eCHARGE 4DRIVERS

Deliverable 7.2

Regulatory and harmonisation recommendations and guidelines for investors and authorities

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TABLE OF CONTENTS

LIST OF TABLES

List of abbreviations and acronyms

Abbreviation	Meaning
AC	Alternating Current
AFIR	Alternative Fuels Infrastructure Regulation (EU regulation)
AI	Artificial intelligence
BMS	Battery Management System
B2B	Business-to-Business
B2C	Business-to-Consumer
B2G	Business-to-Government
CP	Charging Point or Charging Station
CPO	Charging Point Operator
DC	Direct Current
E2E	End-to-End
EC	European Commission
EMSP	Electro-Mobility Service Provider
EPBD	Energy Performance of Buildings Directive
EU	European Union
EV	Electric Vehicle
EVCC	Electric vehicle Communication Controller
EVSE	Electric Vehicle Supply Equipment (Charging Station)
HDV	Heavy Duty Vehicle
ICE	Internal Combustion Engine

Abbreviation	Meaning
ID	Identification
IMP	Incentive Management Platform
ISO	International Organization for Standardization
KPI	Key Performance Indicator
LEV	Light Electric Vehicle
L1e	Light Two—Wheel Powered Vehicle
L3e	Two-Wheel Motorcycle
OCPP	Open Charging Point Protocol
PnC	Plug and Charge
PoI	Point of Interest
RFID	Radio-frequency Identification
SOC	State of Charge
TEN-T	Trans-European Networks – Transport
UX	User experience
V2G	Vehicle-to-Grid
WP	Work package

EXECUTIVE SUMMARY

This document forms part of Work Package 7 (WP7) of eCharge4Drivers: “Guidelines for investors and regulatory recommendations”. It presents regulatory and harmonisation recommendations and guidelines for investors and authorities to foster the sustainable deployment of charging infrastructure and services. It covers the output of two tasks in the project, one on recommendations for regulatory and harmonisation actions and another on guidelines for investors and authorities.

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 the 26 external experts who responded to in-depth interviewees. It also presents information on regulatory frameworks in a selection of European countries.

Harmonisation and regulatory recommendations include design guidance, including for specific zones like heritage areas, clearer differentiation in regulations between public street charging and off-street and more fast charging infrastructure along highways and at destinations to reduce need for slow charging infrastructure on city streets. On the electrical side, an increased need for grid connections should be planned for, as well as smart charging capability. Public authorities should licence operators or operate a permit system to ensure fair and even cover of charging infrastructure, especially in more deprived areas. Integration with public transport and Mobility as a Service (MaaS) is largely missing and should be linked more, both in terms of information and payment means. Dynamic information on availability, price and accessibility is needed and the enforcement of parking/charging stations to prevent their use by non-charging vehicles or over-stayers needs to be stepped up.

Regarding charging technologies, more user-friendly charging stations are needed (display, etc.), which also provide interoperability. A closer cooperation of players in the e-mobility ecosystem is needed to improve customer service.

Charging points on lamp posts is a promising solution but retrofitting lamp posts is not as easy as it may seem, especially for older lighting infrastructure. It needs political support from public authorities and long preparatory work with involvement of the municipal services in charge of public lightning.

Battery sharing for light electric vehicles (LEVs) has proved a promising solution, as demonstrated in Barcelona and Berlin. Upfront planning is needed, particularly in location selection, to ensure accessibility, internet connectivity, and power sources are available. Battery standardisation and interoperability is crucial for scaling up this type of service; in Berlin the solution was to develop modular and scalable infrastructure to support different battery types. Training for staff and users is also important for smooth operation and maintenance, enhancing the overall user experience and service adoption. Standard Operating Procedures should be developed and enforced across all stages of deployment, from site selection to installation and maintenance.

Regarding advanced charging authentication - ISO15118 PnC (Plug & Charge), there is a need for more regulation of interoperability and to invest in internal testing tools and capabilities, prioritising interoperability with industry-standard protocols, and establishing clear protocols for communication and collaboration with partners.

Booking services for CPs are recent and relatively rare but can provide certainty to users and enable better exploitation of the public charging network. For success, early and clear communication and collaboration among partners is needed. Incentives and penalties are needed (and should be clearly communicated) to avoid some drivers misusing the facility (avoiding no-shows, overstaying which blocks the space for the next reserved user, etc.).

1 INTRODUCTION

1.1 Project introduction

eCharge4Drivers is a Horizon 2020 project that ran from June 2020 to November 2024 and carried out by a consortium of 29 partners. Often, charging an electric vehicle (EV) is still not as convenient as refuelling a conventional vehicle, potentially posing a barrier to increase the market uptake of EVs. The eCharge4Drivers project has been working to substantially improve the EV charging experience 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. Using the knowledge generated, the project has proposed an EV Charging Location Planning Tool and guidelines and recommendations, fostering the broad implementation of charging infrastructure in Europe.

1.2 Purpose of this deliverable

This Deliverable is part of Work Package 7 (WP7) of the project: Guidelines for Investors and Regulatory Recommendations. Specifically, its purpose is to present regulatory and harmonisation recommendations and guidelines for investors and authorities to foster the sustainable deployment of charging infrastructure and services.

It covers the output of two tasks in the project, with the following objectives:

Task 7.2: Recommendations for regulatory and harmonisation actions

- Analyse legal gaps and differences in regulations between EU countries that hinder infrastructure expansion in a harmonised way, including enforcement and reserving charging spaces, entities which are allowed to sell energy and any regulations affecting the possibility of bi-directional energy transfer.
- Produce recommendations for a harmonised approach where needed.

Task 7.3: Guidelines for investors and authorities

- Develop guidelines for stakeholders so that their possible investment in charging infrastructure or services is sustainable, covering aspects such as tariff (pricing) structures, sustainable operation of different charging services and additional/ancillary services such as smart charging.

1.3 Intended audience

This deliverable is principally intended to advise public authorities, in particular at regional and local level (cities, counties, provinces, etc.), as well as other organisations deploying or operating Electric Vehicle Supply Equipment (EVSE) and related electro-mobility services (Charging Point Operators – CPOs, Electro-Mobility Service Providers – EMSPs, etc.).

The deliverable is public.

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

This deliverable is structured as follows:

- Chapter 2 outlines the approach to the above tasks (T7.2 and T7.3) and the methodology adopted.
- Chapter 3 provides the results of the 26 interview surveys conducted, concerning regulation and harmonisation issues.
- Chapter 4 summarises EU and regulatory frameworks regarding e-mobility and also national frameworks in eight countries.
- Chapter 5 looks at the return on experience from the ten eCharge4Drivers demonstration sites, including successes and lessons learnt, that can contribute towards deployment guidelines.
- Overall recommendations and guidelines covering all the above aspects are presented in Chapter 6, divided into regulatory and harmonisation recommendations for authorities and guidelines for investors and operators (the latter group including guidelines on charging technologies, charging services, and decision support tools).
- Chapter 7 provides the conclusions of this work.

The work in this report builds on outputs in the following work packages and deliverables:

In WP2: Charging infrastructure and services requirements for a better User Experience:

- **D2.2: Accessibility requirements, tariff schemes and incentives** (public deliverable). This provides a set of requirements to ensure the accessibility and comfortable use of the charging infrastructures by all users paying special attention to users with impairments. It also included an analysis on tariff/ pricing structures and incentives schemes with the aim to provide support to any CPO, MSP or authority to define incentives or charging tariffs.

In WP5: Demonstrations coordination and Implementation

- **D5.2: Report on demonstrations activities** (confidential deliverable). This provides an overview of the demonstration activities performed in the ten demonstration areas of the eCharge4Drivers project. It focuses both on the demonstration achievements per pilot as well as on the user engagement.

In WP6: Evaluation and impact assessment

- **D6.3: Evaluation of project developments, impact assessment and guidelines for future superfast charging systems** (confidential deliverable). This analysed the data collected during the demonstration actives reported in D5.2 above and assessed the performance and impact of the proposed solutions. It provides useful real-life experiences and lessons learned for the innovative project solutions which could interest CPOs, EMSPs, business planners and charging network planners.

In WP7: Guidelines for investors and regulatory recommendations (this work package):

- **D7.1: EV Charging market models** (public deliverable). This developed EV charging market models to allow the results from eCharge4Drivers to be extrapolated to other regions and for future scenarios. This supports the planning of EV infrastructure and policies to see if they are suitable and support the formulation of appropriate strategies. An Agent Based Modelling approach was adopted for this, providing a unique approach to integrate the wide range of requirements in a single model that allows trade-offs between stakeholders.

1.5 Acknowledgements

The contribution of the following external entities who participated in interviews for this topic are gratefully acknowledged:

- Ayuntamiento de Madrid (City of Madrid), Spain
- Berlin Senate, Germany
- BMK (Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology), Austria
- Bordeaux Métropole, France
- City of Edinburgh, UK
- City of Milton Keynes, UK
- Cork City Council, Ireland
- Coventry City Council, UK
- eMO Berlin, Germany
- e-Mobil Baden-Württemberg (eMBW), Germany
- Gemeente Utrecht (City of Utrecht), Netherlands
- Métropole Européenne de Lille, France
- Metz EuroMétropole, France
- ÖĞÜ (Özyeğin Üniversitesi), Turkey
- PPC, Greece
- Roma Mobilità, Italy
- Stad Antwerpen (City of Antwerp), Belgium
- Stockholms Stad (City of Stockholm), Sweden
- Tuncmatic, Turkey
- Urban Foresight, UK
- Watt, Turkey
- YTÜ (Yildiz tekni üni), Turkey

2 APPROACH AND METHODOLOGY

This deliverable represents work in two tasks in eCharge4Drivers, so the approach is presented per task in the following two sub-chapters.

2.1 Task 7.2: Recommendations for regulatory and harmonisation actions

In order to formulate recommendations, information was gathered on the current situation, including successes, barriers, gaps and other issues. This involved two approaches:

- A semi-directive interview survey of 26 stakeholders in Europe, comprising public authorities, CPOs and other experts.
- A desk-exercise collecting the main regulatory frameworks at EU level and in selected countries.

The interview survey aimed to obtain a picture of regulatory and operational issues regarding EV charging across Europe. It targeted external experts, including members of the eCharge4Drivers External Interest Group (EIG). The principal focus was public authorities (city, region, national), as they are the ones mainly dealing with planning, strategy and deployment issues on the ground. Other key stakeholders are CPOs.

It addressed the current practice, any problems/issues, successes, suggestions for improvement, etc. through 39 questions covering the following areas:

- Legal and best practice (existing regulations and whether they are sufficient; mandated data sharing; good practice examples)
- Payment
- Deployment rules and incentives
- EV parking/charging spaces, reservations and enforcement.

Not all respondents were expected to be able to answer all questions: they were invited to focus on the areas where they have knowledge and experience.

The survey was tested with four participants (two in the UK and one each in Germany and Sweden – these four are included in the total of 26 responses). It was refined and simplified as a result, in order to allow interviews to be conducted in about one hour.

Responses are reported anonymously except in the case of purely factual information that is already available in the public domain.

Regarding the regulatory framework, a table was drafted and data was collected for a selection of countries, as well as for the EU level. This table partly complements the interviews and provide a snapshot of existing and known proposed regulations relating to EV charging and associated aspects (e.g. parking, urban planning), and the extent to which commonalities and divergencies exist in Europe.

The subjective feedback from interviewees (what works well, what does not, what problems or gaps exist) are used to formulate recommendations, which were discussed within the consortium and presented to the EIG. These include:

- Regulations and legal gaps regarding energy retailing, EV charging and payment.
- Regulations and legal gaps regarding EV parking/charging spaces, reservations and enforcement, including legal obstacles to enforcement, to dissuade EV users from using a charging space for

longer than is needed to charge or to dissuade non-charging vehicles (e.g. ICE vehicle drivers) from parking in a space reserved for EVs.
- Regulations and legal gaps regarding bi-directional energy transfer for Vehicle-to-Grid (V2G) services.

2.2 Task 7.3: Guidelines for investors and authorities

Leaders of eCharge4Drivers demonstration sites provided feedback on the different technologies and services deployed in their area. This was to ascertain successes as well as less successful experiences, barriers encountered, if or how they were overcome and any lessons learnt.

The feedback requested and provided took the following structure for each service or technology:

- Name of the service and technology and the site(s) at which it was demonstrated
- Challenges and deviations
- Effectiveness: most and least effective solutions
- How effectiveness was measured
- Best practices, insights, lessons learnt and recommendations
- Scaling up challenges and opportunities at regional/national level and at European level
- Scaling up/deployment needs and prognosis in the short-term (1-3 years), the medium-term (4-10 years) and the long-term (11+ years).

Reponses from the responsible partners to the above were then used to propose the deployment guidelines.

3 REGULATION AND HARMONISATION INTERVIEW SURVEY RESULTS

3.1 Respondent profile

A total of 26 interviews were conducted, mostly with external stakeholders but in a few cases with a relevant expert from one of the project partners (e.g. in cases of an eCharge4Drivers partner being a public authority or CPO).

This covered 12 countries: Austria, Belgium, France, Germany, Greece, Ireland, Italy, the Netherlands, Spain, Sweden, Turkey and the United Kingdom.

Most of the 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.
The respondents are listed in the following table. Note that the name of the individual is not given for privacy purposes and that opinions provided by individual interviewees do not necessarily reflect the position of their organisation.

Table 1: Regulation and harmonisation interview survey respondents

Sector	Name of organisation
Public authorities and agencies	• Ayuntamiento de Madrid (City of Madrid), Spain • Berlin Senate, Germany • BMK (Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology), Austria • Bordeaux Métropole, France • City of Edinburgh, UK • City of Milton Keynes, UK • Cork City Council, Ireland • Coventry City Council, UK • eMO Berlin, Germany • Gemeente Utrecht (City of Utrecht), Netherlands • Grenoble-Alpes Métropole, France • Métropole Européenne de Lille, France • Metz EuroMétropole, France • Roma Mobilità, Italy • Stad Antwerpen (City of Antwerp), Belgium • Stockholms Stad (City of Stockholm), Sweden
Charging point operators and service providers	• CEA, France • e-Mobil Baden-Württemberg (eMBW), Germany • PPC, Greece • SMATRICS, Austria • Tuncmatic, Turkey • Watt, Turkey • ZEZ, Turkey
Consultancies and universities	• ÖĞÜ (Özyeğin Üniversitesi), Turkey • Urban Foresight, UK • YTÜ (Yildiz tekni üni), Turkey

3.2 Responses on legal and best practice aspects

3.2.1 Planning regulations

The topic of this question related to parking space design and CP locations aspects. The following is a summary of the responses.

