Telematics Applications: Updated version; project deliverable 2.3.1.
4. ePowerMove project [Aliyev, E. et al] (2025). Innovation plan and process. Project deliverable D7.2 (public).
5. ePowerMove project [Hasibar, J. et al] (2025). Data Management Plan. Project deliverable D7.4 (sensitive).
6. ePowerMove project [Hasibar, J. et al] (2026). Data Management Plan (first update). Project deliverable D7.5 (sensitive).
7. ePowerMove project [Jozič, J. et al] (2026). Design and development of a Grid-Charging-RES. Project deliverable D3.1 (sensitive).
8. Featherman M.S. and Pavlou, P.A. (2003). Predicting e-services adoption: a perceived risk facets perspective. International Journal of Human-Computer Studies, Elsevier / ScienceDirect, https://www.sciencedirect.com/science/article/abs/pii/S1071581903001113
9. FOT-Net and CARTRE projects [various authors] (2018). FESTA Handbook, Version 7, https://connectedautomateddriving.eu/wp-content/uploads/2019/01/FESTA-Handbook-Version-7.pdf
10. Venkatesh, V. et al (2012). Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology. SSRN, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2002388