16th ITS European Congress, Seville, Spain, 19-21 May 2025

Guidelines and recommendations for deployment of innovative EV charging infrastructure and services

Andrew Winder*[1], a.winder@mail.ertico.com
John Paddington[1], j.paddington@mail.ertico.com
Montserrat Anglès[2], montserrat.angles@mosaicfactor.com
Angelos Amditis[3], a.amditis@iccs.gr
Pedro Gomes[4], pgomes@polisnetwork.eu
1. ERTICO – ITS Europe, Belgium
2. Mosaic Factor, Spain
3. Institute of Communication and Computer Systems (ICCS), Greece
4. POLIS Network, Belgium

Abstract

This paper provides some guidelines and recommendations pertaining to charging infrastructure and related services for electric vehicles (EVs). It is based on work in the Horizon 2020 project eCharge4Drivers (2020-2024), in particular based on the project's experiences in demonstrating different innovative systems and services in European countries as well as from interviews with public authorities, operators and other key stakeholders in the e-mobility sector.

Keywords:

Deployment barriers, lessons learned, opportunities and impact
Electro-mobility, EV charging.

Introduction

Charging systems for electric vehicles (EVs) and associated services have developed rapidly in recent years, not always in a harmonised way. New innovations and business models, as well as different policy frameworks according to country or city/region, have made the landscape rather complicated, which can be confusing for EV users and a potential barrier to attracting more people to switch to EVs and light EVs (LEVs). The EU-funded eCharge4Drivers project worked on innovations and trials aimed at making charging more user-friendly, including interoperability aspects, journey planning, battery swapping and the provision of charging stations with better user interfaces.

This paper is based on work in eCharge4Drivers regarding regulatory and harmonisation aspects and on recommendations and guidelines for investors and authorities to foster the sustainable deployment of charging infrastructure and services. The recommendations and guidance in this document are derived from experiences

within eCharge4Drivers in developing and demonstrating solutions, as well as from the perspectives of 26 external experts who responded to in-depth interviews.

eCharge4Drivers project background

eCharge4Drivers was a Horizon 2020 project that ran from June 2020 to November 2024, addressing charging-related barriers to the use and market uptake of EVs. The project worked on different innovations aimed at improving the EV charging experience (for car and light vehicle users) within urban areas and for longer trips.

The project developed and demonstrated user-friendly charging stations and innovative charging solutions as well as smart charging services for the users. After capturing users' perceptions and expectations on the various charging options and their mobility and parking habits, eCharge4Drivers organised demonstrations in ten areas across Europe, comprising six urban or metropolitan areas and Trans-European Network for Transport (TEN-T) road corridors in four countries or regions. These demonstrations included charging stations offering different user-friendly and convenient functionalities for EV drivers, including light electric vehicles (LEVs), such as direct payment methods and bigger, user-friendly displays. Other innovation such as battery swapping for LEVs, retrofitting lampposts with charging points, new pricing schemes, a booking service and an EV Charging Location Planning Tool. The project's innovations are illustrated in the figure below.