- Charging infrastructure is placed on pavements if the width of the pavement after installation remains at least 1.5m.
- It is not allowed to cross footways with cables (local regulation, not national).
- Regulation only exists for on-street, publicly available EV charging infrastructure.
- At national level, there is only regulation imposing that on-street, a part of parking space dedicated to charging is accessible (and not reserved) to disabled persons (25% when there are 50 parking spots). Also a part of parking space supply must have dimensions (7 to 9 meters of length) to allow long vehicles to park and charge
- The national government have issued draft guidelines on the future accessibility requirements for EV charge points, including both site design requirements and the EV station itself. From a local government point of view, concern was expressed that the retrofitting of existing parking spaces would be more difficult to achieve utilising these standards. This city council suggested that the guidelines should allow some flexibility from the standards particularly on narrow city streets.
- On the national level, the National Electricity Recharge Infrastructure Plan (PNIRE, Italy) implements Directive 2014/94/EU of the European Parliament and Council of 22 October 2014. PNIRE provides mostly general information and the way it is implemented is up to municipalities
- Reservation of the parking spot is arranged by traffic law. The traffic sign for 'parking only for EVs' is also arranged by this law. This traffic sign is also a requirement to be able to fine people if they for example park with and ICE at these spots. Traffic law also stipulates the rules for the parking spots dimensions. For fast chargers there are local guidelines for CP design to ensure accessibility for persons with disabilities.
- No specific regulation other than that relating to electrical installation included in the Low Voltage Electrical Regulations.
- For parking space design there is national government best practice guidance (including for disabled bays) plus Accessible Bay guidance. This is for parking spaces in general and not specific to Charging Stations.
- The city's own design guidance aims to introduce design principles to respect the city's built heritage (historic city). Broader design guidance and specific factsheets for different areas e.g. EV charging on-street provision were done in 2023.
- National level regulations for fire protection for garages, covered parking spaces and parking decks, including additional requirements for charging stations for electric vehicles.
- At national level there is a charging infrastructure regulation. At city/state level there is a "street law" with individual regulations on city district level. For on public street parking /charging, CPOs have a contract with the city that sets technical, design and operational standards.
- The provision of a charge point on a previous permitted parking space is exempt from planning rules, however the construction of new EV charging stations will need planning permission. The planning route depends on the applicant and potential impacts but most are obtained through direct local authority approval subject to some form of public consultation.
- There is a local Order which develops the technical document on basic conditions of accessibility and non-discrimination for access and use of urbanised public spaces.

Respondents were asked if the rules and guidance are sufficient. In most cases, the response was "yes", but with some caveats:

- The deployment of slow charging infrastructure within city limits is temporarily, awaiting fast charging infrastructure along highways and on destinations.

- In the future (5-10 years), the city believes that on-street, slow AC charging will not be needed, and fast charging infra will provide the needs of EV drivers. The city is helping in this transition phase but will remove the chargers when they are no longer required.
- The democratic nature of the planning system, which encourages public participation, can sometimes slow down the delivery of key infrastructure projects.
- Critical issues emerged regarding the authorisation process and the synergy with the energy distribution capacity (DSO). Therefore, a new asset regulation was issued in 2023 to correct these issues, simplifying the authorisation process and planning recharging requirements in accordance with the DSO.
- One respondent (from a city) said regulations are insufficient and they also clash with the lack of standardisation of the location of the charging sockets in vehicles, which prevents the proper design of charging areas for any type of vehicle.
- The design of charging stations depends on where the vehicle plug socket is located (front, rear left or right, etc.), so this might make EV chargers inaccessible.
- Lack of design guidance specifically for charging infrastructure is a black hole in some guidance documents.
- Different design appropriate to heritage/protection/conservation areas would be useful.
- More focus is needed on barrier-free implementation of charging infrastructure.
- Current legislation is already quite complex, but it should be more clearly differentiated between public charging on public streets, and public charging on private grounds (e.g. supermarkets). On public streets the planning and installation process is more complex.

3.2.2 Electrical regulations

Regarding types of socket and cable supplies, respondents mostly cited national regulations in their countries, also the EU's Alternative Fuels Infrastructure Regulation (AFIR). Regulations are generally arranged via programme requirements in tenders. For example, the requirement for Type 2 connectors, and sometimes optionally a Type 3A connector, for standard charging points (22 KW), following standard EN62196-2. Sometimes a CHAdeMO plug is provided, but way less. For fast charging points (>22 KW), type CCS Combo 2. Compliance with OCPP (Open Charging Point Protocol) was also mentioned.

Regarding the Grid connection, there are mostly national/regional rules by grid providers. Some specific points were:

- Mostly 3 phase 3x25A or 3 phase 3x. In the Netherlands, CPs have their own grid connections (not needing a transformation point), which is not so commons in other countries. So, the grid operators provide 'grid connection specifications' and if CPs comply with this, they can get their own direct grid connection.
- There is a national decree on access and connection to electricity transmission and distribution networks and on regulating the activity of providing energy recharging services for EVs. An article of this establishes the methodology for calculating the remuneration for the activity of electricity distribution.
- Technical and organisational rules exist for network operators and users, including technical connection conditions for connection to public supply networks.
- In Berlin, the city's model specifies that Grid connection / capacity must be at least at 150 kW per charge point for fast DC-charging; for slow AC-charging the capacity must be at least at 11 kW per charging point.

As regards electrical regulations for smart charging, most respondents said there are none, or that they were not aware of any. The following exceptions are noted:

- In the Netherlands, all public tenders comply with the NAL guidelines for smart charging. NAL = National Agenda Laadinfrastructuur = National Agenda Charging infrastructure. This is a guideline, not a law, but all public bodies comply with this. Bidirectional charging is not obliged in these

guidelines, but more and more cities and regions in the Netherlands are requiring it in their tenders. It is still at an early stage, but there is much interest.
- In Germany, part of the Energy Industry Act (EnWG) allows a DSO to temporarily reduce the performance of certain devices (heat pumps, wall-boxes, air conditioner, battery storage) which obtain electricity from the grid, if the power grid is threatened. This action will only be taken if it is essential to maintain system stability. A minimum power level is secured at any time. This means that the affected devices can continue to be operated.

Other comments on electrical regulations were:

- A respondent in the Netherlands cited their process whereby a contractor can implement in one single labour process the grid connection on behalf of the grid operator and at the same time also implement the charge point for the CPO, so this increases efficiency.
- A comment on lamppost charging was that the earthing of a trial CPO of the product was refused by the grid due to continuing to trip and turn off traffic lights, due to blocking electricity.

Two respondents said the current electrical requirements are sufficient, one said that they define the necessary roles and requirements but do not specify all requirements in every detail, and another said that requirements for grid connections will increase.

A response from Germany stressed the importance of obtaining harmonisation on the requirements for a new grid connection between all DSOs. In Germany more than 800 DSOs are active in operating a low voltage grid. Many of them have their own requirements and processes which makes it complex for CPO.

A response from the Netherlands said that something needs to be arranged regarding low consumption rates, because the city has a contract with an operator and that operator has a contract with the energy supplier and grid operator. There is a need to put grid-conscious charging on top of that.

A response from Spain highlighted the large interoperability gap, e.g. having to have a different app for each CPO/EMSP. They had to replace chargers in some locations, as these were not capable of smart charging and energy management

3.2.3 Operational regulations

Reponses on safety requirements were limited, e.g. regarding grid connection specifications from the grid operator, as well as highlighting existing safety norms, cybersecurity etc. as required in programme tenders. Specific safety requirements usually exist for petrol station sites.

For accessibility and inclusively requirements, including payment, the European AFIR was quoted by some respondents, usually as a basis for national regulations. There are national laws on universal accessibility or on the rights of persons with disabilities and their social inclusion.

Sometimes a city specifies the colour of the CP (e.g. grey). Street design in the Netherlands (CROW guidance) includes how to design/implement and charging spot in the public domain. The NKL (national knowledge institute for charging) provides a set of specifications for programme requirements in tenders. Cities/authorities can pick and choose from this. In the UK, the British Standards Institute (BSI) is currently releasing a kite mark (standard/certification) for accessible chargers and accessible parking bays. Many cities require that a certain number of CPs fulfil certain accessibility standards.

On the topic of data sharing requirements, there were diverse responses:

- National authority e-Control provides register for charging grid.
- Obligation to share data with city through API (all of the mentioned data fields). Double approach (demand-driven for the initial installation and then data-driven for further deployment).

- National regulation: obligation of publication in open data of CPs accessible to the public on a national website.
- In Ireland: Zero Emission Vehicles Ireland (ZEVI) is tasked to create a unifying interoperability data platform for all charge point operators. This strategy is still under development.
- A shared national data platform exists onto which all public charging data goes.
- In Spain: national Order regulating the information to be sent by energy recharging service providers to the Ministry for the Ecological Transition and the Demographic Challenge and to other regional communities/authorities.
- National back-office and public authorities have access to their data, but sometimes data is patchy, with reliability issues. Sometimes energy given to customers but not metered and therefore does not show up on back-office.
- Berlin Model: CPOs have to deliver static and dynamic data; more details are currently developed; quarterly reports are required.

Some other operational requirements were also mentioned:

- Requirement for regional/local governance to manage the delivery of EV charge points because of the risk that the private sector may only concentrate in the high demand locations, leaving the lower demand (and often poorer) areas to be subsidised by the state. There may be a need for a permit/ licensing system.
- Maintenance standards on CPOs apply.

Most respondents considered that current operational regulations are sufficient, but with the following comments:

- From the point of view of CPOs, timelines and permitting should be streamlined, as well as location planning.
- Future integration with public transport and Mobility as a Service (MaaS) would be desirable.
- Mobility managers of companies should attract more people towards EVs, working together with energy companies.
- One said that official information on the location of charging has not yet been made available to users. There is no information e.g. on availability, price, or accessibility.
- In Austria, a charging point data regulation is currently being worked on which will include the obligation to transmit dynamic data.

3.2.4 Operation of Charging Points

In most cases, there is no restriction on who can operate a CP, but in general they require a licence, especially in public places. They are only allowed to operate a CP on street if commissioned by the local authority / highway owner.

If payment is required, there often needs to be a back office, which limits who can provide charging points. They need to comply with banking regulations for contactless payment. In the UK, a regulated energy provider (for supply) can provide an independent connection or via third-party premises where the charger is located. In Berlin, a CPO cannot be a DSO.

3.3 Responses on payment aspects

3.3.1 Price calculation

In nearly all cases, energy use is billed per KWh and per minute. Two respondents cited a fixed starting fee. One said their city offers a monthly subscription model (€49 per month) which includes 80 kWh of charge per month.

Respondents noted that usually car parking is priced separately from EV charging. Two respondents mentioned a surcharge for overstaying: in one case this “occupancy fee” is applied if the vehicle is still parked at the CP 30 minutes after having been fully charged. In another, a surcharge applies if the user stays more than one hour after the end of the charge.

Feedback on this topic was as follows:

- Pricing/billing should be transparent and based on kWh consumption.
- Price on charging duration (besides price per kWh) encourages vehicles rotation.
- Respondents have had feedback that some EV drivers dislike the fact that parking and charging have to be paid for separately: they feel that they should pay only once for both of these services (or that one of them should be free).
- The occupation fee (for overstaying) needs to be high enough to avoid misuse of reserved parking spaces. The inconvenience is that it discourages smart charging. For data connection between CPO, EMPS and the city, everyone uses OCPI (which have limited data fields), there is no way to translate relevant data like occupancy rate/fee, and every EMSP uses their own approach to fully deploy the occupancy fee, which is a huge limitation.
- Consideration of future pricing with a “post-charging package”: once charging is complete, if the vehicle has not left after a given time, there should be an automatic alert from the operator to the user. For spaces dedicated to charging, the “post-recharge package” occupancy fee which will apply. Several candidates to one city’s call of Expression for Interest proposed this system.
- Charging regime is usually set by the public authority. There can be challenges with contactless card payments which are operated by a petrol retailer BP, as this does not go through the national payment back-office.
- In Austria, e-Control (the independent electricity and gas regulator) monitors the charging prices available in Austria an compares them.
- Price per kWh and an additional blocking fee seems to be appropriate and can easily be compared by the user. Everything else (session fee etc.) makes the process more complex.

Finally, around 70% of respondents stated that they are aware of the European Alternative Fuels Infrastructure Regulation (AFIR).

3.3.2 Requirements for payment means and tariff/pricing display

Six respondents said that CPs in their areas required the option to pay by credit/ debit card, with a further one saying this is imminent. In the UK, any new charger above 7.1 kWh needs to have a contactless (tap and go) card payment option. Sometimes bank card payment by scanning a QR code on the charger is possible.

Four respondent said that pricing details are fully available before charging, with another saying this happened previously but no longer. Digital screens to display costs were considered good practice but not always available (makes CPs more expensive). Few said that consumption was shown in real time on the charger, with more saying this information is on an app.

3.3.3 Issues/ problems

Most respondents did not have any major issue with one-off/ ad-hoc payments, or did not know of any problems. One was aware of criminals placing stickers with false QR codes for payment on top of the genuine ones on the charger.

Some operators still require a user on their platform to unlock the charging point, but in general cities wish to avoid users being required to use a CPO’s app.

One CPO said that the new AFIR payment options for ad hoc charging and the insufficient interpretation / description of these new standards are a problem for many suppliers, as development of such new products takes time, the certification process needs time, and it is costly for all actors.

Few issues were mentioned with regard to access to public paid-for charging points not allowing roaming. One said that although CP interoperability is compulsory, sometimes it does not work in practice: it can happen that charging cards of other networks do not work on the city's charging points (and vice-versa) even though agreements between networks exist.

Most did not see a need for any regulation or best practice on discounts offered to users (for example similar to discounts some groups of citizens get on public transport, due to age, income, disability, etc.)

Most were not aware of any CP/ EMSP provider accounts that allow payment for other services, except for some that combine parking and charging. One mentioned a Car Club, which delivered 20 chargers and another ~18 to come, but these are exclusively for use of the Car Club subscribers.

3.4 Responses on deployment rules and incentives

3.4.1 Public incentives or subsidies

For home charging, the availability of incentives and subsidies differ. Oten there are financial grants or tax exemptions, usually at a national level. For example, in Italy there is a grant of up to 80% of the purchase cost of CPs for private homes (€1500 maximum for individual homes and €8000 maximum for apartments). There is no such scheme in Belgium, as national company car incentives cover this. In a few cases, such subsidies or incentives used to exist but have been discontinued.

For public charging, this is usually done by a call for tender / service concession. There are often central government grants e.g. in the UK, the Local Electric Vehicle Infrastructure Fund is a £350million pot of money from government to aid local authorities and their EVSE partners to roll out on-street standard (7kwh) chargers.

