Standards for EV smart charging: A guide for local authorities

Planning for future-proof charging infrastructure in cities

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About

Environmental Coalition on Standards (ECOS) is an international NGO with a network of members and experts advocating for environmentally friendly technical standards, policies and laws. We ensure the environmental voice is heard when they are developed and drive change by providing expertise to policymakers and industry players, leading to the implementation of strong environmental principles.

ECOS is heavily involved in the development of key smart charging standards, both at European and international level, including ISO 15118-20, IEC 63110 and EN 50491-12, ensuring that they are interoperable, coherent with other smart charging standards, and not overly complex.

As a party without vested business interests, ECOS helps lead the dialogue and look for compromise among a wide range of stakeholders with diverging commercial interests

ECOS also engages with policy makers to ensure legislation encourages smart charging, and that laws are supported by robust standards, facilitating the integration of e-mobility into the electricity grid.

The Regulatory Assistance Project (RAP)® is an independent, global NGO advancing policy innovation and thought leadership within the energy community. RAP® works towards a clean, reliable, equitable and cost-efficient energy future. Our team develops and shares global best practices tailored to local priorities, acting as a trusted advisor to promote implementation.

Technological advances and dramatic declines in cost are creating new opportunities to improve the economic efficiency of the power sector, reducing its environmental footprint while improving customer welfare. The rapidly-evolving power sector holds the promise of cleaner and more customer-centric energy use — if policymakers update and adapt the regulatory paradigm.

RAP's global team has firsthand knowledge of the constraints and challenges policymakers face. Building on peer-to-peer relationships, RAP helps decision-makers and stakeholders navigate the complexities of climate and power sector policy, regulation and markets. They see RAP as a trusted advisor for reliable and relevant information and assistance.

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Executive summary

The electrification of road transport is having a profound impact on the energy system - and our cities. We are replacing a system based on polluting fossil fuels with one where cars no longer produce tailpipe emissions and can function as mobile batteries capable of charging virtually anywhere.

Creating a durable, adaptable charging network for electric vehicles requires forward-thinking strategies, including smart charging, where data is shared between the charging infrastructure and the power system.

The benefits of smart charging are many. First, given that the electrification of transport can accelerate the energy transition in other sectors, **smart charging is a key systemic enabler**. It makes it possible for charging to automatically happen at times when the costs of producing and delivering electricity are lower, without compromising the needs of vehicle owners. As a result, smart charging creates a powerful opportunity to use more renewable energy on a systemic level – rather than curtailing its use – by storing electricity in car batteries for later.

Second, **smart charging is essential to maintaining grid stability and reducing costs**. It can reduce peak load on the power system by scheduling charging during periods of low electricity demand. It can also help grid operators respond to short-term imbalances in the grid. Through load management, the overall grid capacity needed to charge cars is lower when charging is done smartly, which reduces the need for grid expansion, saving costs for operators and all grid users.

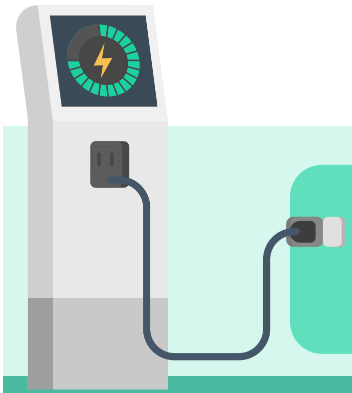
Cities are essential actors in making smart charging happen at a large scale. Many local administrations are working to change existing mobility patterns and reduce private car ownership by improving public transport and shared mobility. Deploying sufficient public charging infrastructure for transport electrification can foster change. It is cities that procure or issue permits for public charging infrastructure, and therefore cities hold the key to unlocking the benefits of smart charging. **When launching public procurements or permitting schemes**[1], **they set requirements for the infrastructure of the near future.**

But, how can local authorities deploy a future-proof, robust smart charging network? To launch the right public procurements, **they need to be aware of developments in regulation and technical standards**. Ensuring that cities can take these standardisation developments into account when procuring charging infrastructure is the purpose of this report.

The current European charging infrastructure regulations set minimum requirements for charging stations. In the near future, these will include smart charging, which is in turn enabled by digital communication standards. These standards provide a link between the energy and transport systems, ensuring infrastructure is interoperable even when running on software protocols built by different manufacturers.

Smart charging standards are at different stages of development but are not yet available for any charging stations built today. However, infrastructure not compatible with future standards risks becoming obsolete before the end of its expected lifetime. As a consequence, to ensure the longest possible useful life for charging stations, cities need to **require operators to consider current standardisation developments when deploying new infrastructure.**

This guide aims to assist those working on public charging infrastructure at a local level. It is designed to help local authorities understand the main benefits of smart charging, the role standards play in achieving these benefits and how the right procurement policies can help deploy charging infrastructure built to last.



What should local authorities ask from charging station operators when issuing a tender?

Charging station operators (CSOs) are the companies contracted to install and operate charging infrastructure. They play an active role in ensuring the infrastructure is built to last. When a city issues a tender for building EV charging stations, CSOs will answer that call.

CSOs must think ahead about how to implement anticipated hardware and software upgrades when the infrastructure is built. **Therefore, cities should require operators to:**

- Ensure infrastructure meets the **latest available smart charging standards;**
- **Integrate upgraded or new standards** into the charging station's software as soon as they are available;
- Install charging stations with **sufficient computing and memory capacity**, for future-proof infrastructure;
- Provide all **technical documentation regarding the protocols applied**;
- In case of newly built infrastructure
  - Implement the ISO 15118-20 standard, which supports **vehicle-to-grid (V2G) technology**, as soon as possible and by early 2024 at the latest;
  - **Anticipate the arrival of the IEC 63110 and IEC 63119** standards, that will be essential for a future when most cars are electric.

