Building Publicly Accessible Electric Vehicle Charging Infrastructure

Summary and Conclusions

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Main findings

The global electric vehicle (EV) market is expanding rapidly, with electric cars now accounting for over 20% of new vehicle sales and the strong uptake of medium- and heavy-duty EVs. While most EVs will continue to be charged at home and depots, publicly accessible infrastructure is essential to support mass adoption and plays an increasingly important role in meeting charging needs beyond these locations, including long-distance trips as well as maintaining confidence in the system. Between 2022 and 2024, the global stock of publicly accessible chargers nearly doubled, reflecting the growing importance of these networks. This report reviews international experiences and best practices in publicly accessible EV charging deployment and identifies policy recommendations for governments that aim to facilitate publicly accessible EV charging.

Early market-led deployment often concentrated on high-demand locations, with lower-demand areas seeing more limited investment, which can constrain wider use and undermine drivers' confidence. In many countries, authorities are increasingly focused on how to guide market growth to align infrastructure deployment with broader public policy objectives, including widespread coverage, competition, affordability and high service quality. Structured, policy-driven roll-out is gradually replacing early, market-led deployment, with developed markets and some emerging economies adopting more co-ordinated, strategic approaches to infrastructure planning.

Building publicly accessible EV charging infrastructure involves substantial upfront investment and considerable uncertainty, particularly during the early stages of market development. In this context, public-private co-operation enables the expansion of charging networks by mobilising private capital and expertise. Policy frameworks that reduce investment risk and provide market certaintyplay an increasingly important role in guiding infrastructure development from the outset, as early deployment decisions can significantly influence the long-term structure of publicly accessible charging markets. The relevance and sequencing of policy measures will depend on national circumstances and policy priorities, including prevailing economic conditions and objectives set across the energy and transport sectors.

Different deployment models grant authorities varying degrees of control over network build-out and will have different downstream impacts on coverage and market structure. A given model will shape public financing requirements and allocation of risks, and guide future market dynamics. Permit-based models generally involve low public cost, but offer limited control over deployment. This control limitation can create a risk of market concentration at economically attractive spots and thus lead to coverage gaps in the long term. Public operator models give authorities more control, but require significant upfront investment and a robust governance structure for these to be effective. Another model involves concessions, which are public contracts where authorities grant a private partner the right to install, operate and/or maintain charging infrastructure deployed on public land for a defined period of time. When properly structured and transparently awarded, concessions enable authorities to shape market entry, prevent over-concentration and preserve contestability over time. For countries that aim to facilitate publicly accessible EV charging deployment with private operators, concessions are an effective model for balancing public objectives with private investment, reducing risk for authorities, promoting competition and making investments bankable, while supporting service quality, coverage and long-term financial sustainability.

In a context of rapid EV adoption, building publicly accessible charging infrastructure is becoming an increasingly urgent matter for governments interested to support the transition. Emerging markets can act proactively, learning from global experiences and anticipating infrastructure needs that are adapted to their national contexts. Public authorities' intervention at early phases of market maturity is particularly valuable, as decisions made at the outset constrain outcomes in the longer term. Network development can be guided early on in a way that is geographically balanced, economically efficient and operationally robust.

Recommendations

Governments aiming to facilitate the deployment of publicly accessible EV charging infrastructure, can consider the following practices that have proved effective in several countries:

Develop policy frameworks that help de-risk charging infrastructure investments

Where governments seek to support long-term transport electrification strategies, clear and credible policy signals, combined with measures that stimulate EV adoption and reduce regulatory uncertainty, are essential to de-risk investments in electric vehicle charging infrastructure. Demand-side policies that accelerate EV uptake, charging infrastructure targets and regulatory measures, such as sales regulations and zero-emission zones have been applied in some countries to create favourable conditions for infrastructure deployment. Co-ordinated policy measures across different levels of government are critical to ensure that EV incentives support the development of the wider ecosystem. Instruments applied in various countries include fiscal incentives for EVs and local policies, such as free parking, charging incentives and toll exemptions. In parallel, some authorities are addressing non-financial barriers to infrastructure deployment to increase predictability and lower investment risk. Holistic planning frameworks that align measures across transport, energy and urban policy can help prevent co-ordination failures and streamline the deployment of charging infrastructure.

Include and co-ordinate electric vehicle charging in urban, transport and energy planning

The roll-out of publicly accessible charging infrastructure is slowed, and its cost increased by infrastructure and administrative bottlenecks that delay project timelines. This forces key steps – such as permit approval, grid upgrades and construction – to occur sequentially rather than in parallel. In contexts where such inefficiencies arise, some public authorities have integrated EV charging in urban planning. Data-driven projections can be used to identify site- and corridor-level demand, secure land for charging infrastructure deployment and anticipate grid reinforcements where necessary. This is particularly important in low- and middle-income countries where many cities and road networks are still being developed. Ensuring proactive co-ordination across transport, energy and urban planning stakeholders to establish clear and standardised guidelines for deployment can mitigate structural administrative constraints and support timely and geographically balanced network expansion. To maximise efficiency and minimise bureaucracy, a unique and reliable communication channel could be established between charge point operators (CPOs) and public authorities, following a "one-stop-shop" model.

Bundle prime and non-prime locations to ensure long-term widespread coverage

In unguided charging infrastructure deployments, charge point operators (CPOs) naturally prioritise prime locations with the highest possible infrastructure utilisation and, thus, strongest revenue profiles. In several markets this has led to persistent under-provision of rural, corridor and socially disadvantaged areas where EV uptake is slower. This puts structurally underserved regions at risk and locks those public authorities into long-term subsidies that aim to ensure minimum coverage. Bundling commercially attractive and less attractive sites within a single tender or concession can help to align private investment incentives with public coverage objectives. Bundles must, nevertheless, remain commercially attractive to attract private investment. This can be supported through site-level exclusivity, appropriate bundle sizing and flexibility to build sites within the same bundle at different times to respond to evolving utilisation and capital constraints.