For charging on the premises of commercial enterprises, educational bodies, etc. the picture is mixed. Sometimes subsidies depend on accessibility to the public for charging. Sometimes there is a grant for eligible places of work (e.g. in Italy, Ireland, Spain, Austria and the UK) but a respondent in France said this was considered but refused by legal advisors, as it was considered as unfair aid to the private sector. But sometimes technical support is provided, rather than any financial incentive or grant. In Berlin there is support for SMEs wishing to buy an EV, charging stations and grid connection costs, or for consulting services in e-mobility, however the German scheme at national level (charging stations for private businesses) has been discontinued.

3.4.2 Requirements to install charging stations

Nine respondents confirmed that the installation of charging stations is mandated in places such as workplaces, residential areas, leisure or retail centres, railway stations or park-and-ride sites. In three cases this was for new developments only and in six cases there was a requirement to retrofit certain existing facilities.

3.5 Responses on EV parking/charging spaces, reservations and enforcement

Regarding parking enforcement actions, in most cases a fine / penalty notice is issued, with towing away also taking place (as for normal parking violations): fine only in seven cases and towing an option in five. One respondent said there is no solution yet in their city.

In the UK, Traffic Regulatory Orders (TROs) can be enforced on EV bays. However, due to the low adoption rate of EVs when charging infrastructure was first installed, retroactive application of these can be a challenge. There is also a penalty for EVs occupying a CP but not plugged in. However, there can be an issue when the amount of the penalty is less than the cost of a full day's parking (e.g. in city centres where on-street parking is expensive).

One respondent said that the chances of getting caught are too small for regulations to be effective. Enforcement via scan cars and sensors is sometimes used by enforcement agents, collecting multiple violations (connected and not charging, over staying cars etc.). Some cite a lack of municipal police officers for this, as they have other more important priorities.

Ground detectors have been tried to ascertain whether a space is actually occupied or not. But there were technical problems, it did not always work well and the link between the CPO and the city police was not ideal. Sensor technology is however being looked at by more cities. Training enforcement agents was a question raised by one respondent. Sometimes municipalities that are part of a wider metropolitan authority do not have the political will to implement means to control (charging under the responsibility of the metropolitan authority but police and enforcement under local control).

There is a difference between countries where enforcement can only be done by the police and those that have civil enforcement officers (e.g. from the city council or a private company contracted by the city). Officers may have handheld readers linked to the back-office charging system. Drivers are notified if they are fully charged or their time is up on their app, with a grace/tolerance period before any penalties start.

Sometimes parking signage had to be adapted, or in the absence of regulations, the EV charging bay was made a no stopping/no parking zone, but with an exception for EVs that were plugged in and charging.

Most CPs do not allow advance reservations, and indeed did not see a need for reservations. One said this was considered but this would require setting up inductive loops, so investment. The costs and more restrictive arrangement meant they did not retain this option for now.

As part of USER-CHI (parallel EU project to eCharge4Drivers), Roma Mobilità experimented with the INCAR app for booking and reservation. In Spain, a respondent said that reservations exist in privately-operated car parks. The person reserving pays a deposit. In the case of a no-show, they lose the deposit and the space is released. A surcharge applies to anyone who blocks the spot. In Germany, the CPO Qwello offers a “reserveNOW” function, which allows users to block a CP for 15 minutes until the user arrives at the CP to plug in (comparable to reserving a car-sharing EV). In other places, where services in underground car parks are provided by a CPO, there is the option to reserve up to 24 hours in advance.

3.6 Other comments

One CPO said that too many regulations within short time period makes it hard for CPOs to save their investment.

When it comes to public charging in cities, Antwerp has worked with mobile (transportable) charging solutions like UZE to reduce the need to install too many chargers (public space pressure).

A comment from Spain was that the public charging network offers prices that are much higher than domestic charging (land costs, equipment amortisation and industrial profit), which is a social problem for users who do not have a private place to charge at home. The intervention of public administrations in the deployment clashes, due to a lack of coordinated planning, with private initiative, so that there are areas without coverage and others with excess supply. The warnings from all car manufacturers about the convenience of low-power charging generate uncertainty about the opportunity to deploy fast charging infrastructure.

A comment from the UK was that commercial rules make procuring CPOs using frameworks are almost impossible due to a £5.2 million contract value limit. There are currently no frameworks or dynamic purchasing systems known that allow for procuring providers when the value of the contract will exceed this value. This makes responding to funding bids significantly more difficult.

One issue mentioned was different EVs having socket ports in different parts of the vehicle. One CP for two vehicles did not allow rapid charging for both, so there was a need to migrate to single CPs.

There is nothing yet for e-mopeds and the creation of mobility hubs (car and bike charging, etc.) would be beneficial.

Bi-directional charging is currently being pursued intensively in Germany; discussions are also starting in Austria on this topic.

One stated that the involvement of interest groups in the project and (price) regulation would be desirable.

In Berlin, 15% of all transactions are done via ad hoc charging; 85% happen with an EMSP contract. Berlin has published an overall strategy for their charging infrastructure plans; they may consider implementing Plug & Charge (PnC) at their Berlin Model Charging stations (currently under discussion). Dynamic pricing might become a topic for CPOs in the future.

4 REGULATORY FRAMEWORKS

A desk study was carried out to summarise the regulatory frameworks relating to electro-mobility at EU level, at national level in a selection of seven European countries, and also a brief overview of some examples of legislation in the USA.

4.1 EU regulatory framework

At European Union level, the main overarching policies pertaining to electro-mobility are contained in the following:

- **EU 2030 Climate and Energy Framework**: Strategy published in 2014 containing climate and emission reduction goals. The original goal was to reduce GHG emissions by 40% (from the base year 1990) in all sectors by 2030. From 2022, the Fit for 55 package raises the GHG emission reduction goal to 55%.
- **Paris Agreement**. Ratified by the EU in 2016 and specifying climate and emission reduction goals. The overarching goal is to keep the increase in global average temperature to well below 2°C above pre-industrial levels.
- **European Green Deal**. Strategy initiated by the EU Commission in 2019 and giving climate and emission reduction goals and measures. The overarching goal is to make the EU climate neutral by 2050.
- **EU White paper on transport**. Published in 2011 by the EU Commission and giving climate and emission reduction goals in the transport sector, aiming for a competitive and sustainable transport system.

As mentioned by some of the questionnaire respondents in the previous chapter, the **Alternative Fuels and Infrastructure Directive/Regulation (AFID/AFIR)** of 2014 is a major specific piece of EU legislation aimed at public charging infrastructure, technical requirements, pricing and fast charging. It is effective since October 2014 (and currently under revision), and specifies technical and operational requirements for public charging and H2 (hydrogen) refuelling infrastructure. The current revision foresees:

- Regulation instead of Directive Note: as a regulation, new policies are immediately effective in all EU member states – no regionally specific changes can be made as a directive would allow.
- Targets for minimum number of charging points and power output along TEN-T network for passenger and heavy-duty vehicles according to the number of EVs in each EU member state.
- Ad-hoc payment via NFC at public DC-chargers (>=50kW)
- Price transparency at charging stations for ad-hoc charging.

The **Clean Vehicle Directive** (2019/1161/EU) focuses on emission reduction and aiming to promote the procurement of low- and zero-emission road vehicles in the public sector by setting minimum targets for new purchases. In addition to purchasing, the directive also includes options such as leasing, renting or hire purchase. Quota for passenger/light duty vehicles: 38.5%; for heavy duty vehicles: 10% (until 2025), 15% (as of 2026); for buses: 45% (until 2025), 65% (as of 2026).

The **Ambient Air Quality Directive** (2008/50/EC) sets specific pollutant limits that must not be exceeded. In case of non-compliance, the EU member states/cities/municipalities must develop air quality action plans with remedial measures. These action plans often address the transport sector.

The **Energy Performance of Buildings Directive – EPBD** (2018/844/EU, under revision) deals with private charging infrastructure and technical requirements. This aims to reduce the energy consumption and to increase energy efficiency of new buildings and buildings under renovation. Facilitating/installing

charging infrastructure is one aspect. The revision proposal foresees a lower threshold when buildings need to prepare parking facilities with cables/pipes and charging infrastructure.

The **Renewable Energy Directive** (2018/2001/EU) covers private charging infrastructure, smart charging and EV data. This Directive foresees a significantly increased EU-wide renewables target of at least 42.5% in final energy consumption by 2030. For the EU transport sector, the following applies:

- The renewables target will be raised from 14 to 29% by 2030 (alternative: 14.5% CO_2 reduction by 2030)
- Access to battery data of EVs (including battery capacity, state of health, state of charge, power set point) by the vehicle manufacturer
- Smart charging capability of private normal-power chargers.

The **Regulation on CO_2 emission performance standards for passenger cars and light duty vehicles** (2019/631/EU and 2023/851/EU), focusing on emission reduction. This sets CO_2 emission standards for new passenger cars and new light commercial vehicles. It replaces previous regulations and foresees gradually increasing CO_2 emission reduction goals for fleets: by 2030: -55% (passenger cars) and -50% (light-duty vehicles) (base year 2021); by 2035: -100% (passenger cars & light duty vehicles), i.e. quasi phase-out for new ICE vehicles by 2035.

The **Regulation on CO_2 emission performance standards for heavy duty vehicles** (2019/1242/EU and 2023/851/EU), covering emission reduction and e-trucks. The revision proposal of the current regulation 2019/1242/EU foresees an increase in emission reductions for HDVs: by 2040: -90% CO_2 emission reduction (base year 2019); e-fuels and biofuels are not counted in reaching this target (only electro-mobility and hydrogen are counted).

Finally, the **Data Act** (under development), which aims to facilitate the access and usage of machine-generated B2B/B2C/B2G data by establishing a fair data-economy and promoting standardisation /interoperability.

4.2 National regulatory frameworks

4.2.1 Austria

At a high level, Austria's **2030 Mobility Master Plan**[1] is the national strategy showing shows ways to avoid, shift and improve traffic and to significantly increase the share of eco-mobility consisting of walking and cycling, public transport and shared mobility.

Technical requirements are covered by the Federal law establishing uniform standards for the infrastructure development for alternative fuels (Bundesgesetz zur Festlegung einheitlicher Standards beim Infrastrukturaufbau für alternative Kraftstoffe). This law, based on EU legislation (RL 2014/94/EU) regulates the rights and obligations of charging point operators as well as technical specifications for publicly accessible charging points.

With regard to the grid connection and integration of charge points in the electricity system, EIWOG 2010, the Electricity Industry and Organisation Act (Elektrizitätswirtschafts- und-organisationsgesetz 2010) defines the CPO not as an electricity company but as an end consumer. It defines "public charging" and gives the technical requirements on the setup of public chargers.

[1] Republic of Austria, Federal Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology (2021): https://www.bmk.gv.at/dam/jcr:eaf9808b-b7f9-43d0-9faf-df28c202ce31/BMK_Mobilitaetsmasterplan2030_EN_UA.pdf

The **Trade Regulation Act** (Gewerbeordnung [GewO] 1994) deals with CP operation, whereby the commercial operation of charging points is a free trade, hence no certificate of competence is required to operate a charging point.

Pricing is covered by the **DLG Services Act** (Dienstleistungsgesetz). This provides regulations for the display of prices by both the CPOs and e-mobility providers. Calibration of charging points is regulated by the Calibration law (Eichrecht Österreich), under which each charging station needs to be calibrated every ten years.

Building charging infrastructure is covered by the Building Regulations of the federal states. At state level, building law in particular serves as a legal instrument to promote the installation of charging points. Each of Austria's nine federal states has its own regulation.

Private charging infrastructure is subject to the **Home Ownership Act** (Wohnungseigentumsgesetz - Novelle 2022). This facilitates the installation of wall boxes for tenants and owners in a community of owners, since the landlord or a community of owners cannot refuse the installation without reason. Fire protection for garages, covered parking spaces and parking decks, including requirements for charge points, is subject to the regulations of the Österreichisches Institut für Bautechnik (Brandschutz bei Garagen, überdachten Stellplätzen und Parkdecks).

In addition, there are several technical requirements at national level in Austria, as follows:

- OVE/ÖNORM E 8016:2012-01-01: Electrical installations - house connections, main lines, measuring equipment.
- OVE E 8101:2019-01-01: Installation regulations for low-voltage electrical installations.
- OVE E 8101/AC1:2020-05-01: Low-voltage electrical installations (Corrigendum).
- ÖVE/ÖNORM/EN 61008/9: Residual current operated circuit-breakers without built-in overcurrent protection (RCCBs) for domestic installations and similar applications.
- Verteilerzertifikat EN 61439: Distribution certificate.
- DIN EN 61851-1: Nominal resistance values and states of charge
- Elektrotechnikverordnung (ETV 2020): Safety of electrical systems and equipment and other systems within their sphere of influence.
- OVE-Richtlinie R 5:2010-10-01: Operating and maintaining the proper condition of electrical systems by laypersons (specifications for systems with rated AC voltages up to 230/400 V installed for use by laypersons).

4.2.2 Germany

The **Master Plan Charging Infrastructure II** is a comprehensive action plan at Federal level, containing 68 (non-binding) measures to accelerate the expansion of charging infrastructure. The measures are mostly on coordinating responsibilities, connecting stakeholders and overarching goals and address aspects such as grid integration, bidirectional charging, charging for e-trucks, funding measures, data access, approval processes, examining potential support for smart/bidirectional charging.

The German **Charging Station Regulation** (Ladesäulenverordnung), based on AFID/AFIR, includes technical requirements, e.g. to require a payment card terminal for charging points as of July 2024. It also gives a definition of public charging and technical requirements on the set-up of a public charger.

The **Pricing Regulation** (Preisangabenverordnung) determines that at all public charging stations the ad-hoc charging price (CPO-price) must be in kWh. The price must be easily visible to the user at the charging station. This will probably be adjusted as soon as AFIR is effective.

The **Metering and Calibration Law** (Mess- und Eichgesetz) determines that at all charging stations where electricity is sold to the user based on kWh, the metering system must be calibrated.

The **Energy Industry Act** (§14a Energiewirtschaftsgesetz) allows DSOs to reduce load for wall-boxes, heat pumps and other controllable consumption system, if the user agrees. In return, the DSO reduces the grid fees of the user. Currently the German Grid Agency (Bundesnetzagentur) is developing a more progressive regulation, which may also enable dynamic pricing models to incentivise user behaviour which prevents the intervention of the DSO. This could be the basis for **smart charging** services.

The **Building Electromobility Infrastructure Act** (Gebäude-Elektromobilitäts-Infrastruktur-Gesetz - GEIG) determines threshold at which number of parking lots of a new or renovated building cables and other relevant infrastructural requirements need to be fulfilled. The current German law is above the minimum of EU regulation (EPBD).