A more detailed list of recommendations is available on page 14.

On page 21 we provide an example of tender specifications local authorities can build on when drafting procurement documents.

PART 1

Why smart charging

– and how cities can make it happen

What is smart charging?

Smart charging makes it possible to manage the flow of energy to (and from) electric vehicles (EVs). This tool helps manage the grid so that consumption occurs at times of the day when it is most beneficial for consumers, the grid, and climate change mitigation. The time needed to recharge the battery of an electric vehicle is usually much shorter than the time the car is parked. Shifting the charging to later hours can avoid additional load on the grid at peak times, such as in the evening. Smart charging also helps integrate renewable energy by aligning electricity demand with renewable energy supply. Thanks to bidirectional charging, car batteries can store this energy and release it to the grid at a later time.

By better matching electricity demand to local energy production, the grid can supply more electricity with the same investment, lowering costs for all. Smart charging can help mitigate the overall impact of transport electrification on grid demand peaks, thereby deferring the need for early grid upgrades. In other words, it allows more charging infrastructure to be integrated into existing grids than possible otherwise. Furthermore, through smart charging, EVs become highly responsive energy system assets that system operators can use to respond to short-term imbalances in the grid – contributing to a more stable energy system. This is relevant for city officials tasked with a common challenge: building charging infrastructure while ensuring a stable electricity supply to power many more electrified end uses.

Finally, smart charging allows EV users to benefit from preferential electricity prices because they can use their (co-)owned, locally produced renewable energy or shift charging to cheaper times. This flexibility in electricity demand ultimately lowers costs for all energy system users.

Smart charging in public spaces – step by step

Let us now examine the different elements specific to publicly accessible EV charging infrastructure - where cars typically charge for longer times - such as car parks and streets.

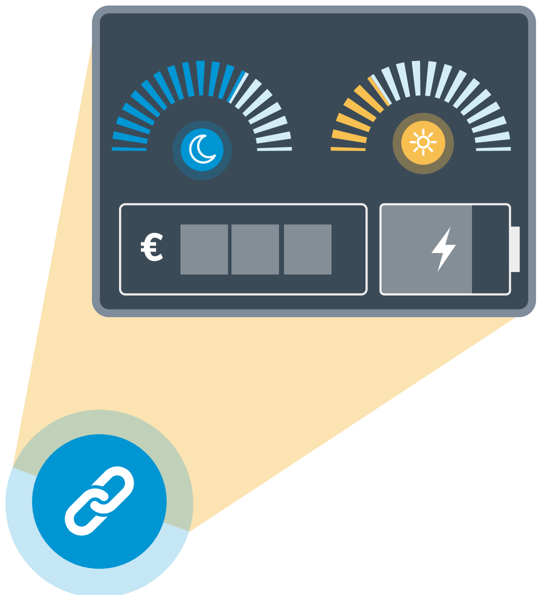
Load management

Charge points installed at a single location are often not all used simultaneously. The flexibility of the charging process, as described earlier, can reduce the concurrent energy needs even further. Consequently, it is already customary to manage demand at locations with multiple charge points, such as on-street charging hubs or parking lots, thereby reducing the costs associated with using higher grid capacity, such as the network fees incurred.

Load management allows the total aggregated power output from individual charge points to actually exceed the capacity of the location's connection to the grid, e.g., ten charge points with 22-kW of charging output each can be connected to a 50-kW supply. Currently, most load management simply balances the charging power for individual vehicles. The available capacity is allotted to the charge points in use at any given time based on measurements such as the actual electrical current drawn by the vehicle and the number of phases used (single-phase or three-phase). Sometimes, predictive systems determine how to allot the capacity.

At the moment, the charging capacity for individual vehicles is managed via the basic charging standard IEC 61851, which allows a charge point to set a maximum current level for charging. This standard only transmits the real-time limit at a given moment and does not allow communication to schedule loads at other times. In most cases, user input is not possible, or is only possible through workaround solutions, e.g., by tracking user behaviour. This leads to a sub-optimal outcome: often all connected vehicles receive limited power until they are fully charged or removed from the charger. If charging stations and vehicles could share more information, energy flows could be managed better, prioritising the vehicle that will leave first, while shifting the charging of other vehicles to overnight charging if the user's schedule allows.

With the implementation of the ISO 15118 standard (more details on page 18), loads can be managed in a much more effective manner. The charging station has information about vehicle charging needs, and allows for better allocation of available capacity to meet the needs of the different EV drivers. The protocol also allows for the transfer of dynamic price information. If this feature is implemented well, it allows the end-user to opt for adjusting charging based on a range of factors, such as those described in the following use cases.



Working with the distribution grid – lessons learnt from pioneering cities

The same mechanism for managing load across various EV charge points can also work across locations and can work with external inputs, such as electricity prices or grid conditions. This approach allows local grid operators to include public EV chargers in flexibility programmes. These programmes aim to reduce the need for grid upgrades by better balancing supply and demand, thereby reducing the costs for all system users.

A multi-year trial in Amsterdam demonstrated that the hosting capacity of the local grid could be greatly increased by implementing a capacity limit, set by the grid operator, for a group of double EV charging stations[2]. Instead of applying the limit to the individual grid connections of charging stations, the charging station operator could allocate capacity over multiple locations within the same grid area. Using an energy management system, the charging station operator can better meet the needs of EV drivers and lower the impact on the grid.

In Stockholm[3], public chargers respond to dynamic signals from the grid operator, reducing the overall power system load at peak times in exchange for reduced grid fees. Both pilots demonstrate how effective energy management can increase the hosting capacity of the grid for public EV charging stations.