Prioritise concession models to ensure a long-term competition

Public authorities can guide the deployment of publicly accessible charging infrastructure to ensure long-term competition, along with affordable and widespread access. Concessions are competitively tendered contracts that grant the right to deploy and operate publicly accessible charging infrastructure on public land. In countries seeking to accelerate deployment while ensuring competitive market outcomes, such concessions for publicly accessible backbone charging infrastructure should be awarded through transparent, open and non-discriminatory procedures. They create competition *for* the market and provide authorities with the highest leverage to introduce service criteria and coverage obligations, aligning deployment with public policy objectives. As concessions inherently grant exclusive operating rights, the risk of market dominance by a single CPO can be reduced by structuring the tendered portfolios awarded in concessions into multiple geographically overlapping bundles of charging sites. Providing users with the ability to choose between multiple CPOs within a reasonable driving distance fosters competition and helps ensure long-term affordability.

Ensure public charging networks are accessible to users

An accessible charging network enables users to easily locate, use and pay for charging services regardless of the vehicle they drive, charger brand, charge point operator or contract-based service they hold. Achieving this requires strong public-private co-operation; provision of transparent and real-time information on charger availability, functionality and prices; establishment of clear uptime; data reporting to ensure reliability, and measures to mitigate vandalism and cable theft. Harmonised communication protocols and open application programming interfaces (APIs) also help ensure interoperability between vehicles, charging stations and backend systems across operators and jurisdictions. These measures, together with information campaigns to educate EV drivers on how to plan charging events during long-distance travels, support seamless user experience, enhance trust in publicly accessible charging networks and facilitate efficient market functioning. Consulting diverse user groups in the design and build-out of charging networks can also ensure they are accessible to a wide range of current and potential users.

Introduction

The electromobility market has experienced unprecedented growth in recent years. Globally, more than 20% of new cars sold are now electric. Annual sales of electric cars have more than tripled in the last four years, reaching over 17 million units in 2024. Medium- and heavy-duty electric vehicles sales are also expanding rapidly, supported by increasingly favourable economics in some applications. According to the International Energy Agency (IEA), the global electric vehicle (EV) fleet could quadruple by 2030 (IEA, 2025). The large and growing number of EVs already on the road, substantial public and private investment committed to the transition and expected acceleration of EV uptake in the coming years underscore the importance of deploying efficient and reliable charging networks.

Publicly accessible EV charging infrastructure forms the backbone of these networks and is needed to support EV adoption. It encompasses charging points or stations that are available for use by the general public, irrespective of ownership or whether they are located on public or private land. This implies that any EV driver may access and utilise the infrastructure without belonging to a pre-defined user group, such as employees, customers or residents. Publicly accessible charging infrastructure should provide transparent and up-to-date information on location, availability and pricing, and comply with technical and interoperability standards that accommodate a broad range of vehicle types and payment methods.

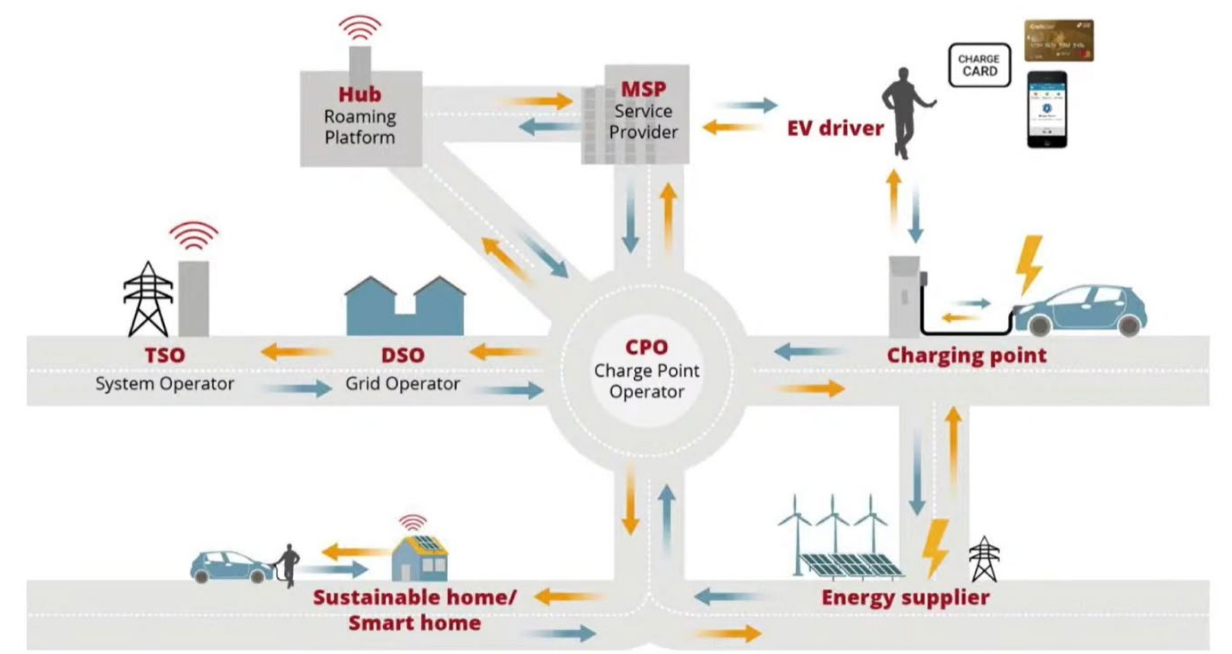
To date, most EV owners have access to home charging, which has facilitated early adoption (IEA, 2025). However, supporting mass market uptake of EVs in some regions will require the availability of affordable and convenient publicly accessible charging infrastructure. While home charging is expected to remain the primary charging method for passenger cars (and depot charging for medium- and heavy-duty vehicles), publicly accessible charging will play a critical complementary role. It will enable broader EV use among households and drivers without access to private charging facilities and enhance the overall reliability of the charging network by ensuring convenient opportunities for in-route top-ups during long-distance trips. This is of particular importance for high-mileage vehicles and medium- and heavy-duty EVs with long duty cycles.

Ensuring reliable and widely available publicly accessible charging infrastructure requires co-ordinated action across multiple stakeholders. Public authorities can play a decisive role at every stage of deployment, from strategic site selection to designing financing and operational models. Building charging infrastructure networks is complex. It involves considerations of grid preparedness, allocation of public space and, particularly in the early stages, the possible use of financial incentives or support. In many countries, effective governance has helped to safeguard grid stability, manage competing demands for urban space and ensure that public resources are used efficiently. This responsibility applies regardless of whether authorities choose to roll out publicly accessible charging infrastructure directly through public operators, procure them through concession schemes or rely primarily on market-led deployment.