The 38th Ordinance implementing the **Federal Emission Control Act** (38. Bundes-Immissionsschutz-Verordnung) set the THG-Quota which obliges mineral oil companies to offset the CO_2 emissions caused by their fossil fuels. The reduction of CO_2 emissions is set centrally by the federal government and increases every year. The current rate is 7% and is expected to increase to 25% by 2030. CPOs and owners of private and commercial electric vehicles can benefit from the THG-Quota and receive money for the saved CO_2 emissions.

The **E-Mobility Act** (Elektromobilitätsgesetz, EmoG) serves as the basis for granting special privileges to EVs in public traffic, such as their own free parking spaces, and enables the vehicles to receive specific e-licence-plate required for this purpose.

The **Fast Charging Act** (Schnellladegesetz) creates the legal basis for the Europe-wide tendering of a Germany-wide network of a total of 1,000 HPC fast charging locations through the Federal Government.

The **Low Voltage Connection Ordinance** (Niederspannungsanschlussverordnung, NAV) regulates the general grid connection conditions in the low-voltage area, under which the DSOs have to connect the end consumers to the low-voltage grid. Charging stations for EVs must be notified to the network operators before they are put into operation and need the permission of the DSO if their power exceeds 12kVA.

The **Homeownership Modernization Act** (Wohnungseigentumsmodernisierungsgesetz, WEMoG) facilitates the installation of wall-boxes for tenants and owners in a community of owners, since the landlord or a community of owners cannot refuse the installation without reason.

The **Measuring Point Operation Act** (Messstellenbetriebsgesetz, MsbG) deals with metering, grid integration and smart charging. It regulates the roll-out/installation and operation of intelligent measuring systems.

4.2.3 Greece

At the overall policy level, the **National Energy and Climate Plan** provides the general directions and national targets for the EV deployment in Greece.

The key masterplan in the e-mobility domain is the **Law 4710/2020 for the promotion of the e-mobility in Greece**. This regulates the rights and obligations of charging point operators and sets the incentive directions for the promotion of the electro-mobility in Greece.

Subsidies are covered by:

- Kinoume Ilektrika, which is an **incentivisation programme** to promote EV sales and the deployment of charging stations in Greece. Three programmes have been announced by the government so far (2020, 2022, 2024) to subsidise the purchase of EVs and the installation of charging infrastructure.
- Fortizo Pantou, which comprises subsidies for the promotion of the deployment of **public EV charging infrastructure**.

In terms of technical guidelines and requirements:

- Ministry decision ΦΕΚ Β' 4380/5.10.2020 provides **technical guidelines for municipalities** in order to perform their e-mobility plans.
- Common Ministry Decision ΦΕΚ Β' 2040/4.6.2019 defines the terms, requirements and technical specifications for the **installation of charging stations**.

4.2.4 Ireland

At the overall policy level, the **Climate Action Plan 2024** is the third annual update to Ireland's Climate Action Plan. It lays out a roadmap of actions aimed at Ireland meeting its national climate objective of pursuing and achieving, by no later than the end of the year 2050, the transition to a climate resilient, biodiversity rich, environmentally sustainable and climate neutral economy. It aligns with the legally binding economy-wide carbon budgets and sectoral emissions ceilings that were agreed by the Irish Government in 2022.

The **EV Infrastructure Strategy 2022-2025**, published by the Department of Transport, sets out the ambition and strategy for the delivery of a national EV charging network, and the practical steps that will be taken to deliver this network across the country. This includes a pool of high-powered chargers every 60 km on Ireland's motorway network as well as home and apartment charging, destination charging and residential neighbourhood charging (including new mobility hubs). It takes a people-first approach, focusing on the different transport needs across the country and is being informed by the piloting of different technologies and charging options in Ireland. The **Implementation Plan** of this strategy provides an initial set of actions and deliverables to support the strategy's delivery. This includes the development the **National Road Network EV Charging Plan** focusing on the national expansion of the charging network on motorways, TEN-T and National roads. and the **Regional and Local EV Charging Network Plan** which provides a pathway for the accelerated delivery of regional and local networks of public EV charging infrastructure in cities, towns and villages across Ireland, in line with both national and European ambitions for cleaner transportation.

Once the feedback from the consultations for the National Road EV Charging Network Plan and Regional and Local EV Charging Network Plan has been incorporated, they will be combined and published as the **National EV Charging Network Plan**. The consolidated national plan will ensure all gaps are addressed across national, local roads, local high-power infrastructure, and remote areas. Includes the TEN-T motorway network, DC Fast and Ultrafast charging in structure and light duty and heavy-duty vehicles along with destination and neighbourhood charging infrastructure.

Electric Vehicle Charging Infrastructure Universal Design Guidelines have been published, covering user needs, charging station design, site design, information and communications. It includes an overview of international best practice, focusing on the UK, Germany, Sweden and the USA.

Regarding **funding schemes**, there are the following in Ireland:

- EU Just Transition Fund in Ireland 2021-2027, managed by the three Regional Assemblies in Ireland and including a Community Facilities EV Charging Scheme, established to provide funding for the cost of installing CPs at a variety of community facilities across the EU Just Transition Fund territory.
- EV Purchase Grant Scheme
- Electric Small Public Service Vehicle (eSPSV) Grant Scheme
- Home Charger Grant Scheme
- Apartment Charging Grant Scheme.

4.2.5 The Netherlands

In the Netherlands, although there are few national regulations regarding e-mobility, the Dutch government has signed the **Climate Agreement** (Klimaatakkoord) to have only sustainable transport in the country by 2050. To manage this, the **NAL – National Charging Infrastructure Agenda** (Nationale

Agenda Laadinfrastructuur) was established in 2019 with the main task of synchronising the rollout of EVs and infrastructure (charge points and grid, including smart charging, cybersecurity, etc.).

Furthermore, there are several Dutch funding opportunities for EVs for private users and companies/employees, for electric buses and trucks.

4.2.6 Turkey

At the strategy level, the main governmental action plan is the **2019-2020-2023 National Smart City Strategy and Action Plan**. The Turkish Ministry of the Environment, Urbanisation and Climate Change stated in 2019 that, in accordance with the aim to expand the EV charging station network, the issue of installation and expansion of stations will also be evaluated within the scope of 2020-2023 National Smart City Strategy and Action Plan.

Two main **non-governmental roadmaps** also exist, developed by **SHURA Energy Transition Center**. SHURA was founded by the European Climate Foundation (ECF), Agora Energiewende and Istanbul Policy Center (IPC) at Sabancı University, and contributes to decarbonisation of the energy sector via an innovative energy transition platform. It caters to the need for a sustainable and broadly recognised platform for discussions on technological, economic, and policy aspects of Turkey's energy sector. SHURA supports the debate on the transition to a low-carbon energy system through energy efficiency and renewable energy by using fact-based analysis and the best available data. Taking into account all relevant perspectives by a multitude of stakeholders, it contributes to an enhanced understanding of the economic potential, technical feasibility, and the relevant policy tools for this transition:

- Transport sector transformation: Integrating electric vehicles into Turkey's distribution grids.
- Net Zero 2053: A Roadmap for the Turkish Electricity Sector (Net Sıfır 2053: Türkiye Elektrik Sektörü için Yol Haritası).

In terms of **national regulations**, there are:

- **Electric Vehicle Charging Stations** (Elektrikli Araç Şarj İstasyonları), dealing with charging infrastructure.
- **Regulation on the Amendment of the Parking Lot Regulation**, 2018 (Otopark Yönetmeliği). This amendment prepared by the Ministry of Environment, Urbanisation and Climate Change, requires at least 5% of the construction permit applications for new buildings with a compulsory parking lot of 20 or more spaces to be arranged in accordance with EVs, including charging units. In addition, at least 10% of the parking lots in new public car parks and shopping mall car parks should be arranged in accordance with the relevant standards for EVs. Lastly, one unit in shopping mall car parks larger than 30,000m^2 and at least two units in shopping mall car parks larger than 75,000m^2 are required to comply with fast charging capacity. This regulation, which has only partially entered into force, has expanded and increased the number of parking spaces of new buildings in the areas where EV parking will be located.
- **Regulation Amending the Type Zoning Regulation for Planned Areas**, 2013 (Planli Alanlar İmar Yönetmeliği) which deals with accessibility of built environment and buildings. This was the very first legal regulation regarding the structuring of charging infrastructure "in order to charge the vehicles operating with electric energy, electric vehicle charging stations can be constructed in parking lots, gas stations or other appropriate locations with the relevant electric institution's opinion in favour." This enables EV charging stations to be constructed without the necessity to alter a construction plan. However, there are two issues with this article; one is that the term "relevant electric institution" had not been defined in any legislation and in practice it leads to ambiguity. Secondly, the criteria for obtaining an opinion in favour from the relevant institution is not made clear. Therefore, on what grounds an opinion in favour will be given is a matter of debate.

With respect to **standards**, there is the Turkish Standards Institute (TSE) Standards TS 13912: **Electric vehicle charging assemblies and stations - Installation and safety requirements**. Two separate

standards for electric vehicles and charging systems were published by TSE in 2021. The first standard was called "Electric Vehicles and Electric Vehicle Charging Systems - Basic Terms and Definitions", which homogenises the basic terms and definitions used in relation to electric vehicles and charging systems. The second standard, named "Electric Vehicle Charging Units and Stations - Installation and Safety Requirements", became the first regulation to standardise the technical criteria for the safe installation of EV charging stations in Turkey. This standard specifies the design and installation of low-voltage electrical installations that connect wired (conductor) charging systems with a rated frequency of 50 Hz or 60 Hz, a rated voltage up to 1000 V aa or up to 1500 V da, for charging electric vehicles. It includes safety requirements for mounting and verification, charging methods, and guidance on location selection.

4.2.7 United Kingdom

The UK's **Climate Change Act** of 2008 defines net zero target for the year 2050.

More specifically for electro-mobility, the **Electric Vehicles (Smart Charge Points) Regulations** 2021 deals with EV private charge points which are sold for use in a domestic or workplace environment and smart cables (defined as an electrical cable which is a charge point and is able to send and receive information). It covers smart functionality, including the ability to respond to signals to increase the rate or time at which electricity flows through the charge point, demand side response services and a user interface. It also covers electricity supplier interoperability, allowing the CP to retain smart functionality even if the owner switches electricity supplier and allowing continued charging even if the charge point ceases to be connected to a communications network. Safety provisions are also included, as well as a measuring system, to measure or calculate the electricity imported or exported and the time the charging lasts, with visibility to the owner of this information. Security requirements are consistent with the existing cyber security standard ETSI EN 303 645. It incorporates pre-set, off peak, default charging hours, allow for a randomised delay function, and provides a statement of compliance and technical file, and a record of all sales for 10 years from the date at which the legislation comes into force.

The UK Government's **Public Charge Point Regulations** 2023 is an Act that distinguishes between all charging points, sets targets for availability of charging points (99% reliability), requires contactless card payment for above 8kW chargers, requires roaming, open data and makes a helpline available. It stipulates open data in OCPI format and requires that a maximum price per kWh be displayed.

Non-governmental guidance in the form of the British Standards Institute (BSI) specification PAS 1899:2022 **Electric vehicles – Accessible charging** – covers design, placement, streetscape and information concerning CPs. In this specification, "Low-powered" refers to CPs with a power rating of 22 kW and below, "High-powered" refers to CPs with a power rating above 22 kW.

Other relevant Acts (laws) are:

- **Highways Act**, 1980, dealing with the creation of highways (in the UK a "highway" is any public road, not just motorways), maintenance and improvement of highways, the construction of bridges and tunnels, access, lawful and unlawful rights and damage with respect to streets and highways, new streets, private streets and financial provisions. Section 162 of this Act prohibits cabling across a road.
- The **Town and Country Planning (General Permitted Development) (England) Order**, 2015, which defines what requires planning permission, including what public authorities can and cannot do (especially around advertising consent).
- **Traffic Signs Regulations and General Directions**, 2016, including definition of signage for EV charging for cars and motorbikes and of marking on street for EVs.
- **Equality Act** 2010, giving equality and inclusion requirements.
- **Highway Code**, 2022, providing rules and guidance for usage of roads. Rule 239 sets out a requirement to park close to charger and avoid creating trip hazard.

- **Building Regulations** – Part S: Approved Document: I**nfrastructure for the Charging of Electric Vehicles**, which defines requirements for electric charging points in buildings. This regulation has superseded certain local guidance. It specifies CPs for new homes which have an associated parking space. Also, for residential building being renovated and which have over 10 parking spaces, they must have one CP per associated space per dwelling, along with cable routes for rest of parking spaces. New and renovated non-residential buildings with more than 10 parking spaces must have one parking space and a cable route (no charger) for 20% of the spaces. Chargers must be at least 7kW rated.

In terms of **standards**, there are:

- Smart Electric Vehicle Charging Testing and Certification (BSI – British Standards Institute). This provides a testing and certification approach - including Kitemark (certification mark) and assesses EV charger safety against risk criteria such as electric shock, fire, overheating, safety in operation, and mechanical hazards.
- BS EN IEC 61851 Electric vehicle conductive charging system and BS EN IEC 61851-1 General requirements, 2019, defines four charging modes.
- BS 7671 Requirements for Electrical Installations and IET Wiring Regulations, 2018 + A1: 2020, cover safe and authoritative installation.
- BS 8300 Design of an accessible and inclusive built environment, BS 8300-1 External environment. Code of practice, 2018, and BS 8300-2 Buildings. Code of practice, 2018. These codes of practice cover accessibility of built environment and buildings.
- BS EN 61386-24 Conduit systems for cable management – Particular requirements: Conduit systems buried underground, 2010. Requirements and tests for cables underground (both electrical and telecommunication).

Guidance documents also exist, e.g.:

- Public Procurement of Electric Vehicle Charging Infrastructure and Services, Transport Technology Forum, November 2023. This procurement approach provides guidance on how to procure EV charging infrastructure by public bodies. It discusses commercial approaches, requirements and high-level outline of Invitation to Tender documents.
- Starter Guide to Electric Vehicle Charging Infrastructure Rollout for Local Authorities, Transport Technology Forum, November 2023. Guidance document for local authorities on EVSE installation.
- IET Code of Practice for Electric Vehicle Charging Equipment Installation, Fifth Edition, 2023. Covers EV charger installation, inspection and testing, vehicle as storage.

4.2.8 United States

Much of the regulatory framework in the USA is defined at State level. This section gives a brief overview of some of the Federal and State regulations and is not in any way intended to be comprehensive.