However, this type of grid interaction is still far from ubiquitous in Europe. Many Member States have not fully implemented the 2019 Energy Market Directive, which prioritises the use of consumer flexibility solutions over investing in grid upgrades. Depending on national regulatory frameworks or even operator choices, only some grid operators offer flexibility programmes or dynamic network contracts. It is key that Member States, transmission system operators, distribution system operators, charging station operators and other relevant energy system actors develop a harmonised approach for enabling demand-response interaction.

Aligning renewable energy and demand

Another type of signal, in addition to those mentioned above, that can be used for smart charging at publicly accessible EV charging infrastructure is the availability of renewable energy. This can be done locally, via an energy management system that measures and forecasts available on-site renewable energy. For example, parking lots with solar carports could make the best use of locally generated energy with a process similar to the load management methods described above.

The increasing number of people who charge their vehicles at home and have rooftop solar can make better use of the energy they generate and often save money. Within an energy community[4], households that do not have their own rooftop solar and driveway, but have jointly invested in renewable energy production, could have similar advantages.

Adjusting to energy market prices

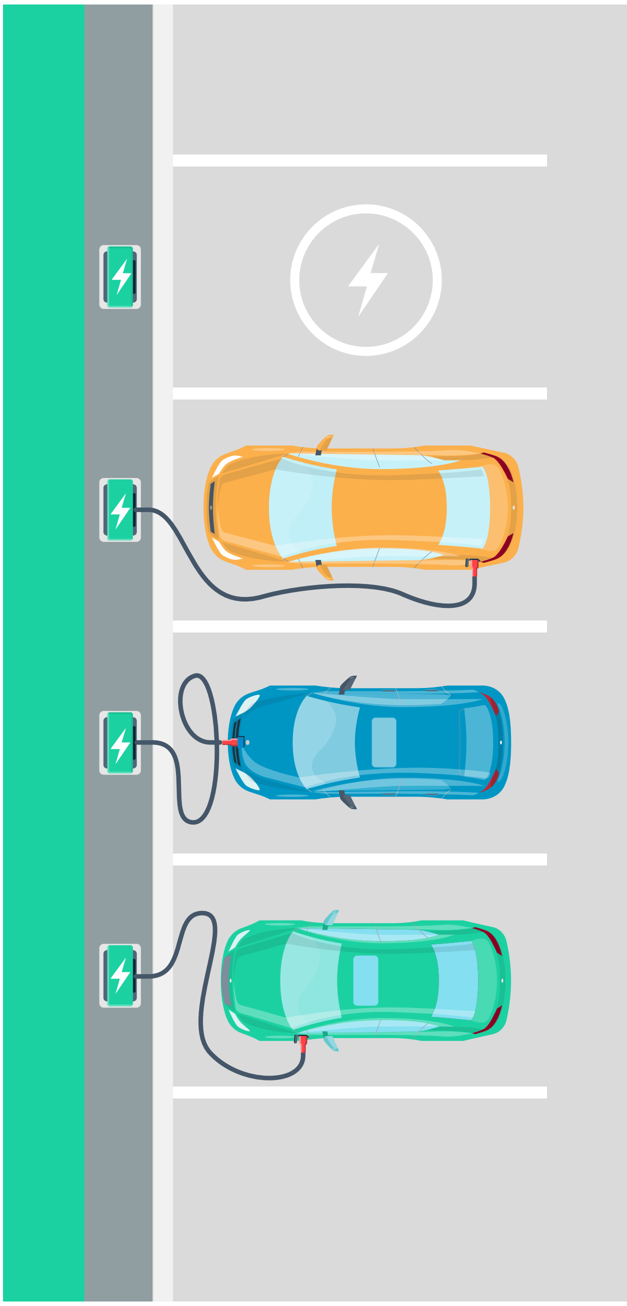
The availability of renewable energy influences wholesale energy market prices, as does the overall demand and supply of energy. On a daily basis, this results in electricity prices fluctuating throughout the day in this wholesale energy market.

Typically, when overall demand is low and renewable energy supply is ample, prices are very low. Shifting flexible loads, such as EV charging, to these periods reduces the stress on the energy system. All system users benefit from this load shifting, not just EV users.

In some countries, consumers are already used to seeing those prices in their residential electricity contract. Smart charging through apps or connected charge points allows users to directly save on their bills by shifting their charge to the lowest-priced hours. For those charging at home, this is already common practice. For public charging, however, prices are often still a flat rate. Apps from car manufacturers or third-party smart charging providers can help extend access to these lower-priced periods to flexible EV drivers at public charging stations. For this to work well, price signals should reach EV drivers[5].

Providing system services

Electric vehicles can also provide system services to transmission system operators balancing the national grid. Energy suppliers or aggregators that can control the electricity demand of larger groups of energy assets, such as electric vehicles, can provide fast frequency response services. In response to signals from the transmission system operator, they can increase or decrease energy consumption, sometimes within milliseconds. Most smart charging services that can optimise for time-varying energy prices are also capable of integrating participating EVs into such a service[6].



Enabling bidirectional power flow

In addition to smart charging, which can adjust the timing of a charging session, a new technology is being developed that enables an EV battery to reverse the power flow. This means the battery is not only able to draw power from the grid but it can also return the same power rather than using it for driving. An EV battery with the ability to discharge power is capable of bidirectional charging and can function as a stationary battery.

Instead of only matching a charging session to renewable energy production, the battery can store the renewable electricity for a later use unrelated to driving. This also prevents curtailment (shutdown) of renewable energy production and increases the amount that can be integrated into the power system. With bidirectional charging, a vehicle can also charge at low-priced moments and allow the energy to be used when power prices are high.

The technology is called vehicle-to-grid (V2G), or vehicle-to-everything (V2X), since the power can be fed back into the grid or can be used, for example, to power a fridge during a camping trip or during a grid outage.