The electric vehicle charging ecosystem

The development of efficient and reliable EV charging networks is intrinsically complex, as it depends on the co-ordinated interaction of multiple stakeholders operating across energy and transport sectors (Figure 1). At the centre of this ecosystem are Charge Point Operators (CPOs) who deploy, own and operate charging points or stations. There are also e-Mobility Service Providers (EMSPs) who manage customer relations with EV drivers by offering access, authentication, billing and digital services. Roaming platforms play a critical enabling role by ensuring interoperability between CPOs and EMSPs, allowing EV drivers to seamlessly access charging services across different networks and national borders. Beyond transport actors, the charging ecosystem is deeply integrated with the electricity system. Energy suppliers provide the electricity that powers charging infrastructure. While Distribution System Operators (DSOs) manage local and regional electricity networks to ensure charging demand can be accommodated without compromising grid stability, Transmission System Operators (TSOs) oversee the high-voltage transmission system and maintain overall system balance. Effective co-ordination among CPOs, DSOs, TSOs and energy suppliers is essential to avoid grid congestion and enable smart charging that can support wider energy system objectives. The EV driver is the ultimate beneficiary, requiring reliable and widely available charging infrastructure that is both privately (home, workplace and depot charging) and publicly accessible.

Figure 1. The EV charging ecosystem



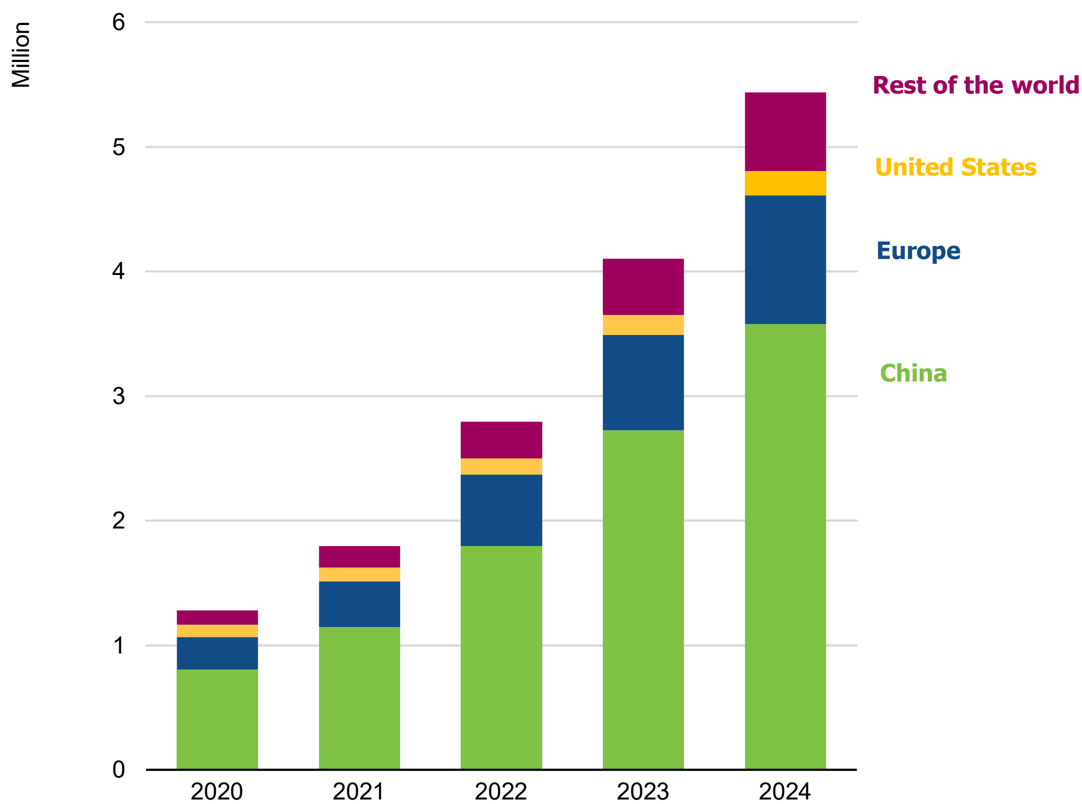
Source: EV Roaming Foundation

Global state of publicly accessible charging infrastructure roll-out

The global roll-out of publicly accessible EV charging infrastructure has accelerated rapidly in recent years, broadly mirroring trends in EV sales. Figure 2 shows that between 2022 and 2024, the global stock of publicly accessible chargers almost doubled, increasing from around 2.3 million to nearly 5 million units, with particularly strong momentum in 2024, when more than 1.3 million charging points were added worldwide. China has been the dominant driver of this growth and now accounts for around 65% of the global publicly accessible charging stock. Europe represents the second-largest market, with publicly accessible chargers surpassing 1 million units and annual growth rates exceeding 35%, while the number of publicly accessible charging points has reached just under 200 000 in the United States. Meanwhile, emerging markets are increasingly contributing to global growth: India added around 40 000 publicly accessible chargers in 2024, Brazil exceeded 12 000 charging points and several Southeast Asian countries collectively expanded their networks to over 24 000 chargers, supported by targeted public policies and private investment. These developments highlight a global transition from early-stage deployment towards more structured, policy-driven charging networks, with China and Europe setting the pace and emerging economies beginning to scale up rapidly (IEA, 2025; Rui et al., 2025).

At the same time, demand for publicly accessible charging is closely conditioned by the availability of private charging options (e.g. home, work and depot charging). However, limited and fragmented data on both public and private charging infrastructure make it difficult to capture a comprehensive view of overall charging provision, with most existing research focusing primarily on publicly accessible networks (Xylia et al., 2025). As a result, observed cross-country differences on publicly accessible charging stock should be interpreted with caution, as they may not fully reflect underlying differences given the limited visibility over private charging availability.