At **Federal level** there are:

- The **Americans with Disabilities Act (ADA)**. This prohibits discrimination against people with disabilities in everyday activities.
- The **National Electric Vehicle Infrastructure (NEVI) Formula Program**. This is a funding programme, with conditions of funding being, for example, multilingual support, general ADA compliance, continuous (24/7) availability of CPs, supporting contactless charging, supporting pricing by kWh and requiring data availability via an API. DC charging requires a CCS Type 1 plug, minimum 150kW. AC Charging requires a J1772 plug, minimum 6kW.

At **State level**, some examples are:

- **Electric Vehicle (EV) Parking Space Regulation** (California). Specifies that a driver may not park a vehicle within any on- or off-street parking space specifically designated by a local authority for parking and charging EVs unless the vehicle is an EV fuelled by electricity. Eligible EVs must be in the process of charging to park in the space. A person found responsible for a violation is subject to traffic violation penalties.
- **Electric Vehicle (EV) Charging Station Open Access Requirements** (California). EV charging station service providers may not charge a subscription fee or require membership for use of their public charging stations. In addition, providers must disclose the actual charges for using public EV charging stations at the point of sale; allow contactless payment and pay-by-phone payment methods; they must install the Open Charge Point interoperability billing standard on each EV charging station; and disclose the EV charging station geographic location, schedule of fees, accepted methods of payment, and network roaming charges to the National Renewable Energy Laboratory. From July 2024, DC fast charging stations must also include Plug-and-Charge payment capabilities.
- **Electric Vehicle (EV) Charging Access** (California), concerning open access to public CPs. Municipalities may not restrict the types of EVs, such as plug-in hybrid electric vehicles, that may access an EV charging station that is public, intended for passenger vehicle use, and funded in any part by the state or utility ratepayers.
- **Electric Vehicle (EV) Fee** (Alabama). Requires EV owners to pay an annual fee in addition to standard registration fees. Owners of fully electric vehicles must pay an annual fee of $203 and plug-in hybrid electric vehicle owners must pay an annual fee of $103. EV fees increase by $3 every four years. A portion of fees contribute to the Electric Transportation Infrastructure Grant Program, which provides grants for EV charging stations.

Note that this last example is largely because in the US, fuel (gasoline/petrol) taxes are hypothecated for road expenditure, so the growth of EVs would reduce the State's budget for maintaining roads. Some other states impose a pay-per-distance road user charge on EVs for this purpose.

5 FEEDBACK FROM PROJECT DEMONSTRATION SITES CONTRIBUTING TO GUIDELINES

This chapter contains the feedback provided by leaders of eCharge4Drivers solutions ad demonstration sites. It is organised by the different technologies and services deployed and tested, in one or more of the ten eCharge4Drivers demonstration sites. These successes and lessons learnt contribute to the deployment guidelines.

5.1 User-friendly EV charging stations

Responsible partner: ABB

Table 2: Feedback from demonstration of User-friendly EV charging stations

Service:	User-friendly EV charging stations	
Demonstration sites considered	**EV charging demonstrations** • Barcelona (ES) • Zellik (BE) • Innsbruck (AT) • Milan (IT) • Bari (IT) • Athens (GR) • Istanbul (TR)	**EV charger tests** • Barcelona (ES) • Gothenborg (SE)
Challenges and deviations	• Delay in charger development due to long delivery times of components. • Delay in definition of services and prep of the demo sites. • Delay in international standardisation of ISO 15118-2 and -20 standards for Plug & Charge due to COVID • ISO 15118 Plug & Charge planned to be ready by 2021-2022 > still not mature in 2024.	
Effectiveness	**Most effective solutions** • Longer and weight-supported charging cables. • Physical accessibility also for wheelchair users. • Connector identification with unified labels. • Reliable, accurate metering of energy delivered to the EV.	**Least effective solutions** • Plug & Charge (unclear standardisation) • Large displays (from 7 inch up to a 32-inch) • Reservation (unclear business model for CPOs)
Measuring effectiveness	Customer feedback from CPOs	
Best practices, insights, lessons learnt & recommendations	**1) Intuitive and user-friendly UX (user experience)** • Intuitive charge session and authorisation with RFID/payment to avoid EV driver complaints to CPO's helpdesk (increased manpower and costs for CPOs)	

Service:	User-friendly EV charging stations
	• Provide clear information if it does not work (i.e. the card has expired, or the authorisation server cannot be reached) to increase success rate. **2) Interoperability of EV and chargers is more complex than expected** • Adjusting technical implementation to the protocol standards does not work: intensive testing and fine-tuning is required. • Independent testing and certification bodies involved to ensure that a new vehicle or charger is interoperable with the existing ecosystem. **3) Cooperation of ecosystem** • Close cooperation of players in the e-mobility ecosystem is crucial to make the system work and lead to customer satisfaction. **4) Lean methodology** • Clear functionality definition all together • Early testing of prototypes • Early involvement of EV drivers to get 'real feedback'. **5) CharIN Trade Association: key stakeholder** • Effective to discuss all aspects of the deployment process of charging cars and heavy-duty vehicles, from technical specifications to certification, from charge site geometry to charger power (and funding) level segmentation. • Key organisation in the European legislation on e-mobility. **6) Protocol standardisation** • For charging • For back-office charger management • For remote charger monitoring and diagnostics • For charging subscription and secure authorisation/payment management • For roaming.
Scaling up: Challenges and opportunities	**Regional/National level** • Ensure interoperability between all EVs and chargers **European level** • Support interoperability by European legislation requiring new vehicles and chargers to be tested and certified by accredited test houses and notified bodies. Avoiding barriers from regional/national regulations: i.e. legal metrology is strongly national/regional function, hampering the roll-out of charger networks. European regulations can harmonise the situation in individual countries like the AFIR (Alternative Fuels Infrastructure Regulation) from the EC.

Service:	User-friendly EV charging stations
Scaling up/deployment needs and prognosis	**Short-term** (1-3 years) • Enforce EU EV certification and chargers to ensure interoperability, and support emergence of sufficient test houses in all countries. **Medium-term** (4-10 years) • Learn from market experiences and improve European-level regulations like the AFIR and MID/MIR (Measurement Instruments Directive/Regulation). **Long-term** (11+ years) • Stimulate usage and sharing of EV and public transport instead of fossil-fuel driven individual vehicles, in urban environments. This will save precious materials (steel, battery components, etc.) and space in cities (cars parked for +90% time and occupy an enormous amount of space), as well as requiring less charging infrastructure if vehicle sharing and public transport is encouraged.

5.2 Battery swapping

Responsible partner: Swobbee.

Table 3: Feedback from demonstration of Battery swapping

Service:	Battery swapping
Demonstration sites considered	• Berlin
Challenges and deviations	• Securing suitable locations for swapping stations. • Negotiating contracts with property owners. • Ensuring necessary electrical infrastructure at site. • Operational challenges: maintain availability and reliability of battery stocks, managing logistics on multiple locations, ensuring consistent user support. • Regulatory hurdles around speed limits, dedicated space for riding, and battery standardisation. • Lack of universal battery specifications across manufacturers difficult interoperability between battery technologies, adding complexity to the system and causing delays, requiring additional adaptations. • Location scouting and contract negotiations with property owners were time-consuming, especially in high-traffic areas where accessibility and logistical demands were greater than planned. • Seasonal variations in user demand (more pronounced than expected) > need for more robust real-time inventory management and logistics solutions to avoid peak-hour battery stock shortages (even if forecasting models anticipated demand fluctuations). • Unexpected regulatory changes required more dynamic operational responses and adaptive strategies to mitigate impact, e.g. ban on e-scooters on public buses and trains due to fire safety concerns, reducing potential for integration with public transport.

Service:	Battery swapping	
	• reduction in number of rental e-scooters permitted within Berlin's S-Bahn Ring limited market capacity, complicating deployment.	
Effectiveness	**Most effective solutions** • Designing stations to host different battery technologies to mitigate lack of standardised batteries across manufacturers, serving more vehicles. • Securing suitable sites through location scouting and early stakeholder engagement, minimising installation delays.	**Least effective solutions** • Relying on existing PT infrastructure for integration with e-scooter sharing.
Measuring effectiveness	Analysed KPIs: • Uptime of the swapping stations. • Rate of successful battery swaps without user issues. • Customer satisfaction ratings. • Operational: battery availability and health monitoring. • Real-time data: battery usage, demand patterns, user feedback to track system efficiency. • Battery interoperability: number of different vehicle models successfully using the swapping stations without technical issues.	
Best practices, insights, lessons learnt & recommendations	• **Flexibility** in technology and operations is critical. **Battery interoperability** as crucial factor for scaling e-mobility services. • support different battery technologies to adapt to market's **fragmented landscape** and cater to more vehicles. • real-time tracking and inventory management systems essential in handling the **fluctuating demand** for batteries during peak hours. • Need for greater agility in responding to external factors, like regulation and user behaviour. • Importance of proactive stakeholder engagement, especially with local authorities and property owners, to navigate regulatory hurdles and secure strategic locations. Early and open communication helped mitigate delays in site selection and approval process. • Need for modular and scalable solutions-battery stations must be adaptable to different technologies, and scalable as demand grows. • Critical role of user experience in adoption: providing training and responsive customer support to get trust and satisfaction.	
Scaling up: Challenges and opportunities	**Regional/National level** • Government incentives and regulatory frameworks need to be aligned to encourage private sector participation.	**European level** • Priority: interoperability of battery swapping stations across borders. Need for standardisation of battery

Service:	Battery swapping
	• Subsidies or tax breaks for businesses investing in battery sharing. • Public-private partnerships to set up battery swapping or charging stations in high-demand areas. • Complex negotiation: multiple local authorities, delaying deployment timelines. technologies and regulatory requirements and tariffs for electric mobility services. • Opportunity: develop a unified European network of battery swapping stations that allows users to access services seamlessly across countries. • Barrier: regulatory disparities (varying safety standards and licensing requirements). • Critical for scaling: collaboration with EU bodies to streamline regulations and encourage adoption through EU-wide policies.
	Key technical areas: battery standardisation and interoperability, for battery swapping stations. Developing universal battery packs that fit different vehicle models to enhance scalability and user convenience. Integration of enhanced booking and reservation systems for public charging infrastructure to improve UX, real-time availability data, and seamless payment options. Opportunity to leverage advanced AI and predictive analytics to better forecast battery demand and optimize logistics. But critical to ensure data privacy and cybersecurity as reliance on cloud-based and connected systems increases.
Scaling up/deployment needs and prognosis	**Short-term** (1-3 years) • Opportunity: expanding network of battery swapping stations and enhanced booking services in urban areas. Demand for micro mobility services (e-scooters and e-bikes) and focus on reducing urban emissions offer a favourable market. **Medium-term** (4-10 years) • Advances in battery technology (higher energy densities and faster charging capabilities) to improve service efficiency and UX. The integration of renewable energy sources into charging infrastructure will be a priority to enhance sustainability. **Long-term** (11+ years) • Battery technology developments could reduce need for frequent battery swapping. Could be a shift in demand towards shared mobility services rather than individual ownership of L1e vehicles reducing demand for battery swapping or current micromobility services. Businesses will need to diversify their service offerings: integrating EV services or focusing on last-mile logistics solutions. • Potential threat: regulatory changes prioritising larger-scale EV infrastructure over micromobility solutions.

5.3 Charging points on lamp posts

Responsible partner: GAM (Grenoble Alpes Métropole).

Table 4: Feedback from demonstration of lamp posts

Service:	Charging points on Lamp Posts	
Demonstration sites considered	• Grenoble Alpes Métropole (Varces Allières et Risset and Claix municipalities)	
Challenges and deviations	• Need for political support: 7 municipalities participated in workshops, however with the workload of their technicians already being high, and the fact that the trial, although interesting, was not considered a priority, only 2 municipalities finally participated. • State of public lighting network: some municipalities did not want to participate due to old public lightning network. • Need 24-hour power supply: public lighting is switched off during the day and sometimes at night (at least 01:00 to 06:00). Only 1 out of 6 points available night and day. The only one still in use. • Lack of availability of electrical plans containing number of light points per cabinet, length of cables between cabinet and lamp post, location of day/night contactors, diameter of electrical conduits. • Electricity bills: cities afraid of paying for electricity consumption and not being able to re-invoice GAM. • The fact that only two municipalities participated meant a reduction in the total number of charging points from that initially foreseen. • Process delays: • Lack of electricity plans for one municipality. • No offer on first consultation (installer selection); a second consultation was needed. • Charging point cannot read RFID card of GAM network. Recent cards could be read but not first-generation cards. Solution: inviting users with first generation cards to use the app to charge; then (mid-2024), CP software modified to be able to read also first-generation cards. • Difficulties in connection to the building: drilling of slabs and walls, routing on metal structure under roof, expensive. Alternative: connection to the electrical cabinet outside building, technically feasible and less expensive.	
Effectiveness	**Most effective solutions** • Connecting to the electrical cabinet directly instead of the lamp post itself to get 24 hr power supply. • Additional consultant service to complete lacking information from electrical plans. • Electricity bills: service contract between GAM and cities.	**Least effective solutions** • Remote management is too expensive to control power supply to leave network powered 24 hrs a day. • Passing a 2nd cable through the sheaths, but cluttered even after using a specific vacuum cleaner.

Service:	Charging points on Lamp Posts
Measuring effectiveness	• Operational feasibility • Acceptable cost
Best practices, insights, lessons learnt & recommendations	• Need to have political support from public authorities. • Some technical solutions not adapted (expensive). • Need of anticipation, long preparatory work with involvement of the cities. • Involvement of services in charge of public lighting.
Scaling up: Challenges and opportunities	**Regional/National level** • Same challenges as above. **European level** • Not known.
Scaling up/deployment needs and prognosis	**Short-term** (1-3 years) • Many difficulties reduced the scope of the experimentation but willing to expand the experiment. **Medium- and long-term** • Not known.

5.4 Plug & Charge

Responsible partners: IDIADA, BMW, Hubject, ZES.

Table 5: Feedback from demonstration of Plug & Charge

Service:	Plug & Charge
Demonstration sites considered	• Zellik (BE) • Innsbruck (AT) • Milano (IT) • Istanbul and western Turkey region (TR) • Athens (GR)
Challenges and deviations	• Technology and environment complexity: difficult development and preparation causing delays (e.g. backend-charging station prep or prepping charging stations and installation of digital certificates). Many internal/external components and systems involved in functional chain. • Short timeline. Deployment on charging infrastructure slower than expected. • Dependencies on vehicle dev process: maturity of external partners (CPOs, mobility operators, EVSE manufacturers). • Cross-company collaboration necessary (e.g. interoperability and E2E testing, fault analysis). Dependency on other companies testing, delayed deployment process. • Time delays: different setups for CPOs with third-party backend-system (not PnC-enabled).