The advantages of this technology are numerous. Apart from integrating more renewable energy into the system and easing periods of stress on the grid, it will reduce the need for stationary batteries and grid upgrades, and can provide emergency power supply during grid outages. In short, it will help to build a more stable and greener grid.

What is the EU doing for smart charging?

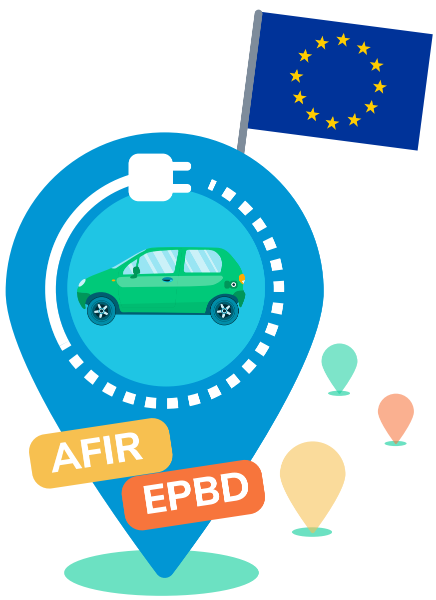
The regulatory framework

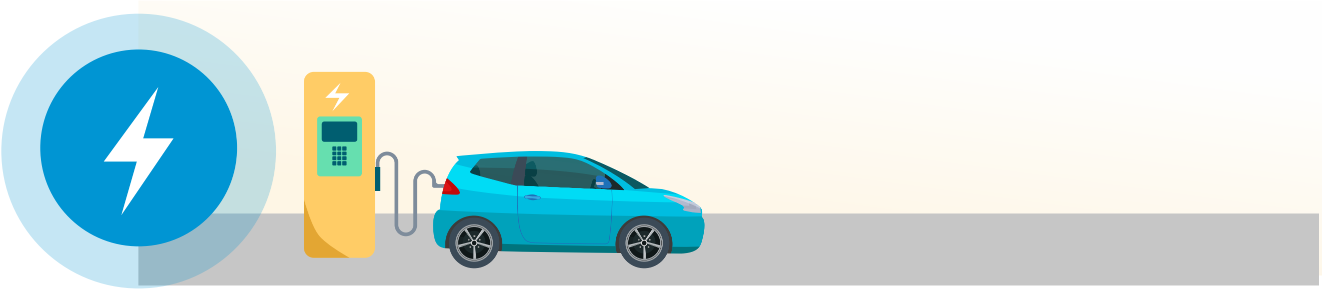
The framework conditions for the rollout of EV charging infrastructure in Europe are set by directives, which must be transposed into national legislation, and regulations. Some of them target vehicle emissions, such as the CO_2 emission performance standard for cars and vans, while others, such as the 2019 Energy Market Directive, lay out the electricity market conditions for the use of distributed flexibility such as EV smart charging in wholesale energy markets and for efficient grid operation.

In 2021, as part of the 'Fit for 55 Package'[7], the European Commission published several legislative proposals to update the existing legislation and further reduce the EU's carbon emissions. The most relevant files for EV charging infrastructure are the Alternative Fuels Infrastructure Regulation (AFIR), which regulates public charging, and the Energy Performance of Buildings Directive (EPBD), which covers private charging. These two pieces of legislation directly influence the type and amount of public charging infrastructure that each Member State should plan in coordination with local authorities.

The package also includes an update to the Renewable Electricity Directive (RED), which requires Member States to ensure all future private charge points be capable of smart charging. The more charge points in off-street parking locations, such as in residential buildings and workplaces, the lower the need for public charging. However, for those who rely on public charging for switching to an electric car, the benefits of smart charging are not as readily available as in the typical charging-at-home scenario with a private charge point.

At the time of writing, these proposals are still under discussion in the European Parliament and European Council.





Alternative Fuels Infrastructure Regulation (AFIR)

The Alternative Fuels Infrastructure Regulation (AFIR) is a guiding regulation for publicly accessible charging infrastructure. It sets targets for the rollout of such infrastructure, as well as the relevant requirements for EU Member States and for charge point operators.

The AFIR will harmonise charging infrastructure with regard to plugs, the availability of different payment methods and smart charging capabilities. Making this information, as along with location and pricing structures, available to EV drivers will make it easier for them to find and use public charging infrastructure across Europe.

Depending on the outcome of the negotiations between the European Parliament and the Council, the AFIR will require new or retrofitted charging infrastructure to be capable of smart charging and, in some cases, bidirectional charging, so that it can be a tool for better system integration of electric vehicles. The AFIR lists the technical standards that need to be finalised to ensure the large-scale deployment of smart charging.

The AFIR will replace the current Alternative Fuels Infrastructure Directive[8]. The change from directive to regulation means that it will become a binding legislative act, instead of requiring a lengthier process of transposition into national legislation. Final adoption is expected in 2023. New and retrofitted public charging infrastructure will have to comply with the smart charging requirements after a transitional period.

Energy Performance of Buildings Directive (EPBD)

Another legislative file that is essential for the rollout of sufficient charging equipment is the EU Energy Performance of Buildings Directive (EPBD). The EPBD determines how many charging stations must be installed in new, renovated and selected existing buildings. The Directive is currently under revision and is planned to be adopted in spring 2023, with Member States transposing it into national legislation by 2024.

It is likely that the ambition will be strengthened compared to the version of the EPBD currently in force. Depending on the negotiations, new non-residential buildings and those undergoing renovation will need to install a charge point if they have more than five parking spaces, instead of the current threshold of 10 parking spaces. Furthermore, it will be mandatory to lay the necessary cables for some, or all, remaining parking spaces so that a charging station can be installed later. This will be required for residential buildings with more than three parking spaces, too. National and local decision-makers can raise this ambition to include residential buildings with fewer than three parking spaces, for instance family homes.