Figure 2. Stock of publicly accessible chargers by world region

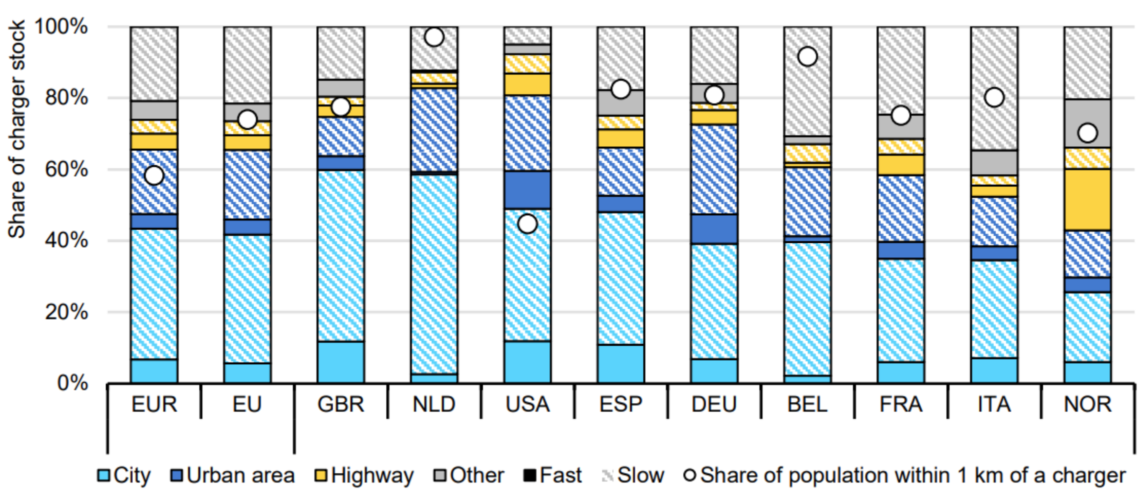


Source: Adapted from Global EV Outlook 2025 (IEA, 2025)

No single "one-size-fits-all" approach exists

The building of publicly accessible EV charging infrastructure requires different strategies that reflect local conditions, user needs and policy objectives. The required scale of publicly accessible charging infrastructure is closely linked to the availability of private off-street charging options, including home, workplace, transport hubs, terminals and fleet depot facilities. Areas with widespread access to private charging generally require fewer publicly accessible charging points, whereas locations with limited private provision must compensate with higher levels of publicly accessible charging capacity. This must be supported by appropriate choices of charger power, spatial placement and density. Slow Alternating Current (AC) charging points or stations are generally best suited to locations where vehicles are parked for extended periods, such as residential streets and public car parks. As a result, authorities often prioritise AC charging. This can be offered at lower prices in neighbourhoods with limited access to private off-street parking to ensure access for drivers who cannot charge at home (ACEA, 2022; Transport & Environment, 2022). This approach may be particularly relevant in dense urban areas and multi-unit residential developments where car ownership levels are significant, private off-street charging is structurally constrained and public space can still be allocated without conflicting with broader urban policy objectives. However, in cities that prioritise reducing the use of public space for private vehicles, authorities have already deliberately limited widespread curbside AC charging in favour of alternative solutions. These include collaboration for off-street deployment on private land and the development of fast-charging hubs (Mobility Portal, 2021). Direct Current (DC) fast and ultra-fast charging stations are designed to support rapid turnover and to minimise downtime. They are well suited to high-traffic locations, transport hubs and strategic corridors, such as highways and inter-urban routes (ACEA, 2022; LaMonaca and Ryan, 2022; Nasri et al., 2025).

Figure 3. Type and location of publicly accessible charging in selected world regions and countries, 2024



Source: Global EV Outlook 2025 (IEA, 2025)

International experience confirms that no single deployment model is universally optimal. Instead, effectiveness relies on balancing the portfolio of charging solutions by tailoring it to housing stock, population density, commuting patterns and travel behaviour. As illustrated in Figure 3, across Europe and the United States today, most publicly accessible charging points are in cities and urban areas where longer parking durations favour slow AC charging. Highway chargers account for a small share of points but a larger share of capacity, reflecting their role in in-route charging (IEA, 2025). On the contrary, Chinese cities with dense urban environments defined by high-rise housing and limited curbside space rely heavily on DC fast chargers. In Beijing, for example, around half of publicly accessible chargers are DC fast chargers, concentrated in central urban districts where spatial constraints favour centralised fast-charging hubs over dispersed low-power AC installations (Rui et al., 2025). These differences underline how charging speed and location are shaped by urban form and land-use constraints, and why a single, universally applicable deployment model is unfeasible (see Section 5).

Models for deploying publicly accessible charging infrastructure

Public authorities can deploy publicly accessible charging infrastructure on land under their management through different models, most commonly, permit-based models, public operator models and concession models (EIB, 2024).

- *Permitting Model*: CPOs apply for permits from authorities to install and operate charging points in specific locations. If approved, they must meet basic requirements and compete with other providers, without exclusivity on public land.
- *Public Operator Model*: The local authority directly purchases, installs and operates the charging infrastructure, acting as the CPO.
- *Concession Model*: Governing authorities grant exclusive rights to one or more CPOs to install and operate charging points on public land within a region, typically for a set period. Concessions can be developed individually or in collaboration with neighbouring municipalities or regions. Concessions must be awarded through open and transparent competitive bidding process to maximise participation and receive higher-quality bids. The selection criteria must be tailored to the authority’s strategic objectives. These include service quality, installed charging power, investment timescales, future-proofing and upgrades. The concession tender documents can differ by use cases, distinguishing between urban charging networks, regional coverage or high-power charging on national highways.

The different models have advantages and disadvantages for different stakeholders, including public authorities. The most suitable model depends on the maturity of the e-mobility market and the resources available to public authorities.

Aligning infrastructure deployment with public policy objectives

Public authorities are uniquely positioned to steer publicly accessible EV charging deployment towards overarching public policy objectives that the market alone may not fully deliver. Regardless of whether authorities choose to deploy infrastructure directly through public operators, procure it through concession schemes or rely predominantly on market-led investment, their role remains pivotal in setting the conditions under which networks develop. Likewise, while priorities may differ across stages of market maturity, from early network expansion to later optimisation and densification (Kok and Rajon Bernard, 2025a), certain foundational aspects require attention from the outset.

Early, consistent and ongoing guidance can help to ensure that publicly accessible charging infrastructure develops in a way that is geographically balanced, economically efficient and operationally robust. For countries aiming to achieve the goal of balanced, efficient and robust networks, public authorities should, throughout the deployment process: support widespread roll-out, safeguard long-term market competition and transparent pricing for end-users, and secure reliable and interoperable publicly accessible charging networks.