Service:	Plug & Charge	
	• ISO15118-2 complexity > CPOs need time to get technical requirements and ecosystem setup. Lack of stations or vehicles supporting ISO15118. • Integration with Hubject, required custom processes and extensive research = additional time and resources. • Technical restructuring and changes in the software team, needing a restart of the project. • Lack of testing tools, needing reliance on external teams for testing.	
Effectiveness	**Most effective solutions** • Testing iterations > recognise implementation issues and identify and deploy solutions in TLS Handshake, TCP communication, and ISO15118 technology. • ISO15118 core elements maturity communication by "of the shelf"-SW-Stacks. • Cross-company test-events (mainly CharIN or bilateral) for interoperability testing. • Collaboration with key-partners of the PnC-ecosystem (Hubject, Ionity, DCS, EA) to support certificate handling, technical and consulting advice. • Clear comms channels and regular meetings with partners = efficient problem-solving and align deployment goals. • Extensive research, detailed requirements and flexibility to changes (i.e. need to change technical structure and SW team) to overcome setbacks and progress towards deployment goals.	**Least effective solutions** • E2E-Quality and robustness are dependent on different market players. Improving robustness = coordination effort. • Inadequate testing tools for ISO15118 compatibility and integration with existing charging infrastructure = deployment delays and inefficiencies. • Relying solely on another company's testing capabilities = dependencies and delays in verification phase, lower deployment effectiveness.
Measuring effectiveness	• Re-testing and checking the correct implementation with technical norms. • Dashboards with usage data and error rates. • Completion of Integration Milestones: finalisation of back-end integration for ISO15118 Plug & Charge feature, as tangible measure of progress and effectiveness in addressing technical challenges. • Feedback from stakeholders (internal and external): on functionality and performance of deployed solutions to assess effectiveness in meeting project objectives.	

Service:	Plug & Charge
	• Deployment Timeliness: comparing to initial project timelines = insights into efficiency of implemented solutions to overcome deployment challenges. • No explicit measuring, but different follow-up or ad-hoc consultation sessions.
Best practices, insights, lessons learnt & recommendations	• Obtaining procedures for the validation of the Plug & Charge technology, the list of test cases, and the check sheets for the analysis of the technology. • PLC between EVSE and EVCC according to ISO15118 more robust than communication between EVSE and EVSE-BE. • In some cases, ISO-standard more aligned with a customer's perspective and needs. • High importance of seamless UX/UI for Plug & Charge on all touchpoints (App, vehicle, EVSE, EMSP), as well as error handling (UX/UI, diagnostics, etc) and to manage the certificates. • Value for the customer is limited by coverage of enabled charging stations. • Dedicated person/team expert in ISO and ecosystem. • Implementation without longer breaks. • Deployment of ISO15118 Plug & Charge feature is challenging > importance of thorough research, clear communication with partners, and adaptability in changing technical structures. • Unexpected changes in technical structure and software team caused restart of the integration process > contingency plans and agile project management approaches needed. • Deployment need validation procedures from IDIADA and implementation Guidelines from HUBJECT. • Solutions open to all market partners to accelerate coverage and ensure a seamless customer experience. • Platforms for cross-company-collaboration regarding testing and quality. • Need regulation of interoperability between PKIs and ecosystems > more complexity if more players pushing into the market with different ecosystems not compatible with each other. • Hubject offers EVSE-checks for the PnC implementation to support CPOs and EVSE-OEMs and ensure a proper implementation. • Invest in internal testing tools and capabilities, prioritising interoperability with industry-standard protocols, and establishing clear protocols for communication and collaboration with partners.
Scaling up: Challenges and opportunities	**Regional/National level** • Spain: invest in installation of further charging points that can be managed by PnC-able CPOs. • Turkey: collaborate with industry partners and regulatory bodies to establish standardised testing protocols **European level** • European Ecosystem for managing a PKI to avoid monopolisation of digital certificates by one entity. • European PnC. Or semi-public use cases for PnC. • Ensure ecosystem interoperability (e.g. PKIs and

Service:	Plug & Charge
	and certification processes for ISO15118 compatibility. Pools) > to limit complexity since memory for root certificates is limited. • Harmonised regulations **and interoperability** standards across European countries to facilitate tech integration and adoption.
	• Future of this tech depends on entrance and integration of multiple PKIs and the use of cross-signed certificates to expand an enhanced UX integrating EV charging payment. Otherwise, market is limited to one ecosystem, limiting interoperability and monopolising management of payment methods. • Coverage of PnC-enabled CPOs must be improved. • Interoperability of ecosystems must be ensured. • ISO15118 = implementation is open to interpretation. Clarification on grey zones would be useful but needs to be aligned in a standardisation group. • Developing testing tools for ISO15118 compatibility, enhancing interoperability with existing charging infrastructure, streamlining integration process with partners like Hubject.
Scaling up/deployment needs and prognosis	**Short-term** (1-3 years) • Expanding charging infrastructure. • Enlarge coverage of CPOs. • Leverage semi-public use cases. • Ensure reliability and robustness above state of the art. • PnC deployment based on ISO15118 to ensure cybersecurity, crucial with adoption of e-mobility and roll out of public charging infrastructure, making multi-contract handling possible. • Additional regulations on usage of contract certificates between partners be necessary (already discussing in EU STF group). • Increased industry collaboration and awareness-building efforts, • Regulatory hurdles and technological limitations. **Medium-term** (4-10 years) • After expansion of CCS charging infrastructure is solved, PKIs need to be diversified. • Number of CPOs and MOs need to increase and adapt to enhanced payment service. • Develop PnC as a standard-Payment method. • + EVs and EVSEs and CPOs/EMPs supporting PnC EV-users = seamless and secure way of charging in public. Commercial vehicles = service will become more important for easy and secure charging. • Opportunities: advancements in testing tools and interoperability standards • Threats: market fragmentation and competition.

Service:	Plug & Charge
	Long-term (11+ years) • PnC = standard for passenger + commercial vehicles. • Opportunities: ISO15118 PnC technology adoption and streamlined charging processes • Threats: disruptive innovations and shifting consumer preferences.

5.5 Enhanced booking service

Responsible partners: ZES, POLIBA

Table 6: Feedback from demonstration of Enhanced booking service

Service:	Enhanced booking service	
Demonstration sites considered	• Region of Istanbul and western Turkey region • Bari (ITA)	
Challenges and deviations	• Difficulties with the platform's native language support > reminders and notifications designed for customer convenience. • The need to add business rules to the command used in stations > not initially anticipated, requiring additional development effort. • Difficulty in advancing the process due to platform limitations was unforeseen, leading to delays in deployment. • Issues with socket occupancy affecting customers' reservations and potentially leading to penalties. Solutions: socket occupancy checks and notifications to ongoing chargers. • Need to inform customers via SMS when notifications turned off, requiring additional Comms strategies. • Absence of regulatory challenges = smoother deployment process in terms of compliance. • Find available charging points for booking > ABB CPs developed not enabled for reservation as expected and main local CPOs are not in the project consortium (postponing test and demonstration, reducing demo and data collection period). • Small issues during connection through Hubject to the involved CPO for reservation but easily solved.	
Effectiveness	**Most effective solutions** • Implementing business rules to the reservation system > greater flexibility in managing reservations, adapting reservation system to specific requirements. • Designing reminder and notification processes > enhanced UX, communicating reservation status to customers.	**Least effective solutions** • Penalty for occupied sockets: proved ineffective and potentially detrimental to customer satisfaction. Created frustration for customers and did not effectively resolve issue of socket occupancy. • Reliance on SMS notifications: not an efficient solution. Some customers may not have appreciated receiving

Service:	Enhanced booking service
	• ABB not supporting booking service solved by involving external CPO (Eurolink Systems) located in Rome with wall-box enabling reservation and installed at the University campus in Bari to test the service. . notifications via SMS, especially if they had turned off notifications for the app. This solution could have led to confusion and inconvenience for customers.
Measuring effectiveness	• Successful test of the service proved being interoperable, offered through the Hubject platform. • Customer feedback: Monitoring customer satisfaction and feedback on the reservation system and notification processes. • Reservation usage: Tracking number of reservations made and successful completion to assess usability and effectiveness. • Reduction in penalties: solution implemented to address penalties for occupied sockets resulted in a decrease in penalties incurred by customers. • App engagement: app usage and engagement metrics to determine effectiveness of notification processes in keeping customers informed and engaged.
Best practices, insights, lessons learnt & recommendations	• Ensuring all actors are involved and active in the process and all necessary equipment ready for deployment. • need to change platform developer through midway deployment > led to delays in integration of certain features. Importance of having contingency plans to mitigate such risks. • no project partner available to test with their chargers the booking service developed in Bari > involving external partners. • Partners: early and clear communication and collaboration to successful integration and service implementation. • Clear project objectives and timelines, thorough testing and verification, proactive risk management, and continuous communication with stakeholders. • Booking service easy to deploy short term > long term CPO should manage a calendar with all reservation requests coming from different EMP to allow successful long-term reservations. CPO to inform users approaching a reserved CP. • Invest in training for end-users, providing accessible support channels for troubleshooting, regularly evaluating and updating deployment strategies based on feedback and lessons learnt. • Consistency and quality can be ensured by standardised procedures, regular quality assurance checks, and continuous improvement and accountability.
Scaling up: Challenges and opportunities	**Regional/National level** • Collaborate with relevant stakeholders: government agencies and industry partners, to develop **European level** • Interoperability standards and seamless cross-border mobility for EV users through harmonised charging

Service:	Enhanced booking service
	standardised protocols and regulations that promote adoption of EV charging infrastructure. • Deploy the use of parking sensors to inform customers on occupancy of and its parking slot to avoid undesired surprises. • Regulations should allow to inform the police on illegal occupation of the parking slots by non-electric vehicles to favour removal and limit discomfort. protocols and roaming agreements.
	• Interoperability, user experience design, and data security require further attention and improvement to enhance the reliability and effectiveness of the services demonstrated. • user acceptance and needs when developing charging infrastructure and services. Interests of operators are not primary in projects which aim at being user centric.
Scaling up/deployment needs and prognosis	**Short-term** (1-3 years) • Increasing public awareness and adoption of EV. • Regulatory challenges and infrastructure limitations. **Medium-term** (4-10 years) • Tech and infrastructure advancements. • Market saturation and competition. • Assuming expansion of EV market towards sustainability goal of 2035-2050, booking service will become essential to optimize the use of the existing charging infrastructure. **Long-term** (11+ years) • Sustainable mobility solutions and environmental benefits. • Disruptive technologies and shifting consumer preferences.

5.6 Route Planner

Responsible partners: ICOOR, POLIBA, ZES

Table 7: Feedback from demonstration of Route Planner

Service:	Route Planner
Demonstration sites considered	• Bari (IT) • Greece • Turkey (Istanbul + western Turkey) • Spain

Service:	Route Planner

Challenges and deviations

- Service only supported OCPP 1.6j and not OCPI, essential for interoperability with other companies and systems. Enabling OCPI support and integrating with Route220 system took longer than expected (extensive research and dev).
- Difficulty in clearly observing and measuring the progress made by other companies involved in the project.
- Changes in the software team and lack of ongoing workshops disrupted effective communication, causing delays and misunderstandings.
- Ensuring compliance with relevant regulations (no significant regulatory issues, presence of similar services in the market).
- Route220 company experienced difficulties accessing ZES services, hindering.
- Challenges in selection of CPs to be included in the offline route planner. Initial list did not include all the available CPs in Puglia Region.
- Deployment of the real time route planner was not possible by today due to the unavailability and lack of responsiveness of the service provider (Route 220).
- Laborious update and data collection> Deployment requires to feed the tool with updated info on availability of CPs and PoI, which is available online when CPs are interoperable (many CPs are not interoperable > can be accessed only through dedicated services of the owners). This requires:
- Collecting data from several sources to guarantee having adequate coverage.
- Build a database with data available on public sources (e.g., openstreetmap) integrated with information manually introduced by experts of the region, related to nature locations PoI.
- Meta characteristics of many paths need to be precomputed and stored in a matrix > The route planner considers multiple arcs (links) during its execution. Arcs are comprised of the path between a given POI and another POI, e.g., the path between charging station A and restaurant location B. The meta characteristics of the path (e.g., its distance) are stored and then used internally in the route planner. Depending on the number of POIs, the matrix may take up two days to be compute. Updating POI list needs recalculating (offline) part of the input matrix.

Effectiveness

Most effective solutions

- Developed and enabled OCPI support to facilitate data exchange and interoperability with Route220 and other systems. It enabled seamless integration and real-time data exchange between ZES and Route220, critical for the enhanced routing service.

Least effective solutions

- Discontinuation of workshops resulted in a breakdown of communication and coordination when software team underwent changes.
- Progress monitoring without clear and consistent method for tracking improvements proved ineffective, making it

Service:	Route Planner
	• Integration with Hubject platform to enable tariff requests and improve interoperability, streamlining the sharing of data and services. • automatic collection of updated detailed information > involved the main stakeholders and solved the issues, for each pilot, with their help. provide, in a future. difficult to assess contributions and coordinate efforts effectively. • Manual data collection is inefficient and cannot be reproduced or repeated frequently. Need a solution for a collection of data in an automated and integrated way, an online availability of these resources is necessary.
Measuring effectiveness	• Performance metrics: assessing success of data sharing and interoperability with Route220 and other systems through OCPI and Hubject integration. • Usage data: number of successful route plans and utilisation of charging points to gauge the effectiveness of the service in the pilot region. • Structured questionnaires with quantitative ratings and qualitative feedback from users to evaluate the functionality and usability of the route planner.
Best practices, insights, lessons learnt & recommendations	• Plan integration with external platforms (like OCPI and Hubject) early in the project to identify potential technical challenges. Integration is crucial for seamless data sharing and enhanced service functionality. • Feedback from experienced EV users highlighted need for user-friendly interfaces and accurate, reliable route planning features. • Commitment, ongoing communication, and coordination among project partners essential to address challenges and ensuring smooth deployment. • Regular workshops and consistent communication strategies vital to maintain project momentum and address issues promptly. • Change in the software team significantly disrupted progress > need for comprehensive handover processes and continuous team communication. • Integrating different systems and ensuring interoperability > more complex and time-consuming than anticipated. • Engaging users early and frequently for feedback can provide valuable insights and ensure the service meets their needs. • Flexible development with agile methodologies • A robust testing • Standardised processes, ensuring uniformity across regions and teams. A rigorous quality assurance process, including regular audits and reviews to uphold high service standards. • Route planner is a powerful tool to plan long distance trips for customers based on their preferences.