For the existing non-residential buildings, the legislation is set to become slightly more ambitious as well, but will still leave the vast majority of buildings - those with fewer than 20 parking spaces - without EV charging stations. National and local legislators can raise the ambition here as well.

All charging stations will have to be capable of smart charging, which is essential for linking EV batteries to the building's electricity system. This enables excess electricity produced from solar panels to be stored by the car, either for driving or for powering the building or the grid, if the car is able to reverse the power flow (V2X technology, see page 18).

The EPBD does not foresee the use of standards to underpin requirements on EV charging but relies on the AFIR to ensure the necessary standards are adopted. However, some standards that are necessary for public charging will also have a role to play in private charging, such as ISO 15118-20, which enables V2X.

The role of standards in enabling a smart energy system with future-proof infrastructure

What is a standard?

A standard is a commonly agreed way of doing things, set out in a document providing rules, guidelines or characteristics for activities or their results. Technical standards are market-driven, voluntary agreements on technical specifications developed at national, regional or international levels. Standards can enhance product safety and quality, improve environmental protection, and lower transaction costs and prices.

An EV charging plug is an example of something specified by a technical standard. Adhering to this standard allows products of different manufacturers, such as a carmaker and a charging station developer, to function together, instead of being limited to proprietary solutions that only work with devices of the same brand. Such interoperability is vital because the success of the electromobility transition partly depends on smooth charging experiences.

The standardisation process

Standards are a key instrument for trade and competitiveness. In some cases, standards are not only a market tool; they can also be associated with legislation and policies. This is the case in Europe, where standards are often used to support legislation and have a strong impact on its implementation.

The European Commission has the power to ask the European Standardisation Organisations (ESOs) to develop and adopt European Standards (ENs), defining the corresponding technical specifications in support of an EU policy or legislation via Standardisation Requests. Standards resulting from such a mandate are known as harmonised European standards (hENs). It is important to note that, when hENs are referenced in the EU Official Journal, they provide presumption of conformity with essential legal requirements.

European standards are developed by European Standardisation Organisations, such as the European Committee for Standardisation (CEN) and the European Committee for Electrotechnical Standardisation (CENELEC). Their international counterparts are the International Organisation for Standardisation (ISO) and International Electrotechnical Commission (IEC), respectively. These organisations draft standards by (in theory) bringing together all interested parties, such as industry, government, certification and testing bodies, consumer organisations, environmental NGOs, authorities, labour organisations, and academia.

In practice, however, mainly big businesses are able to engage systematically in standardisation, which often makes these processes dominated by private interests, leaving public interests such as environmental protection underrepresented. Only in the European context do societal stakeholders have an official role in standardisation recognised by the EU Standardisation Regulation. As an environmental NGO, ECOS represents environmental interests and contributes to the drafting of standards. At the international level, civil society's access to the drafting process is not systematically facilitated and is therefore rather ad hoc.

Many European standards are based on international standards[9], especially for global sectors such as the automotive sector. Unfortunately, this means that in some cases, European standards and, consequently, the regulations they support can depend on decisions taken at ISO or IEC, at times causing significant delays.

Standards requested under the Alternative Fuels Infrastructure Directive (AFID)

In the context of e-mobility, the Alternative Fuels Infrastructure Directive (AFID) sets the standard for electric vehicle plugs. Now that smart charging technology is evolving, legislation[10] is moving towards specifications for smart charging communication as well.

The implementation of the legal requirements charge points must fulfil – such as the type of socket – relies on technical standards. However, since key smart charging standards are not finalised, the AFIR proposal does not yet set requirements for the full set of smart charging possibilities.

The Commission has asked European Standardisation Organisations to adopt key smart charging standards at the European level, which should at the same time speed up the international standardisation process. Among these are standards that will be based on ISO 15118, IEC 63110 and IEC 63119 (see page 16). The drafting of these standards is ongoing[11] at the international level. This work has to be finalised before European standardisers can adopt the standards at the European level.

International standards are progressing slower than needed for smart charging to facilitate the integration of EVs into the electricity grid. This will regrettably impact the adoption of smart charging standards needed to support EU legislation. The Standardisation Request by the European Commission sets a deadline for IEC 63110 and IEC 63119 to be adopted at the European level by 2023, but the likelihood of standardisers meeting this deadline is low at this stage. However, since the European Commission requested a European version of these standards, it is certain they will be deployed in charging infrastructure at some point in the near future and charging station operators need to anticipate them as well as possible.

Importantly, as the technology evolves thanks to enabling standards, the legislation will as well, given that the Commission has the power to add requirements for charging stations.

Our recommendations
- making infrastructure ready to evolve with standards

Keeping up with the latest standards is essential for modern, future-proof EV charging infrastructure. As technology evolves, standards are continuously revised to capture the state of the art, generally every five years, or sooner should regulatory or technological developments require updated standards. To integrate e-mobility into the electricity grid by means of ever-evolving digital communication technologies, smart charging standards will need to be continuously updated. This fact must be considered when procuring EV charging equipment.

Charging infrastructure needs to be future-proof. In other words, the evolution of standards that can be anticipated - such as smart charging standards requested by the European Commission - should not lead to outdated infrastructure. This is key to ensuring the viability of long-term investments in a rapidly evolving market. If communication standards can be upgraded over the years, the most expensive parts[12] of charging stations will last their intended lifetime.

Therefore, hardware and software should be upgradable as much as possible, with some encouraging examples regarding hardware already out there. For instance, the city of Amsterdam requires charge points to be modular, facilitating the replacement of components[13].