Ensure widespread coverage in the long term

The business case for the building of publicly accessible charging infrastructure is subject to the interplay of market conditions and regulatory environments. There are several factors that influence the profitability of charging infrastructure – one of which is utilisation rates. The utilisation rate measures how extensively charging infrastructure is being used and how quickly investments monetise. The economic viability of building out publicly accessible charging infrastructure, particularly in the early stage, can be challenging as the utilisation rate of infrastructure may be low at some sites due to the limited number of EVs on the road (ZEV Alliance, 2024).

Private sector players entering the market or expanding their networks are logically attracted to investing in sites with high demand (prime locations). As such, areas with low population density and places where penetration of EVs is more delayed compared to others are less attractive (Bhatt et al., 2024; Kirshenberg S et al., 2024; LaMonaca and Ryan, 2022). As a result, the building of publicly accessible charging infrastructure in unguided markets is unevenly distributed. Urban centres have most often remained the focal point for charging infrastructure deployment, leaving intercity corridors and rural regions underserved (IEA, 2025). In Canada, charging in rural and remote regions, and along highway and road corridors represents a small share (1-2%) of total charging stations (Dunsky, 2024). Studies show unequal roll-out in urban centres where people living in lower-income neighbourhoods have less access to publicly accessible charging infrastructure (Bhatt et al., 2024; Rajon Bernard et al., 2024; Yu et al., 2025). While this pattern is expected in the early phases of roll-out, reflecting spatial differences in EV adoption, its persistence in the medium- to long-term could lead to undesirable outcomes that exacerbate existing inequalities in accessibility to services and transport costs.

Public authorities can steer the development of publicly accessible charging infrastructure networks to avoid the concentration of infrastructure in prime locations and prevent the creation of underserved areas in the long term. Establishing a dedicated charging infrastructure masterplan as part of a broader EV strategy constitutes a key governance instrument for widespread and balanced coverage. Such a masterplan can define spatial planning principles and deployment targets that provide regulatory certainty while guiding the market.

In practice, some jurisdictions such as Germany and the city of Delhi have operationalised this approach through structured tendering mechanisms designed to secure investments across a mix of more and less attractive charging locations. The economic attractiveness of locations was determined based on the expected number of charging operations and their expected daily and annual average utilisation rate.

In both cases, authorities created bundles of charging sites that included prime and non-prime locations, which were then offered via a tendering process for infrastructure development:

- On the basis of the Fast Charging Act, the Federal Ministry of Transport (BMV) initiated the *Deutschlandnetz* tender to build a user-friendly network of publicly accessible high-power charging points. Thereby, the elimination of "white spots" or underserved areas along federal motorways and in rural, urban and suburban areas is ensured (BMV, 2021). The public tender guides the installation and operation of approximately 1 000 sites featuring at least 150 kW per charging point. In two separate calls, bidding bundles contained a mixture of commercially attractive, and less attractive sites and areas. The tender also included a smaller bundle to allow small and medium enterprises (SMEs) to have equal access to the market.
- Delhi's State Nodal Agency (SNA) identified a total of 100 land parcels from various land-owning agencies across the region and aggregated them into bundles consisting of 7-11 sites each (DDC-D, DoT-Delhi and RMI, 2022). These bundles were then offered on a concessional basis through an open tendering process.

This approach taken in Germany and Delhi supports the long-term objective of widespread coverage by securing infrastructure investments in areas with lower expected use rates. It also helps to prevent the public sector from being locked into subsidising deployment in locations that remain of limited profitability in the longer run. However, it is important that bundles still have a viable business case to attract investment from the private sector. This is particularly so in countries or regions where EV adoption is low, where even infrastructure deployed at prime locations face difficulties in recovering investment costs in a foreseeable future. In these cases, authorities may stipulate in tenders that different sites within a single bundle can be built at different times. This allows CPOs to prioritise limited capital for locations with higher expected use rates, while still guaranteeing widespread coverage in the longer term. This has been successfully applied in Greek concession tenders (ITF, 2024).

Simultaneously, these tenders may create attractive opportunities for the private sector by incorporating features that address some of the significant challenges of building charging infrastructure. The concessional agreements in Delhi have incorporated the following:

- *Smoothing capital and operational costs* – While concessionaries are responsible for covering costs associated with obtaining equipment and metered connections, power distribution companies were mandated to provide electricity connections of up to 100 kW on each site. This cost-sharing approach has helped to ease challenges associated with the costs of upstream electrical infrastructure (NITI Aayong et al., 2023). Additionally, land is offered on a revenue-sharing basis, where concessionaries pay a fixed rate (INR 0.7 per kWh (USD 0.008 per kWh) of electricity sold) to the site-owning agency for the duration of the agreement (DDC-D, DoT-Delhi and RMI, 2022; NITI Aayong et al., 2023).
- *Creating flexibility* – Only 30% of the space within each bundle is designated to meet pre-defined contract requirements, including offering charging at a mandated price to consumers and

complying with specifications on the type and number of chargers to be installed. The remaining 70% is left flexible, allowing the operator to set prices and choose the combination of chargers (such as AC versus DC) based on site-specific economic and technical considerations (DDC-D, DoT-Delhi and RMI, 2022). This flexibility helps mitigate risks associated with evolving technologies and varying levels of feasibility across locations (OECD, 2023).

- *Minimising bureaucracy and bottlenecks* – To deploy charging stations across Delhi, CPOs must navigate a complex maze of land-ownership patterns and regulations to access parcels of land (DDC-D, DoT-Delhi and RMI, 2022). To address what can otherwise be a very time-consuming process dealing with various land-owning agencies, the bundles offered sites that fall within the jurisdiction of just one land-owning agency. Additionally, the State Nodal Agency (SNA) provided the concessionary with regulatory support for applications, permissions, quality checks and site feasibility assessments. The SNA also supported early electricity connections at sites by co-ordinating with power distribution companies (NITI Aayong et al., 2023).
- *Safeguarding affordability* – Unlike typical bidding criteria that focuses on revenue maximisation, Delhi selected the service charge to the end consumer as the basis for bidding. Because bundles combined with other incentives strengthened the business case for private investment, competition among bidders resulted in negative service charge bids. Delhi EV owners can charge their vehicles for just INR 12-20 per kWh (USD 0.13-0.22 per kWh), which translates to under INR 2 per km (USD 0.022 per km), a rate that is among the lowest in the world (DDC-D, DoT-Delhi and RMI, 2022; NITI Aayong et al., 2023; OECD, 2023).