Service:	Route Planner
	• Unifying and automating the data collection process. Consistency is compromised when manual data collection is needed.
Scaling up: Challenges and opportunities	**Regional/National level** • Increase investment in EV charging infrastructure to support wider service deployment. • Engage with regulators to ensure supportive policies and frameworks for EV services. • Awareness campaigns to educate potential users on benefits and availability of the service. • Essential> operate service on different CPOs and booking functionality to enable customers to plan the trip and reserve the charging options. • Integrate (interoperability) CP information, and make publicly available data on PoIs (information currently owned by companies like Google, Booking, TripAdvisor, etc.) **European level** • Promote adoption of common interoperability standards to facilitate cross-border service integration. • Collaboration with different countries and service providers to share best practices and harmonize services. • European funding and support to expand EV services across borders. •
	Ensuring real-time accuracy of charging station data and availability is crucial. Enhancing the scalability of the platform to accommodate increased data volumes and user numbers is necessary. Improvements to the user interface are essential for enhancing usability and accessibility. interests of operators are not primary in projects which aim at being user-centric like eC4D. All input data must be unified, and the calculations of all input matrices must be harmonised and optimised.
Scaling up/deployment needs and prognosis	**Short-term** (1-3 years) • Opportunities: Rapid expansion of EV infrastructure, growing user base, and advancements in technology. • Threats: Regulatory hurdles, high initial investment costs, and interoperability challenges. • Route Planner to be refined to adapt the routing to real time info from the charging infrastructure and from customer needs that change dynamically. • Route Planner deployment is fundamental for development of EV mobility. **Medium-term** (4-10 years)

Service:	Route Planner
	• Opportunities: Technological advancements, increased EV adoption, and improved infrastructure. • Threats: Market competition, evolving regulatory landscape, and potential technological obsolescence. • Routing service will become essential to optimize the UX in long distance trips using artificial intelligence. **Long-term** (11+ years) • Opportunities: Integration with smart city initiatives, advancements in autonomous driving, and widespread EV adoption. • Threats: Changes in user behaviour, emergence of alternative technologies, and potential decline in demand for certain services.

5.7 Smart charging service

Responsible partners: CEA, VERBUND, VUB.

Table 8: Feedback from demonstration of Smart charging service

Service:	Smart charging service
Demonstration sites considered	• Grenoble (FR) • Barcelona (SP) • Zellik (BE) • Innsbruck (AT)
Challenges and deviations	• Challenge 1: Interface developed EMS system with CPO back-end to obtain details of infrastructure descriptions and ongoing sessions to return optimal charging profile for each charge point. • Challenge 2: BSM changed the EMS optimisation objective from maximising the “self-production ratio” to reducing the “charging cost” based on the day/night electricity price profile because of new business model that BSM wishes to put in place. • Challenge 3: charge points operated by BSM had the OCCP 1.6 protocol, but smart charging profiles not fully supported. Optimised profiles sent by our EMS could not be executed autonomously by the charge point itself > power set point sending method was redesigned to overcome this problem. • Challenge 4: ensure that EV users gave us their ‘user preferences’ via the mobile app after connecting their electric vehicle to the charge point. User preferences are crucial parameters for our EMS computing to obtain optimised solution for managing the EV charging infrastructure and ensure each EV is fully charged before departure. • Demonstration to be executed together with ABB chargers at the Austrian demo site in Innsbruck (operated by SMATRICS). SMATRICS demounted its ABB chargers from the demo location due to commercial/operational decisions. Interface to the ABB chargers could not be tested in the field in Austria but verified in a lab environment at VERBUND and with an additional virtual ABB-charger in dedicated SW-environment. Instead of the ABB

Service:	Smart charging service
	chargers, demo site in Innsbruck equipped with high-power-chargers from Alpitronic. VERBUND implemented additional interface from the micro grid management system (MGMS) to the Alpitronic chargers in order to continue with the demo. • Difficult to capture drivers' feedback: smart charging requires specific additional actions of the user. Communication to the driver in the demonstrator done through information panels on charging site on the procedure as well as the benefits of smart charging, along with e-mail communication to the companies in the SME zone. Feedback assembled through e-mail address available for questions or suggestions + eC4D survey without any result. • Delays in deployment (+18 months) due to huge delays in PWD developments and later bankruptcy. This reduced potential period for running the demonstration and complicated the processing of demonstrator data and experiences. • V2G Charger tech developed by PWD was to be mitigated by purchase of commercially available V2G chargers. During demonstration, only 2 chargers for CCS plug available and certified by Synergid for the Belgian market. 1 proved not to be controllable (impossible to integrate into the smart charging system) 1 was produced only on demand and manufacturer was unwilling to sell and deliver within the project timeline. • Slight changes in functionality of the service: • No bi-directional (Vehicle-to-grid, V2G) chargers included in demonstration. • Limited number of users > extend demo period beyond deadline to capture as much feedback as possible. Main reasons: • Increase supply of chargers in the immediate surrounding of the demonstrator leading to an over availability of chargers with a higher visibility of non-eC4D chargers. • Additional user actions by the user required for smart charging might favour the use of non-smart charging infrastructure. • EV drivers mainly company cars in Belgium, accompanied with charging expenses covered by employer. The monetary incentive (tariff reduction) for smart charging does not affect the driver and loose its effect.
Effectiveness	**Most effective solutions** • Challenge 1: interoperability in the design by using standard equipment (CP with OCPP 1.6) and protocols like Open Charge Point Interface (OCPI 2.2 version). This made it easy to interface with any CPO back-end and to execute an optimal charging profile provided by our EMS system for all standard charge points. • Challenge 2: modular structure in design of EMS,
	Least effective solutions • CPO may already use smart charging solutions from other 3rd parties. • Real commercial operation phase not possible > service includes a control of the real-time charging power of the EV at the charge point > service also affects client-relation of CPO with their customers. The service that UCII-4 offers could affect CPO commercial and operational

Service:	Smart charging service	
	easily configured with one or several optimisation objectives, i.e. maximising self-production ratio using local renewable energy and reducing charge cost. CEA use case charging infrastructure, the EMS is configured to maximise the self-production ratio, while in BSM use case charging infrastructure, it is configured to minimise the cost of charging. • Challenge 3: new method of sending the power setpoint. Consists of sending a new power setpoint if the power is modified and different from the value sent previously. The normal situation is to send a full profile for the hours to come and let the charge point change the power set point itself. Here, we had to send a new set point each time the power set point needed changing. • Challenge 4: sent a message to our EV users to encourage them to let us know their user's preferences and developed AI SW (machine learning) to estimate preferences based on charging sessions history. • VERBUND developed the MGMS in house > SW adaption and interface to the chargers to deal with challenge of changing CPO infrastructure was possible.	responsibilities/ competences. SMATRICS uses its own smart charging HW and SW for balancing of the chargers; a real-time balancing of the chargers with the updated micro grid management system (MGMS) by VERBUND is currently not reflected in the terms and conditions that SMATRICS has with its customers / EV users.
Measuring effectiveness	EMS successfully interfaced with Grenoble, Barcelona and Luxembourg charging infrastructures. Charging service was optimised with EMS. Effectiveness of provision of additional charging power to the CPO exceeding the grid connection capacity was measured by verifying the functionality of the service during the demonstration and an additional simulation of the potential cost savings on an annual basis.	

Service:	Smart charging service
Best practices, insights, lessons learnt & recommendations	• Anticipation of problems and implementation of appropriate solutions at design stage: interoperability by using the standard communication protocols and standard equipment, making the interfacing easy with the charging infrastructures. • Unit testing of all components and of the data flow in between. Internal test bed to verify service functionality facilitates development and roll-out of new services. • Regular communication with partners to perform tests to avoid difficulty and misunderstanding. • Meeting with technical experts when integrating solutions developed by separate teams > avoid simple technical problems to take too much time. • CPO may use own smart charging solutions > willingness to adapt / change existing solution is low but crucial. The functionality of the service needs verified before applying it to a commercial environment / charging locations in the field. • Early engagement with CPO to include HW requirements (ie. stationary battery) in planning phase. • Service could also be used to lower the needed grid connection. • Good and effective communication to drivers, with a way to capture feedback. Smart charging is difficult to understand and can lead to (perceived) loss of charging comfort = less driver participation. • Suitable tariff structures or other incentives to engage users to participate.
Scaling up: Challenges and opportunities	**Regional/National level** • Enough grid connection capacity crucial as charging infrastructure need is increasing rapidly. The implemented service can increase available capacity by adding a stationary storage system and enable charging locations/more charging points per location. **European level** • Embed tariff structures suited for smart charging in CPO-MSP communication standards.
	KPIs could be improved if we had access to traffic forecasts. EMS might need to be tested on different use cases: supermarket, park & ride, airport car parks, larger charging infrastructures (more charge points). Functionality was implemented and tested with two different suppliers of charging infrastructure (ABB and Alpitronic). To allow for a broader scale-up of the system, the compatibility of the communication interface to additional hardware suppliers should be foreseen. The driver interface is key as it establishes the interaction between the driver and the smart charging service. For the project, a QR-code based web-interface has been developed. For recurrent users, account-based or app-based interfaces preferred option with flexibility on functionalities and ease of use can be integrated, more security (e, g, avoid QR-code fraud).

Service:	Smart charging service
	Cater 'new' users through hybrid solution > app to provide additional information (e.g. historic session, cost savings, CO2 savings) to incentivize use of the service. More flexibility on tariff structures in CPO-MSP communication. In the absence of ISO15118 and OCPP2.0 and beyond, options for tariff schemes suitable for smart charging are not standardised and difficult to apply uniformly and at large scale. Financial incentive to participate in smart charging has shown to be important. This must be solved for wide scale application of smart charging.
Scaling up/deployment needs and prognosis	**Short-term** (1-3 years) • Upgrading existing charge points with stationary storage systems to allow additional charging points / higher charging power. • Increasing importance of smart charging due to increasing EV and Renewable Energy Sources (RES) > increased grid pressure and imbalance, energy price volatility. **Medium-term** (4-10 years) • Including stationary storage systems already in the planning and building phase of new charging locations. • Include grid balancing services with EVs that go beyond local balancing of the smart charging service today. **Long-term** (11+ years) • Increase of Electricity cost > solution will get more pertinent and valuable. • Widespread use of EVs as grid balancing assets.

5.8 Preventive Diagnostic and Charging optimization service

Responsible partner: CRF.

Table 9: Feedback from demonstration of Charging optimisation service

Service:	Charging optimisation service	
Demonstration sites considered	• Turin (IT)	
Challenges and deviations	• Service is a cloud model-based system that needs a big amount of vehicle data. Challenge > algorithm refinement to acquire the HV battery data and the management of the buffering to store and cache the data to be sent to the cloud when the network was not present. • Testing phase performed with a single vehicle in limited period = limits assessment of a service based on ML / model-based system.	
Effectiveness	**Most effective solutions** • Change strategy to transfer the data by leveraging onboard HPC storage	**Least effective solutions** • Not specific: development of final solution for data transfer problem was a continuous

Service:	Charging optimisation service	
	capability and the WiFi network in the plant area > improved transfer of big amounts of data to the cloud. Must be further improved when PoC is brought to production.	improvement based of partial failures.
Measuring effectiveness	Cloud metrics and KPI highlighted when some messages missing.	
Best practices, insights, lessons learnt & recommendations	• Problem of the urban canyons > project served to experiment several scenarios to consider for a real product. New technologies like Multi-access Edge Computing, future 6G and new Edge computing development approaches > help to further improve the solution reached in the project. • Pre-process and compress onboard the vehicle data to be sent to the cloud (like any other ML or model-based system that requires to process big amount of data). This best practice is useful for all the new Autonomous Driving vehicles.	
Scaling up: Challenges and opportunities	**Regional/National level** • No technical aspects could be constraint for the deployment of this service in EU expect the transfer of vehicle data to extra EU countries.	**European level** • No problems in EU. • Extra EU vehicle data regulations to be considered.
	Services based on big data = big number of acquisitions and missions is required to assure a good service level.	
Scaling up/deployment needs and prognosis	**Short-term** (1-3 years) • HPC based onboard architecture to be exploited. **Medium-term** (4-10 years) • Digital twin technologies. **Long-term** (11+ years) • Evolution of connected services is rapidly changing > unrealistic to make forecast on 10 years and beyond time scale.	

5.9 CP Location Planning Tool

Responsible partner: ICOOR.

Table 10: Feedback from demonstration of CP Location Planning Tool

Service:	CP Location Planning Tool	
Demonstration sites considered	• Barcelona, Luxemburg, Northern Italy	
Challenges and deviations	• Collection of the information needed to run the algorithm. Data regarding current and planned CPs, the structure and distribution of the population, the presence of specific facilities that may attract charging demands (e.g., hospitals, malls, industries). • Cost estimates not easy to obtain. Cost per charging point depends on several factors. Estimating cost of setting up a new charging station (may entail renting/purchasing the terrain, needed upgrades to energy network) is intricate.	
Effectiveness	**Most effective solutions** • Even if don't have a solution for automated collection of data, digitalisation of processes and to the sharing of data could provide, in future, an online availability of these resources.	**Least effective solutions** • Manual collection of data inefficient > requires much time and work, cannot be reproduced or repeated frequently.
Measuring effectiveness	Manual collection of data was effective > provided data covering all the needs of the pilots.	
Best practices, insights, lessons learnt & recommendations	• Commitment of all the relevant stakeholders; availability of digitalised data, possibly online.	
Scaling up: Challenges and opportunities	**Regional/National level** • South of Europe > existing infrastructures (CPs) are limited.	**European level** • N/A
	• LP based on static demand estimated, e.g., the demand stemming from residential houses or working areas over twelve hours. This entails that charging stations are not necessarily installed around POIs that may attract dynamic demand (e.g., shopping malls). More elaborate demand models are needed. • LP designed to deal with large areas (e.g. a country) and smaller areas (i.e., cities). Region is divided into hexagons which are inputted to the algorithm. The algorithm can handle up to 2.000 hexagons within a reasonable computational time budget. Thus, area of each hexagon may be significantly larger in case of a country, when compared to that of a city. Having different	

Service:	CP Location Planning Tool
	granularities is not ideal. In particular, the tool is more informative on cities.
Scaling up/deployment needs and prognosis	**Short-term** (1-3 years) • Planning tools can be very useful for a strategic national deployment of new stations since CP are limited in European southern regions. **Medium-term** (4-10 years) • CP Location Planning Tools should be developed to capture static and dynamic demand aspects, user elasticity. • A more accurate modelling of user preferences is needed. Ie. preferences related to cost, proximity, and renewable energy. **Long-term** (11+ years) • Problems will change from the planning of new CPs to the upgrade of existing CPs and to the balance of the charge on the grid. New tools will be necessary.

6 RECOMMENDATIONS AND GUIDELINES

6.1 Regulatory and Harmonisation recommendations for authorities

The following are derived from the findings in Chapters 3 and 4 of this deliverable.