To support the transition to e-mobility, a large number of charging stations needs to be built as soon as possible, even while key software standards are still under development (see page 17). Cities should not wait to deploy charging infrastructure, but should consider the evolving nature of standards when procuring charging stations. Contractual agreements should guarantee that charging infrastructure operates according to the latest available standards while ensuring that upgraded or new standards will be integrated into the charging station's software as soon as they are available, either replacing the old standard or functioning in parallel.

Such upgradability requirements are needed to ensure charging station operators prepare for this transition as well as possible, and to avoid electronic waste because old charging stations become obsolete if locked into old technologies. Importantly, all technical documentation of both hardware and software should be available to the procuring authority so that third parties can upgrade the infrastructure in case the manufacturer or operator ceases operation.

Ideally, revised or new standards are ‘backwards compatible’ with current standards, leading to a smooth transition from one standard to another. However, it must be noted that while backwards compatibility is a concern among most standardisers and efforts are made towards smooth transitions, technological changes sometimes make a leap forward, complicating matters. In that case, standardisers aim to devise strategies for both standards to run in parallel, which means the charging stations and EVs need to support both versions (such as when moving from ISO 15118-2 to ISO 15118-20). When this is not possible (such as in the case of the transition from Open Charge Point Protocol to IEC 63110), standardisers try to ensure the different versions of communication protocols can coexist.

Overall, a balance needs to be found between product availability, that allows charging stations to be built now, and long-term service life. Guaranteeing upgrades and preparing for running standards in parallel is the best way to ensure future-proof infrastructure.

How can local authorities make sure the charging infrastructure is future-proof?

The following should be taken into account:

Make sure that charging station operators (CSOs) - the companies contracted to install and operate charging infrastructure - play an active role in ensuring the infrastructure is built to last. This means CSOs must think ahead about how to implement anticipated hardware and software upgrades when the infrastructure is built. **Cities should require operators to:**

- Ensure infrastructure meets the latest available smart charging standards;
- Integrate upgraded or new standards into the charging station's software as soon as they are available, either replacing the old standard, or functioning in parallel. This is best accomplished by means of contractual agreements on an implementation timeline with CSOs;
- Provide all technical documentation regarding the protocols applied so that third parties can upgrade the infrastructure in case the manufacturer or operator ceases to exist;
- For newly built infrastructure
    - Implement the ISO 15118-20 standard as soon as possible and by early 2024 at the latest. This standard supporting V2G technology is well advanced and will soon be available for widespread use. Therefore, operators of newly built infrastructure should be required to implement the standard as soon as it is commercially available.
    - Anticipate the arrival of the IEC 63110 and IEC 63119 standards. These important standards are further from completion but should be foreseen nonetheless. While it is unclear at what level these future standards will be compatible with the current ones, efforts should be made to prepare for the coexistence with the new IEC standards, and eventual migration towards them. For instance, operators should install charging stations with sufficient computing and memory capacity.

In Part 2, we elaborate on key smart charging standards in the making.

PART 2

Knowing your standards

– a review of the standards needed for electromobility grid integration

Let's dive into the standards making smart charging possible. For smart charging to work, the different actors within the electromobility ecosystem have to be able to communicate information on pricing, electricity needs and availability of EV charging stations to match demand and supply. This is needed for the EV and charging station to agree on a charging schedule that serves the needs of the EV driver and the electricity grid. Technical standards enable such communication.

All European public charging stations currently operate using the IEC 61851:2019 standard to connect to vehicles. This standard ensures safe charging, minimising risks such as electric shocks or overheating. It also allows for the exchange of basic information between the EV and the charging station, such as when the car is ready to be charged. It supports a form of load management, such as limiting the charging power level at certain times. In very basic terms, the standard thus enables 'smart' charging, understood as adjusting the power flow based on external signals.

However, to properly integrate the increasing number of EVs into the electricity grid, all participants involved in EV charging need more advanced ways of communicating than those provided by the standards currently in use. Several standards are under development to make this happen.

Standard	Replacement for	Advantages (selected features)	Expected timing	
			Publication	Implementation
ISO 15118-20:2022 International	IEC 61851 (as only communication method) or ISO 15118-2	• Improved – Charging experience; – Smart charging services; – Grid services; – Cybersecurity. • Bidirectional power flow for – More renewable energy uptake – Grid stability; • Grid code support features.	Published in 2022	2023/2024
IEC 63110 International	OCPP or proprietary protocols	• *De jure* standard[14]; • Support for bidirectional power flow; • Fast frequency response services.	2025	2026
IEC 63119 International	OCPI or proprietary protocols	• *De jure* standard; • Alignment with other EV-related IEC standards.	After 2026	After 2027
EN 50491-12 European	Proprietary protocols	• Integration of EV into Energy Management Systems (EMS); • Large-scale smart charging; • Improved interoperability countering proprietary solutions.	EN 50491-12-2 published in 2022	Through IEC 63110
IEC 63402 International	Proprietary protocols	• International version of EN 50491-12.	2024	Through IEC 63110

Table 1 Overview of standards discussed in this guide

ISO 15118-20
Vehicle-to-grid (V2G) standard

The key standard enabling more elaborate communication between the electric car and the charging station is ISO 15118 Road vehicles - Vehicle to grid communication interface. This standard is part of the Combined Charging System (CCS) charging standard that is dominant in Europe and North America.

Currently, ISO 15118-2 standard on Network and application protocol requirements is being installed by car manufacturers and in large EV charging stations. An updated and expanded version – ISO 15118-20 2nd generation network layer and application layer requirements – was published in early 2022 and is currently undergoing interoperability tests. The importance of this latest version can hardly be overstated. The standard will improve the charging experience for EV drivers and make it more grid-friendly (avoiding grid overload) and secure. At the same time, it will enable bidirectional power flow, allowing the utilisation of EV batteries for storage of renewable energy.