Going forward, authorities should move beyond purely focusing on achieving spatial coverage in charging networks. Ensuring the capacity of new and existing infrastructure will become increasingly critical. As the EV market grows, the demand for charging risks outstripping the capabilities of initial stations.

Ensure long-term competitive markets

Long-term competition in publicly accessible EV charging markets is crucial to ensure low prices for the end-user, high charger uptime and service quality, and continuous innovation. Assessing such competition requires defining the relevant market within a given geographical area, ensuring that users have access to a sufficient number of substitutable charging alternatives (see Section 4). This benefits users and ultimately reduces the systems cost of electrification. A growing body of evidence shows that geographically concentrated charging markets where few CPOs operate a large share of sites in a region (or one charger type) can weaken competitive pressure on prices and service quality (European Commission, 2023; ICCT, 2025a).

Public authorities can play an important role in fostering markets' long-term competitive environment, particularly during the early stages of deployment. Public authorities frequently oversee land in strategically advantageous locations, such as sites along major highway and transport corridors, and within dense urban areas. They, therefore, have multiple models for building publicly accessible charging infrastructure on publicly owned land, with each approach carrying significant implications for competition.

Permit-based models can accelerate early deployment. However, they provide few tools to manage market structure (ITF, 2024). First-moving CPOs secure scarce high-value locations, which may not only lead to underserved areas in the long-term (see previous section), but to market dominance by few CPOs. This undermines long-term competition, with negative outcomes on end-user prices (ICCT, 2025).

Public operator models can ensure alignment with public policy objectives and avoid private market power, but shift risks to the public balance sheet. While this model has been successful in a few cases, such as in cities with strong governance structure, it is rarely scalable due to the financial and operational constraints faced by public authorities (ITF, 2024). Furthermore, it can have similar outcomes of single-provider dominance, where a municipal utility company maintains market dominance over public charging and has limited competitive pressure on pricing or service quality from other providers, particularly if public prime locations are given to the municipally-owned company. Recent market studies by competition authorities (Bundeskartellamt, 2024a) find that carefully designed land allocation mechanisms for charging infrastructure deployment can reduce the risk of market dominance and the resulting higher prices to end-users.

> *In many cities and municipalities, competition in the supply of charging opportunities does not function properly, as public spaces for charging stations are often only allocated to municipal utilities or individual providers. As a result, there are only a few providers in many regions, which leads to these providers having a dominant market position. This means that consumers have little choice and the risk of higher prices increases, as providers do not have to fear competition. Better regulations on the allocation of space could prevent this situation.* (BMK, 2024)

The third model authorities can follow to roll out publicly accessible charging infrastructure on public land is through concessions. Concession models allocate exclusive rights to deploy and operate charging infrastructure through competitive tenders for a specific site or bundle of sites, typically for a fixed period of time and under clearly specified performance and coverage obligations. To ensure effective competition, such concessions must be awarded through transparent, open and non-discriminatory procedures. The design and implementation of concession frameworks can also be institutionally and contractually complex, requiring careful specification of obligations, risk allocation and monitoring mechanisms. It may pose capacity challenges for authorities with limited prior experience, particularly in developing tender documentation, guidance materials and contract management practices. When properly structured, however, concessions enable authorities to shape market entry, prevent over-concentration and preserve contestability over time through contract design, duration limits and rebidding. This makes concessions an efficacious model for combining widespread coverage objectives with sustained competition and private investment at scale (see Section 4).

Ensure public charging networks are accessible

Charging infrastructure should be accessible. An accessible network is also one that is reliable and not, for example, frequently out of service. Users should be able to trust and depend on it to meet their needs, from daily commuting to longer journeys (Rajon Bernard et al., 2024). Networks must also allow users to seamlessly find, use and pay for charging regardless of the vehicle they drive, brand of charger or network operator. Beyond the number of charging points and the network coverage, two key factors underpin a truly accessible public charging network: reliability and interoperability. Some jurisdictions have gone further by developing guiding frameworks that include standards and specifications to support building public charging infrastructure that is accessible for all users (see Box 1). Consulting diverse users, including those with disabilities can help ensure these frameworks translate into charging networks that are designed for a broad range of users with different needs (Harvey et al., 2026).

For public authorities who wish to advance EV adoption, doing so requires more than expanding physical infrastructure. As the market moves beyond early adopters, mainstream consumers will expect a mature, dependable system and display less tolerance for unreliable or fragmented networks (Kurani and

Ogunmayin, 2023; Malarkey, Singh and MacKenzie, 2023; Singh, Quinn and MacKenzie, 2025). Building an accessible charging network can benefit from strong public-private co-operation, the implementation of uptime and data-reporting requirements, and the adoption of open hardware and software standards (Ferwerda and David Roldan, 2025; Ferwerda and van Dinther, 2023; Muratori et al., 2025). Such provisions can be embedded in concession agreements and procurement frameworks. These include service-level agreements governing maintenance, uptime and performance, drawing on international best practices and existing guidelines for public authorities (Mol et al., 2022; Sustainable Transport Forum, 2020).

Reliability

Concerns related to the reliability of publicly accessible charging networks can impede broader EV adoption. When drivers cannot depend on chargers to function as needed, confidence in switching to electric mobility declines (Rajon Bernard et al., 2024). Research in the United States found that the perceived reliability of charging stations had the same effect on EV purchase intentions as an additional 32 000 new public chargers, reducing EV prices by 32% or extending vehicle range by 540 kilometres (Singh, Quinn and MacKenzie, 2025).

A charger can become unusable due to various causes, such as unresponsive screens, payment system failures, connectivity issues or physical damage resulting from vandalism. The latter includes missing cables, damaged screens and broken connectors (see Section 5). To address reliability concerns, jurisdictions have introduced or are in the process of developing standards, uptime and data-reporting requirements, sometimes linked to enforcement mechanisms to ensure compliance. In developing such standards, it is important to determine which malfunctions are covered and what data reporting requirements apply. Other measures include standards relating to communication protocols and component durability, as well as mandating that charging network operators provide real-time information on charging availability and functionality(Powell and Johnson, 2024; Rajon Bernard, 2023). Service-level agreements in contracts with CPOs offer another mechanism for ensuring reliability, with penalties for non-compliance introduced in some cases (see Section 5) to ensure operators maintain functional charge points.