6.1.1 Planning

- 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. Better to prioritise CPs in car parks where vehicles can enter facing the CP or reverse in so the CP is near the rear end, depending on the socket location.
- 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** along highways/motorways and at destinations (including home charging) to reduce the need for slow charging infrastructure on city streets. Furthermore, EV drivers should not be encouraged to drive into city centres because there is better charging infrastructure there than in suburban area.
- 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.

6.1.2 Electrical

- 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.

6.1.3 Operational

- 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.

6.1.4 Pricing, payment, parking and enforcement

- While pricing is a matter for CPOs, 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 any difference in price between payment by this means and using a CPO account should be made clear.
- 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 a 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. Nevertheless, a tolerance period (e.g. 30 minutes) could be applied from the end of charging until any supplementary fees or penalties start to apply.

Recommendations are not given 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.

6.2 Guidelines for investors and operators: Charging technologies

The following guidelines are organised by the technologies developed and deployed in eCharge4Drivers and are derived from the findings reported in Chapter 5, also from Chapter 3 where they relate to good practice rather than regulations or harmonisation.

6.2.1 User-friendly charging stations

- Ensure interoperability between all EVs and chargers.
- Need for Protocol standardisation.
- Close cooperation of players in the e-mobility ecosystem is needed.

6.2.2 Battery sharing concept for light electric vehicles

- Upfront planning, particularly in location scouting, to ensure accessibility, internet connectivity, and power sources are available.
- Involvement of local stakeholders and fluent communication with all stakeholders
- Battery standardisation and interoperability is crucial for scaling e-mobility services.
- Modular and scalable infrastructure to support different battery types.
- Implement robust training programs for staff and users will ensure smooth operation and maintenance, enhancing the overall user experience and service adoption.
- Ensure consistency and quality, standard operating procedures (SOPs) should be developed and enforced across all stages of deployment, from site selection to installation and maintenance.

6.2.3 Charging points on lamp posts

- Need to have political support from cities.
- Some technical solutions not adapted (expensive)
- Need of anticipation, long preparatory work with involvement of the cities.
- Involvement of services in charge of public lightning.

6.3 Guidelines for investors and operators: Charging services

6.3.1 Advanced charging authentication - ISO15118PnC

- Need regulation of interoperability between PKIs and ecosystem.
- Invest in internal testing tools and capabilities, prioritising interoperability with industry-standard protocols, and establishing clear protocols for communication and collaboration with partners.

- ISO-standard difficult to navigate: need for a dedicated person/ team expert in ISO and ecosystem.
- Cross-company collaboration necessary (e.g. interoperability and E2E testing, fault analysis). Dependency on other companies testing, delayed deployment process.
- Coverage of PnC-enabled CPOs must be improved.

6.3.2 Enhanced booking service enabling better exploitation of the public charging network

- Partners: early and clear communication and collaboration to successful integration and service implementation
- Booking service easy to deploy short-term. In the long-term, the CPO should manage a calendar with all reservation requests coming from different EMP to allow successful long-term reservations. CPO to inform users approaching a reserved CP.
- Invest in training for end-users, providing accessible support channels for troubleshooting, regularly evaluating, and updating deployment strategies based on feedback and lessons learnt.
- Consistency and quality can be ensured by standardised procedures, regular quality assurance checks, and continuous improvement and accountability.

6.3.3 Trip planning and routing services

- Plan integration with external platforms early to identify potential technical challenges. Integration is crucial for seamless data sharing and enhanced service functionality.
- Need for user- friendly interfaces and accurate, reliable route planning features.
- Commitment, ongoing communication, and coordination among project partners essential to address challenges and ensuring smooth deployment.
- Integrating different systems and ensuring interoperability > more complex and time-consuming than anticipated.
- Engaging users early and frequently for feedback can provide valuable insights and ensure the service meets their needs.
- Flexible development with agile methodologies and robust testing.

6.3.4 Smart charging suite unlocking new business opportunities

- Anticipation of problems and implementation of appropriate solutions at design stage: interoperability by using the standard communication protocols and standard equipment, making the interfacing easy with the charging infrastructures.
- Unit testing of all components and of the data flow in between. Internal test bed to verify service functionality facilitates development and roll-out of new services.
- Regular communication with partners to perform tests to avoid difficulty and misunderstanding.
- Early engagement with CPO to include HW requirements in planning phase.
- Suitable tariff structures or incentives to increase participation and user engagement.

6.3.5 Preventive diagnostic and charging optimisation service

- Need for an improved transfer of big amounts of data to the cloud. Pre-process and compress onboard the vehicle data to be sent to the cloud.
- New technologies like Multi-access Edge Computing, future 6G and new Edge computing development approaches > help to further improve the solution reached in the project.

6.4 Guidelines for investors and operators: Decision support tools

6.4.1 EV charging location planning tool

- Commitment of all the relevant stakeholders; availability of digitalised data, possibly online.

6.4.2 Incentives schemes and tariff structures towards e-mobility sustainability

- Involve interest groups in the project and pricing structures.
- Pricing in kWh is mostly appropriate in paid-for parking areas, but including a time element in areas where parking is free, to discourage long stays after the vehicle is fully charged.
- Develop pricing that incentivises local/regular users to take out a contract, but without unduly penalising ad hoc users, including visitors. Long term parking in off-street locations (car parks) linked to a CPO contract at attractive prices is important for residents who do not have their own parking space (equality issue), but balance this with the need to promote public transport, active mobility and, where needed, car sharing, as an alternative to car ownership in dense urban areas.
- In case of reservable CPs, current occupancy knowledge is essential (e.g. sensors to check if a space is occupied even if the charging infrastructure is not being used), and a deposit should be taken to ensure that users respect their reservation. This would be lost if the driver does not arrive within (for example) 15 minutes of their booked timeslot. Reservations should not be back-to-back and overstaying drivers should have a rising penalty after, say, 15 minutes. They should also be informed by app and/or SMS.

7 CONCLUSIONS AND OUTLOOK

The recommendations and guidance in this document have been derived from experiences within eCharge4Drivers in developing and demonstrating solutions, as well as from the perspectives of the 26 interviewees.

They have been presented to the consortium and members of the External Interest Group (EIG), e.g. at the project's Final Event. They will be widely disseminated by the consortium and in case of significant feedback which might change some of the guidelines or recommendations, an update to this deliverable will be provided.

A summary version of the recommendations and guidelines is under production, as a pdf document to be uploaded to the project's website, where feedback will be invited and which can evolve and improve over time.

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9 ANNEX A – INTERVIEW QUESTIONNAIRE TEMPLATE

INTRODUCTION

About eCharge4Drivers

eCharge4Drivers is a European project funded under the EU's Horizon 2020 programme, running from June 2020 to November 2024 and deployed by a consortium of 30 partners.

Charging an electric vehicle (EV) is still not as convenient as refuelling a conventional vehicle, potentially posing a barrier to increase the market uptake of EVs. eCharge4Drivers works to substantially improve the EV charging experience within cities and for long trips. The project is developing and demonstrating user-friendly charging stations and innovative charging solutions as well as smart charging services for users. For further information, see https://echarge4drivers.eu .

This interview survey

This survey is part the "Recommendations for regulatory and harmonisation actions" activity (Task 7.2) within the eCharge4Drivers project. As part of this task, project partners are interviewing stakeholders involved in electric vehicle charging in Europe or Worldwide.

The questions contained within this survey aim to collect information on regulatory aspects regarding EV charging in different areas of Europe and to obtain your views on the existing best practice and regulation in your city, region or country. The survey also contains questions on whether there is need for new best practice or regulation.

Generally, the focus is on public (available to anyone) and shared charging infrastructure (at offices, educational, leisure sites), but we are also interested in your thoughts around charging for private (residential) facilities.

When answering questions about regulations or current practices, please state at which level these exist, for example if a regulation, legal requirement, policy or guidance is for your entire country or if there are ones that are specific to your municipality or region.

Data protection

Personal information will be retained purely for the purposes of analysing survey results. Contact details will be retained for the lifetime of the project in case of the need for further follow-up questions.

Data will be stored according to the Data Management Plan of the eCharge4Drivers project (available on request). Results of the survey will be presented in an anonymous fashion, unless we obtain separate written approval from you.

We treat any opinions are your own and not necessarily representative of your organisation.

INTERVIEW QUESTIONS

Contact / Organisational information

1. Respondent's name

2. Respondent's email address

3. Name of the respondent's organisation (company, public authority/agency, etc.)

4. Type of organisation

☐ Local public authority (city, municipality) ☐ Local or regional public agency

☐ Regional government (region, state, province) ☐ National public agency

☐ National government (ministry, department) ☐ Research institute or University

☐ Charge Point Operator ☐ EV manufacturer

☐ Service provider (EMSP* or other services) ☐ EVSE* manufacturer/installer

☐ Consultant ☐ Association

☐ Other (please specify):

* *EMSP = Electro-Mobility Service Provider*

* *EVSE = Electric Vehicle Supply Equipment (charge points and associated equipment/systems)*

5. Country

6. Your main role or interest in EV charging

Part A: Legal regulations and best practice

7. What national (or local) **planning regulations** for Charging Station design and deployment exist, if any?

Please also comment if these are local, regional or national rules and if they apply to off-street and on-street; also if there are any differences in the regulations for fast chargers. Please provide a link if possible.

Parking Space design and charging point locations, include distance from kerb/ pavement edge (access issue for pedestrians/ wheelchairs, avoiding cables crossing footways)	
Any other **planning** regulations (optional)	

8. Are these planning regulations sufficient / appropriate for todays EV charging needs? What do you think should be changed (if anything)?

9. What national (or local) **electrical regulations** for Charging Station design and deployment exist, if any?

Please also comment if these are local, regional or national rules and if they apply to off-street and on-street; also if there are any differences in the regulations for fast chargers. Please provide a link if possible.

Types of socket and cable supplies	
Grid connection	
Smart charging (where charging is delayed subject to electricity prices) or Bi-directional charging	
Any other **electrical** regulations (optional)	

10. Are these electrical regulations sufficient / appropriate for todays EV charging needs? What do you think should be changed (if anything)?

11. What national (or local) **operational regulations** for Charging Station design and deployment exist, if any?

Please also comment if these are local, regional or national rules and if they apply to off-street and on-street; also if there are any differences in the regulations for fast chargers. Please provide a link if possible.

Safety requirements	
Accessibility / inclusively requirements (physical layout, user interface, payment options)	
Data sharing (location, type of charging point, availability of charging points, reservations of charging points, prices)	
Any other **operational** regulations (optional)	

12. Are these operational regulations sufficient / appropriate for todays EV charging needs? What do you think should be changed (if anything)?

13. Are you aware of any specific good practice examples in relation to EV Charger supplier / charging points (not already mentioned above; maybe practices that exceed the minimum regultions)?

If so, please give a brief description:

14. Are there any restrictions on who can operate a charging point?

☐ No: any company can operate a CP, no licence required

☐ Any company can operate a CP but they require a licence

☐ There are restrictions (please describe: for example if it needs to be an energy retailer, etc).

15. How is the energy use billed? (Pricing structure: please tick all that apply)

☐ Price per KW/h ☐ Price per minute ☐ Price per visit (fixed fee)

☐ Standard or minimum starting fee ☐ Other (specify):

16. Do you have any views or feedback on pricing/billing (what is best; what to avoid; issues encountered in your city/region/country)?

Part B: Payment

17. For EU Countries: Are you aware of the Alternative Fuels Infrastructure Regulation and the requirements around payment? (e.g. the provision of ad-hoc payment)

☐ Yes ☐ No ☐ Not applicable (respondent is not in an EU Member State)

18. Are there any regulations regarding the following?

☐ Requiring credit / debit card as a method of payment

☐ Providing the tariff details before charging

☐ Requirement to show consumption and cost (real-time on a display on the charger)

☐ Requirement to show consumption and cost (real-time by other means e.g. app)

Any comments on the above (good practice or missing/insufficient regulations):

19. Are there any issues or problems relating to one-off or ad-hoc payments? (for example visitors without an app or charging card)

☐ Yes (please describe):

☐ No ☐ Don't know

20. Are there any issues or problems relating to access to public paid-for charging points not allowing roaming / third party account access? (e.g. EU-wide agreements / agreements with other operators)

☐ Yes (please describe):

☐ No ☐ Don't know

21. Do you see any need for regulation or best practice around discounts offered to users? Particularly with regard to fairness, incentives or inclusivity

☐ Yes (please describe):

☐ No ☐ Don't know

22. Are you aware of charging point / electro-mobility service provider accounts that allow payment for other services? (e.g. tolling, vehicle maintenance, public transport, parking, Mobility-as-a-Service packages, etc.)

☐ Yes (please describe):

☐ No

Part C: Deployment rules and incentives

23. If there are any public incentives or subsidies for charging point installation (national, regional or local level), please summarise them here.

Mention if they are financial (e.g. tax discount / exemption, grant funding or loan), legal (reduced administration), operational (other non-financial support). If possible, please provide links to any regulations.

For home charging

For public charging available to all (on-street and public car parks)

For commercial /educational property / business use (supermarkets, offices, leisure facilities)

24. Is the installation of charging stations mandated/ in workplaces/residential areas/leisure or retail centres/ railway stations or park-and-ride sites?

☐ Yes, for new constructions (please describe, including for what kinds of construction and number or percentage of spaces with charge points):

☐ Yes, for existing facilities (please describe, including for what kinds of construction and number or percentage of spaces with charge points; also is there a time period by which they have to be equipped):

☐ No ☐ Don't know

Part D: EV parking/charging spaces, reservations and enforcement

25. If a non-electric vehicle is using an EV charging space in a public space (on-street or a public authority-operated car park), what enforcement actions can be taken (if any)?

☐ Registered owner is fined / penalty notice ☐ Vehicle towed away ☐ Vehicle clamped

Any comments on the effectiveness of enforcement or anything that should be changed?

26. Are you aware of any charging points allowing advance reservations?

☐ Yes ☐ No

If yes, please describe:

Which operator handles the reservations? What kinds of parking places? (on-street, car parks, etc.)	
Is any advance payment or deposit required?	

What happens if a user arrives late or does not show up at all? And if another user is waiting?	
What happens if a user overstays the planned time (and another user has reserved a slot afterwards)?	

Part E: General observations

27. Any other comments?

Possibly including (optional suggestions):

- *What works well; what doesn't work well / what barriers exist*
- *Future regulations / projects / plans*
- *Usage levels and user feedback*
- *Other services like battery swapping for light EVs or regulation for induction charging*
- *Lessons learnt*

28. Would you like to join the eCharge4Drivers email list? (e-newsletter 2-3 times per year + notifications of project events)

☐ Yes ☐ No

Many thanks for your cooperation!