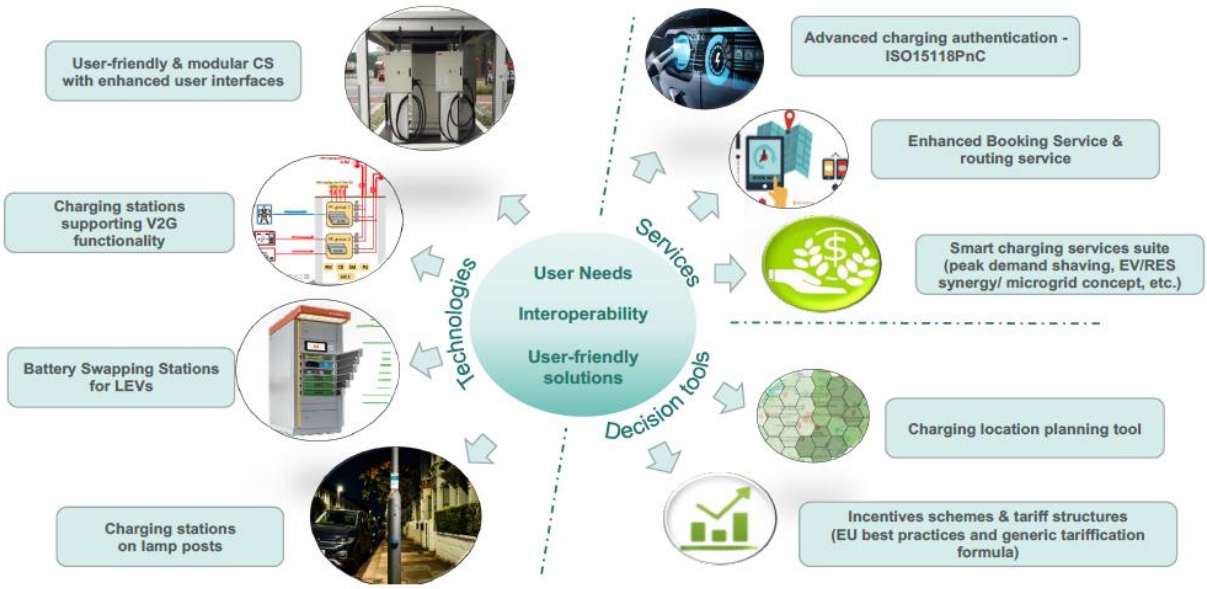

Figure 1: eCharge4Drivers solutions – user-centric, interoperable charging technologies & services

Guidelines regarding charging technologies

User-friendly EV charging stations were developed by ABB and deployed at seven trial locations in six European countries. Some issues encountered included delays to the development due to long delivery times of components and delays in international standardisation of ISO 15118-2 and -20 standards for Plug & Charge due to COVID restrictions during the first half of the project.

The charging stations featured longer and weight-supported charging cables, enhanced physical accessibility (including for wheelchair users), connector identification with unified labels, reliable, accurate metering of energy delivered to the vehicle and large displays (from 7 inch up to a 32-inch screen).

Figure 2: ABB wallboxes (2 AC, 2DC) demonstrated in Bari, Italy

Further roll-out requires close cooperation of players in the e-mobility ecosystem, as well as further standardisation of protocols (in particular for back-office charger management, remote charger monitoring and diagnostics, charging subscription and secure authorisation/payment management, and for roaming.) and interoperability between all EVs and chargers. An enhanced user experience is key, including clear information if it does not work (i.e. the card has expired, or the authorisation server cannot be reached). Early testing of prototypes and early involvement of EV drivers to get 'real feedback' is key to successful development.

Battery swapping for LEVs was trialled in Berlin and Barcelona. Issues identified included securing suitable locations for swapping stations, negotiating contracts with property owners (time-consuming, especially in high-traffic areas with different and sometimes conflicting demands) and ensuring necessary electrical infrastructure at the site. Operational challenges included maintaining availability and reliability of battery stocks, managing logistics on multiple locations, and ensuring consistent user support. Regulatory hurdles include dedicated space for riding (use of bike or bus lanes for LEVs, or not authorised), and battery standardisation. The lack of universal battery specifications across manufacturers adds complexity to the system. Seasonal variations in user demand (more pronounced than expected) meant a need for more robust real-time inventory management and logistics solutions to avoid peak-hour battery stock shortages. Regulation in the e-microscooter sector (limit to the number of scooters and operators in some cities, bans on taking them on public transport) is also a factor.

Figure 3: Battery swapping station in Barcelona

Involvement of local stakeholders and good stakeholder communication is essential, as are modular and scalable infrastructure to support different battery types. Training programs need to be implemented for staff and users to ensure smooth operation and maintenance. To ensure consistency and quality, standard operating procedures should be developed and enforced across all stages of deployment, from site selection to installation and maintenance.

The project installed and demonstrated charging points on lampposts in two municipalities of Grenoble Alpes Métropole in France. This initiative needed political support (more municipalities were interested but due to workload and this not being a political priority, it was only progressed in two). The state of the public lighting network is a key factor: in some cases it is old; also there is a need for a 24-hour power supply (public lighting is switched off during the day and sometimes at quiet periods in the middle of the night). This solution can be more expensive than might first appear, especially with older infrastructure and the need to deal with different agencies, with long preparatory work. Although several suppliers now provide charging on lampposts, this is more common for new lighting infrastructure rather than retrofitting legacy equipment.

Guidelines regarding charging services

Plug and Charge (PnC) based on ISO-15118-2 was trialled at five locations in Europe. The technology and environment complexity made the development and preparation difficult, with delays (e.g. backend-charging station preparation or prepping charging stations and installation of digital certificates). Many internal and external components and systems are involved in the functional chain. Significant cross-company collaboration was necessary (e.g. interoperability and E2E testing, fault analysis). Dependency on other companies testing can delay the deployment process. Charge Point Operators (CPOs) need time to get technical requirements and the ecosystem set up, as there is a lack of stations or vehicles supporting ISO15118.