Box 1. Building infrastructure accessible for all

The German National Centre for Charging Infrastructure published requirements (DIN SPEC) to ensure infrastructure is accessible for persons with disabilities. Requirements are applicable to the planning, deployment and equipment of charging infrastructure - charging infrastructure is considered accessible when persons with disabilities are not faced with any barriers in finding, accessing and using the infrastructure, and can do so, in principle, without assistance.

The link between an accessible loading area or public pedestrian infrastructure and charging stations should be barrier-free- the longitudinal and transverse slope of connecting paths and surface design of connecting routes should be constructed for access for persons with disabilities. Other requirements apply to the dimensions of parking spaces and areas, and the charging equipment itself- charging cable, card readers, payment terminals and screens. For example, a suitable cable management system must prevent the use of attached charging cables from obstructing movement between the charge point and the vehicle.

DIN SPEC is a non-obligatory guiding framework with standards and specifications to support the delivery of charging infrastructure that is accessible to all. The requirements aim to fill a gap where a standardised approach to the delivery of barrier-free charging infrastructure has yet to be developed. DIN SPEC may be the basis for a later, obligatory DIN standard.

Source: (DIN SPEC, 2024)

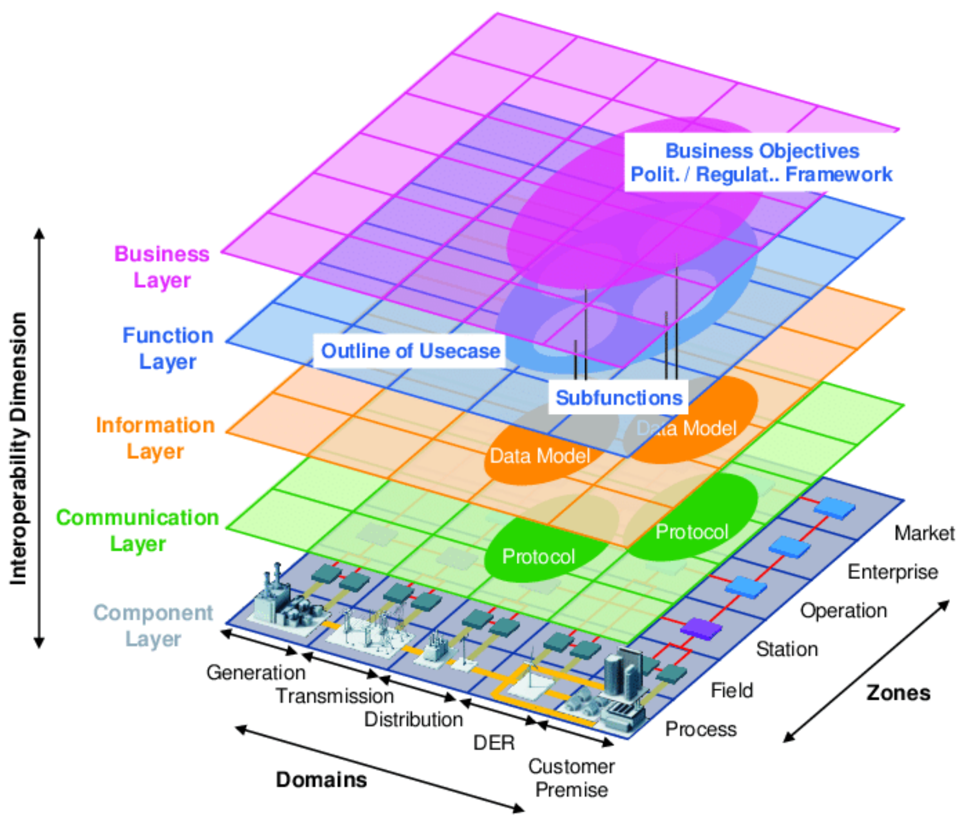
Interoperability

An interoperable charging network allows multiple systems and actors to function together seamlessly. The vehicle, user and charger interact smoothly- drivers can access any charger, plug in without compatibility issues and pay without needing multiple accounts. Communication between the charger and the car safely delivers power and handles authentication and session details.

Hardware interoperability relies on standardised connector types that ensure compatibility across vehicle and charger models. Software interoperability enables communication among vehicles, stations and networks across vendors and jurisdictions relying on roaming services (Rajon Bernard et al., 2024). It allows drivers to authenticate, pay and access charging services across providers and facilitates real-time information-sharing on station availability. Standardised communication protocols play a vital role in enabling this interoperability. Examples include:

- *OCPP (Open Charge Point Protocol)* to communicate between chargers and CPOs for managing charging stations
- *OCPI (Open Charge Point Interface)* to communicate between CPOs and EMSPs for EV roaming
- *ISO15118* for vehicle-to-charger communication

Figure 4. Smart Grid Architecture Model (SGAM)



The Smart Grid Architecture Model (SGAM) (Smart Grid Coordination Group, 2012) provides a structured way to map how actors, systems and communication interfaces interact across the EV charging ecosystem, including EVs, chargers, CPOs, and EMSPs (Figure 4). By locating these interactions across technical and operational levels, SGAM helps identify where interoperability standards and communication protocols are required. It is particularly useful in policy and planning to analyse interoperability gaps, co-ordinate stakeholders and guide the development of interoperable EV charging infrastructure.

Interoperability is a pre-condition for smart, bi-directional EV charging to integrate seamlessly into the broader energy ecosystem (Ferwerda and David Roldan, 2025; Joint Office of Energy and Transportation, 2024). It is equally important for companies and governments investing in infrastructure deployment, as it enhances market efficiency and improves the business case for network expansion (Mol et al., 2022).

Jurisdictions can promote interoperability by regulating connector types; advancing and supporting the harmonisation of communication protocols; developing APIs and engaging in close collaboration among industry stakeholders (Ferwerda and van Dinther, 2023). As an example, the European Commission adopted a new Implementing Regulation in April 2025 to operationalise data-sharing obligations under the Alternative Fuels Infrastructure Regulation (AFIR), rules and specifications that aim to make EV charging data uniform and interoperable across the European Union (EU).