Overall, the ISO 15118-20:2022 version is more robust and provides more features than ISO 15118-2. Especially for direct current (DC) fast charging, ISO 15118-20 offers a more robust communication pathway. The standard allows the system to renegotiate the energy transfer without interrupting the charging. This means the amount of power used over time can be reliably adjusted in response to specific events during the charging session, which will improve the charging experience, even in the event of congestion in the power system.

The ISO 15118-20 standard is best known for enabling bidirectional power flow, also called vehicle-to-grid (V2G). This feature allows the car battery to return power to the grid or a building, which truly integrates the vehicle into the electricity grid and enables sophisticated grid services. An EV capable of bidirectional energy flow can function similarly to a stationary battery, thereby contributing to the storage of renewable electricity and supporting grid stability. The V2G feature also allows the vehicle to provide emergency power supply during a grid outage.

ISO 15118-20 also introduces a minimum set of grid code support features, which allow the vehicle to be disconnected[15] for safety reasons, for instance, in the event of a grid failure. These features can also ramp up the power delivered to the vehicle for enhanced fast charging, and enable a fast reaction to unpredicted grid connection point constraints.

The standard also includes a clear strategy for backward compatibility with 15118-2, the DIN SPEC[16] and basic charging according to IEC 61851. Importantly, ISO 15118-20 adds specific debugging capabilities that can help improve the charging experience over time. The standard also refines the way price information is integrated into the charging plan, thus allowing the vehicle (according to the user's preference) to better adjust the charging according to the electricity price.

ISO 15118-20 also provides enhanced Plug & Charge capabilities. This means an EV driver can be recognised by the charging station simply by connecting the vehicle, without any further need for identification through an app or QR code.

The enhanced communication security features of ISO 15118-20 make the charging system more robust against cyberattacks.

Because of all of the advantages of ISO 15118-20, it is key to leapfrog ISO 15118-2 whenever possible, and implement ISO 15118-20 as fast as possible in EVs and charging stations. This will unlock smart charging benefits faster and result in a more robust charging experience. It is expected that wide-scale implementation can start in 2023 or 2024.

IEC 63110

Protocol for management of EV charging and discharging infrastructure

Currently, communication between the charging station and the charging station management system (CSMS) is most often provided by the Open Charge Point Protocol (OCPP), an open-source protocol that is not an official international standard. It connects the charger and the software needed to manage the charging, providing communication essential for commercial public charging, such as meter values and charging requests. The most recent version is OCPP 2.0.

However, some governments might want to give this standard legal standing to guarantee interoperability. That can happen only if the standard is adopted by official standardisation organisations, which is not the case for the OCPP. Therefore, an officially recognised international standard is currently under development.

The IEC is working on a standard covering both charging and discharging (V2G) of EVs: IEC 63110. The standard is being designed to support large-scale EV deployment and fast system scalability. IEC 63110 may replace the OCPP standard and other – proprietary – protocols, covering the communication flows by many e-mobility actors, as well as the exchange of data with the electricity system. Concretely, it will connect the EV with the smart grid and smart home, covering energy transfer management and reporting required energy, grid usage, contract data, metering data and the like. It will also facilitate the management of charging stations, such as firmware updates, monitoring and maintenance. It will provide information needed for authentication of the vehicle and authorisation of the energy transfer and payment, including pricing, roaming and metering information. Importantly, IEC 63110 will allow bi-directional charging (V2G) and fast frequency response services (see page 18).

OCPP has an influence on IEC 63110, but it is unclear what kind of compatibility it will have with the international standard. The teams behind the two protocols are investigating whether they can ensure coexistence and a smooth transition to IEC 63110. Provided there are no unexpected delays, the standard will be published in 2025, and implementation can start the year after.

IEC 63119

Information exchange for charging EVs everywhere - roaming

Another important standard to ensure the functioning of a smart EV charging ecosystem is IEC 63119. It aims at creating an internationally harmonised way for secure payment services and roaming, so that contracts for charging services remain valid across borders and charging station operators.

E-Mobility Service Providers (eMSPs) arrange charging service contracts for EV drivers, Charging station operators (CSOs) operate the charging stations that deliver the electricity to the car and the management system that monitors and controls the charging infrastructure, while e-mobility roaming hubs ensure the relevant information is exchanged between those actors. Communication between all actors involved needs to be standardised to ensure a smooth charging experience for the EV driver. For instance, because EV drivers with charging contracts receive the electricity from the CSOs, but pay for the EV charge to eMSPs, providers and operators have to be able to trust and connect with each other. This way, drivers can charge at multiple charging stations internationally. The ultimate goal is to allow all EV drivers to charge their car at any charging location.

IEC 63119 is still in a relatively early drafting phase. At the moment, charging is often organised through the Open Charge Point Interface (OCPI), an open-source protocol that allows eMSPs to communicate with CSOs, for instance regarding authorisation, charging details and electricity prices.

OCPI supports smart charging in that it can transmit information, such as different prices or charging speeds over time, from the CSO to the eMSP (and ultimately to the user) and can change the speed of charging in response to a request by the eMSP who has an agreement with the EV driver.

IEC 63119 aims to deliver the same capabilities, but in the form of an international standard, which should be aligned with other EV-related IEC standards. This is key for a smooth integration of EVs into the electricity grid, and to ensure governments can mandate the use of standard in all charging infrastructure.

The timeline of the standard's publication and implementation are still unclear, but it is not expected before 2026.

EN 50491-12

Customer Energy Management (CEM) standard

The above-mentioned standards are needed for public charging stations, which could be located in parking lots inside or next to buildings, for instance at the supermarket or in hotel parking lots. In this case, EV batteries can interact with the energy needs of the building. This form of smart charging is managed through the building's energy management system (EMS).