There is a need to invest in internal testing tools and capabilities, prioritising interoperability with industry-standard protocols, and establishing clear protocols for communication and collaboration with partners. Actors in PnC should have a dedicated person/team expert in ISO and its ecosystem, to negotiate ISO15118. Coverage of PnC-enabled CPOs must be improved.

An enhanced booking service for charge points was tested in Italy and Turkey. This proved complex in terms of charge point occupancy, notifications to users (SMS if app notifications are turned off), and the fact that many charging points are not available for reservation.

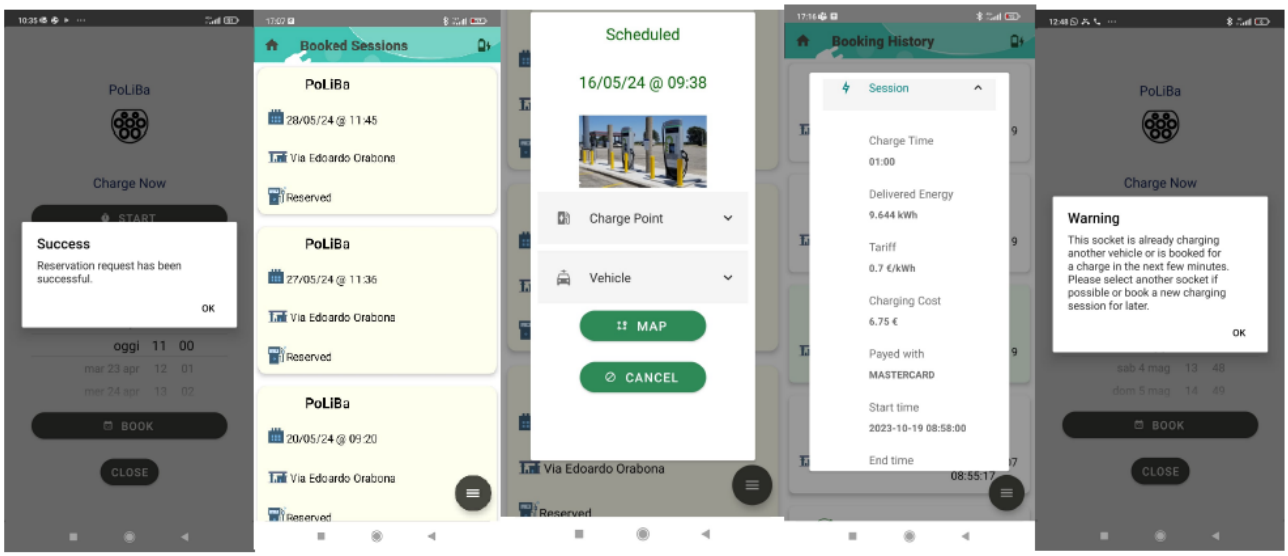

Figure 4: Booking service app

Early and clear communication and collaboration between partners is needed for successful integration and implementation of booking services. Although imminent (short-term) reservations are easier to deploy, bookings further in advance are more complex, with the CPO needing to manage a calendar with all reservation requests coming from different e-mobility service providers, to allow successful long-term reservations. Consistency and quality can be ensured by standardised procedures, regular quality assurance checks, and continuous improvement and accountability.

Guidelines regarding decision support tools

The project developed an EV charging location planning tool. This is aimed at operators and authorities, to determine where charging infrastructure should ideally be located. Challenges included collection of the information needed to run the algorithm in this tool and data regarding current and planned charging points, the structure and distribution of the population and the presence of specific facilities that may attract charging demands (e.g., hospitals, malls, industries). Also, cost estimates not easy to obtain. The cost per charging point depends on several factors such as renting/purchasing the land, required upgrades to energy network, as well as

the charging infrastructure itself. A key requirement is the (online) availability of digitalised data for the area under study.

Identified gaps and recommendations for authorities

The following are derived from a series of interviews with 26 stakeholders, covering 12 countries (Austria, Belgium, France, Germany, Greece, Ireland, Italy, the Netherlands, Spain, Sweden, Turkey and the UK). Most of these respondents (16 out of 26) were from public authorities: 13 city councils, one national government ministry and two public agencies. Seven were CPOs and three were 3 consultancies or universities.

Planning recommendations

- Design guidance should include design for specific zones like heritage areas.
- Location of the charger relative to the parking space should consider that the charging socket can be in different places on the car. This is more of a challenge for parallel (on-street) parking.
- Clearer differentiation in regulations between public street charging and off-street. Regulation affecting off-street charging should mirror good practice on-street, even with public charging on private property (parking facilities for retail, business or leisure facilities, park-and-ride sites, etc) e.g. in terms of signage, accessibility, means of payment and information on pricing, occupancy, etc.
- National regulation in future should focus more on fast charging infrastructure and off-street (or at-home) slow charging, to reduce the need for slow charging infrastructure on city streets, occupying parking space (especially in city centres and other dense urban areas). Care should be taken not to inadvertently encourage EV drivers to enter city centres in order to avail themselves of better charging infrastructure than is available in the suburbs or less trafficked areas.
- CPs should be placed where there is a good mobile phone signal and/or free Wi-Fi, to enable phone payment, functionality of apps, etc.

Electrical recommendations

- National plans and strategies need to foresee the increased need for grid connections.
- New chargers should be capable of smart charging and energy management.
- Harmonisation should be progressed on requirements for a new grid connection between DSOs. Many have their own requirements and processes, which makes it very complex for CPOs.

Operational recommendations

- Where local authorities permit public charging by more than one CPO on their territory, a permit/ licensing system should be to ensure even and fair cover of charging infrastructure, including in areas of lower demand. Demand may be constrained due to lack of charging facilities, as well as relative poverty or low vehicle ownership. For example, some cities in the USA mandate that to install CPs in their city, a CPO has to deploy a certain percentage (e.g. 20%) of them in defined lower-income areas.
- CPOs should share data through a city-wide or (better) national data platform; local authorities need to

specify this in tenders.

- Future integration with public transport and Mobility as a Service (MaaS): this is more a harmonisation action for local and regional authorities, who may have a public transport fare and payment system, car or bike sharing service, etc. (e.g. using a smartcard or app) that could be expanded to allow use for EV charging.
- Dynamic information on availability, price and accessibility is needed: both comprehensive and reliable.

Pricing, payment, parking and enforcement recommendations

- The transparency of pricing, including for combined charging and parking where applicable, needs to be regulated by consumer law. New CPs should allow bank card (credit/debit) payment and there should be no difference in price between payment by this means and using a CPO account (AFIR non-discriminatory pricing clause).
- Where parking is paid for, the pricing should normally be the same as for ICE vehicles, to avoid that EVs use a space just because it is cheap or free, even if they do not need to charge.
- If it is not possible to legally require an EV to charge when parked in an on-street charging station, then an alternative is to use signage that prohibits all parking in that space, with a plate giving an exception for EVs that are plugged in and charging. A tolerance period can be applied from the end of charging until any supplementary fees or penalties start to apply, in zones with limited nearby alternative charging, to avoid users occupying a charging station for many hours, depriving others of charging.

Conclusions

The above suggestions have been derived from experiences within eCharge4Drivers in developing and demonstrating solutions, as well as from the perspectives of the 26 interviewees, as well as consulting with the project's External Interest Group (EIG). They are considered dynamic and will be further refined and validated.

The eCharge4Drivers project did not propose recommendations on grants or financial incentives, as there is no clear best practice. Some countries have used (or are using) these as instruments to foster early EV adoption, but others have ceased such schemes, either due to regulations requiring charging infrastructure for new buildings, because of budgetary constraints or because politically can appear to be a subsidy for richer citizens (EV owners) and does not help those who use public transport, walk or cycle.

Acknowledgement

This content of this paper comes from work carried out by the eCharge4Drivers project consortium. This project has received funding from the European Union's Horizon 2020 Framework Programme, through the European Climate, Infrastructure and Environment Executive Agency (CINEA) under the powers delegated by the European Commission and under Grant Agreement No. 875131. Opinions expressed and arguments employed herein do not necessarily reflect the official views of the European Commission.

References

1. eCharge4Drivers project (A. Winder, M. Anglès et al, 2024). *Regulatory and harmonisation recommendations and guidelines for investors and authorities*, eCharge4Drivers Deliverable 7.2 (EU Horizon 2020 programme)
2. eCharge4Drivers project (J. Roca et al, 2021), *Accessibility requirements, tariff schemes and incentives*, eCharge4Drivers Deliverable 2.2 (EU Horizon 2020 programme)
3. eCharge4Drivers project (E. Karfopoulos et al, 2024), *Report on demonstrations activities*, eCharge4Drivers Deliverable 5.2 – confidential report (EU Horizon 2020 programme)
4. eCharge4Drivers project (E. Karfopoulos et al, 2024), *Evaluation of project developments, impact assessment and guidelines for future superfast charging systems*, eCharge4Drivers Deliverable 6.3 – confidential report (EU Horizon 2020 programme)