The European standard EN 50491-12, or Customer Energy Management (CEM) standard, allows for a smooth integration of the EV into the EMS. The CEM coordinates energy demand and supply (for example from solar panels) within a building, ensuring that energy is used at the most optimal moment, for instance when the general energy demand is lower or when on-site renewables are available, and energy is cheaper.

The CEM standard will be crucial to make smart charging a reality on a large scale, since it guarantees interoperability of electrical devices and energy management systems. Technically, this standard represents different categories of energy flexibility. In other words, devices and systems developed by different manufacturers can be connected to the energy management system, which simplifies the implementation of energy management systems and reduces costs for consumers because it is no longer necessary to buy devices from a particular brand.

After the publication of a key version of this standard (EN 50491-12-2) as a European standard in 2022, the CEM standard is now being discussed at the international level and may be adopted as international standard IEC 63402 by 2024.

In order to enable customer-friendly integration of EV charging equipment into a building energy management system, it is key that other standards, such as IEC 63110, build on the energy flexibility abstractions defined in the CEM standard. This is seen as the de facto implementation of the standard.

Example of specifications for standards in procurement

Smart charging can be a game changer for EV charging in cities. Therefore, making sure the right standards and upgradability requirements are present in procurement specifications is key to ensuring new charging infrastructure is built to last. We recommend that procuring authorities include requirements in public tenders or permitting procedures for charging infrastructure on implementation timelines and future upgradeability.

To make it easier for local authorities, we are including below an example of how specifications could be set out in procurement documents. These example requirements are useful to complement other sources, such as the Sustainable Transport Forum's Recommendations[17] for public authorities on recharging point tenders.

	Applicants demonstrate the upgradeability of the charging infrastructure by fulfilling the following requirements:
1	Applicants shall provide full documentation of the software protocols and hardware specifications, such as physical connectors, in order to allow modular upgrades throughout the entire lifetime of the infrastructure.
2	Applicants shall describe which standards the infrastructure supports and how they anticipate and actively pursue implementing future standards and other developments they deem relevant, in order to ensure upgradeability.
3	Applicants shall ensure that the charging infrastructure (the whole of hardware, local and remote software) supports ISO 15118-20:2022 by March 2024: **a)** edition updates are implemented within 12 months after publication date; **b)** corrigenda are implemented within 3 months after publication date.
4	Applicants shall ensure that the charging infrastructure supports IEC 63110 within 24 months after the publication date: **a)** edition updates are implemented within 12 months after publication date; **b)** corrigenda are implemented within 3 months after publication date.
5	Applicants shall ensure that the charging infrastructure supports IEC 63119 within 24 months after the publication date: **a)** edition updates are implemented within 12 months after publication date; **b)** corrigenda are implemented within 3 months after publication date.
6	Applicants shall demonstrate a commitment to lifetime interoperability of the charging infrastructure by declaring which methodologies the company is using to determine real world interoperability with EVs, and by regular testing.
7	Applicants shall ensure that the infrastructure's processor and memory have sufficient resources, or can be upgraded in the future. This is important to support the simultaneous use of multiple versions of standards on all communication interfaces (e.g. a newer version as well as a fallback option for backwards compatibility, or a different standard on the same interface). Communication between the following interfaces must be ensured: **a)** car <> charging station; **b)** charging station <> charging station management system; **c)** charging station management system <> third-party roaming systems.

Table 2 Example of requirements for future-proof EV charging infrastructure as recommended by the authors

Notes and references

1 For readability, the term procurement will be used to refer to both procurement and permitting schemes.

2 https://www.hva.nl/urban-technology/gedeelde-content/nieuws/nieuws/2022/03/eerste-resultaten-flexpower-3.html

3 https://www.ellevio.se/foretag/elektrifiering/elbilsladdning/laddgator/

4 https://energy.ec.europa.eu/topics/markets-and-consumers/energy-communities_en

5 See Start with smart: promising practices for integrating electric vehicles into the grid, Regulatory Assistance Project (RAP), for more on pricing models for smart charging.

6 More on smart charging services and how they combine multiple energy system services in Time is now: smart charging of electric vehicles, Regulatory Assistance Project (RAP).

7 European Green Deal: Commission proposes transformation of EU economy and society to meet climate ambitions https://ec.europa.eu/commission/presscorner/detail/en/IP_21_3541https://ec.europa.eu/commission/presscorner/detail/en/IP_21_3541

8 Directive 2014/94/EU https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32014L0094 Directive 2014/94/EU https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32014L0094

9 This is because of the 'primacy of international standards' principle.

10 The Alternative Fuels Infrastructure Directive will be replaced soon by the Alternative Fuels Infrastructure Regulation.

11 A key version of the ISO 15118 standard has been recently finalised and is currently being tested to ensure interoperability of cars and charging stations.

12 This is mostly the mechanical and power conversion equipment.

13 Sustainable Transport Forum, 2020 Recommendations for recharging point tenders, https://transport.ec.europa.eu/transport-themes/clean-transport-urban-transport/sustainable-transport-forum-stf/reports/2020-recommendations-recharging-point-tenders_en

14 De jure standards are subject to be cited in legislation. In that case, they are recognised to support the regulation they underpin.

15 This is called ‘island detection’.

16 This is the predecessor of the ISO 15118 standard, specifically of DC fast charging, developed by the German standardisation body DIN.

17 Sustainable Transport Forum, 2020 Recommendations for recharging point tenders, https://transport.ec.europa.eu/transport-themes/clean-transport-urban-transport/sustainable-transport-forum-stf/reports/2020-recommendations-recharging-point-tenders_en

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