How planning and policy can support infrastructure deployment

Effective planning and coherent policy frameworks can accelerate deployment of publicly accessible charging infrastructure while ensuring that networks develop in a cost-efficient, resilient, and future-ready manner. Public authorities can influence the pace and scale of infrastructure roll-out by reducing investment risk and improving market predictability. Clear long-term strategies supported by transparent rules and consistent implementation provide the certainty required to mobilise private investment and avoid fragmented or sub-optimal infrastructure development.

To achieve these outcomes, policymakers may combine robust analytical tools with proactive co-ordination across sectors and administrative levels. This includes leveraging data and modelling to anticipate future demand, aligning charging deployment with electricity grid planning, reserving land and grid capacity ahead of need and simplifying administrative processes to reduce delays and costs. It also calls for a more integrated approach to transport and energy planning- one in which the transition of mobility systems and the expansion of energy infrastructure are treated as a mutually dependent process. By addressing these dimensions in a holistic manner, public authorities can reduce risks, minimise infrastructure bottlenecks and create the conditions for scalable, affordable and reliable publicly accessible charging networks.

Effective policy frameworks help de-risk infrastructure investments

Building publicly accessible EV charging infrastructure requires large upfront investment and entails considerable operational uncertainty, particularly during the early stages of market development when utilisation rates are often low and investments difficult to monetise. At the same time, the scale of infrastructure deployment required to deliver a robust and widespread publicly accessible charging network means that needed investment often exceeds public budgets. Private sector participation therefore, often plays an important role, leading authorities in many markets to develop policy frameworks that reduce investment risk, improve predictability and create market certainty. Clear and credible signals of long-term commitment to electrification combined with measures that stimulate EV adoption and reduce regulatory uncertainty can significantly improve investment conditions for charging infrastructure (IEA, 2022). To provide this certainty, governments across many markets have developed, or are developing, comprehensive electromobility strategies that bring together complementary regulatory measures needed to underpin a publicly accessible charging network (IEA, 2024a; Vergiler, 2024).

A critical driver of the charging infrastructure business case is the size and growth trajectory of the EV fleet. Charger utilisation rates are strongly linked to EV adoption and uncertainty around future demand is consistently identified as a key deterrent for investment. Demand-side policies that accelerate EV uptake, therefore, can play an indirect but crucial role in de-risking infrastructure investment. Empirical analyses show that early-stage EV purchase incentives, such as purchase subsidies, tax exemptions or company car benefits, have significantly increased EV adoption in multiple markets, thereby improving the utilisation prospects of publicly accessible chargers (Hardman et al., 2018). Norway, through long-standing fiscal incentives for EVs, including exemptions from purchase tax and value added tax (VAT), alongside local policies favouring EV use, such as free parking, charging and toll exemptions, has achieved rapid EV adoption well ahead of other countries. This policy mix not only shifted vehicle purchasing behaviour, but also enabled the emergence of a commercially viable EV charging market. While such incentive structures are context-specific, the Norwegian case illustrates how strong EV adoption policies at early market stages can translate into lower infrastructure investment risk. Many other markets have since adopted comparable fiscal incentives and use incentives adapted to their national contexts (Azərbaycan Respublikası, n.d.).

Regulatory measures that restrict or discourage the use of internal combustion engine vehicles can further strengthen these demand signals. Low- and zero-emission zones have been found to influence fleet renewal decisions, particularly for commercial vehicles operating in urban areas. In the Netherlands, the announcement and phased introduction of zero-emission freight zones provided long-term clarity to operators. This led to a sharp increase to above 70% in electric truck sales after implementation in early 2025 compared with just 10% in 2024 (ICCT, 2025b). Although primarily designed as air-quality measures, such zones can have important secondary effects on setting favourable conditions for EV charging infrastructure deployment.

Beyond stimulating demand, favourable policy environments can also reduce risk by lowering non-financial barriers to infrastructure deployment. It is frequently highlighted that administrative complexity, lengthy permitting procedures and uncertainty around grid connections can significantly increase project costs, thereby deterring investment even where demand prospects are favourable. Germany’s Charging Infrastructure Masterplans II and 2030 are transparent and holistic strategies in which clear and precise measures are aligned across transport, energy and construction policy remits. Potential co-ordination failures are thereby effectively diminished and infrastructure deployment streamlined (BMV, 2025; BMV, 2019). Masterplan II addresses specific challenges which came with progressesing market maturity in Germany. Central pillars are the simplification and acceleration of deployment, promotion of competition and price transparency, improving power grid integration and boosting user-friendliness and innovation.

At early stages of market maturity, several places have complemented these measures with explicit targets for publicly accessible charging infrastructure relative to the EV fleet size (ZEV Alliance, 2024). For example, the EU policy framework under the Alternative Fuels Infrastructure Regulation (AFIR) (European Parliament and Council of the European Union, 2023) introduced national fleet-based targets for publicly accessible charging for light-duty vehicles. These have helped align infrastructure deployment with EV uptake and, in practice, are already being met by practically all Member States. AFIR also marks a shift from targets based on the number of charging points to targets based on installed power (expressed in kilowatts per battery electric vehicle and per plug-in hybrid electric vehicle). Power-based metrics better reflect user experience and system adequacy, as they account for charging speed and technological progress rather than simply counting charging points. By allowing flexibility in charger configuration, power-based targets reduce the risk of inefficient over-investment in low-utilisation assets and enable operators to tailor deployment to local conditions.

In addition to fleet-based targets, distance-based requirements are used to ensure geographic coverage and enable long-distance travel. Corridor-focused obligations, such as the requirement under AFIR to deploy high-power chargers at regular intervals along the European TEN-T core network (European Parliament and Council of the European Union, 2023), address a segment of the market that may have marginal profitability in the early stages, but is critical to ensuring network coverage and reliability. By setting minimum coverage requirements, policymakers reduce uncertainty for both drivers and investments.

Rather than relying on uniform solutions, successful approaches in many countries often combine policies that accelerate EV adoption, streamline regulatory frameworks and align infrastructure targets with measurable demand indicators to reduce investment risk and improve the business case for EV charging infrastructure.

Data and modelling are essential to anticipate future needs and guide investment decisions

While publicly accessible EV charging networks are expected to expand rapidly over the coming decade, the scale, pace and geographical distribution of this expansion remain highly region-specific and is subject to significant uncertainty. Robust forward-looking data and modelling tools are essential to anticipate future needs and guide efficient investment decisions.

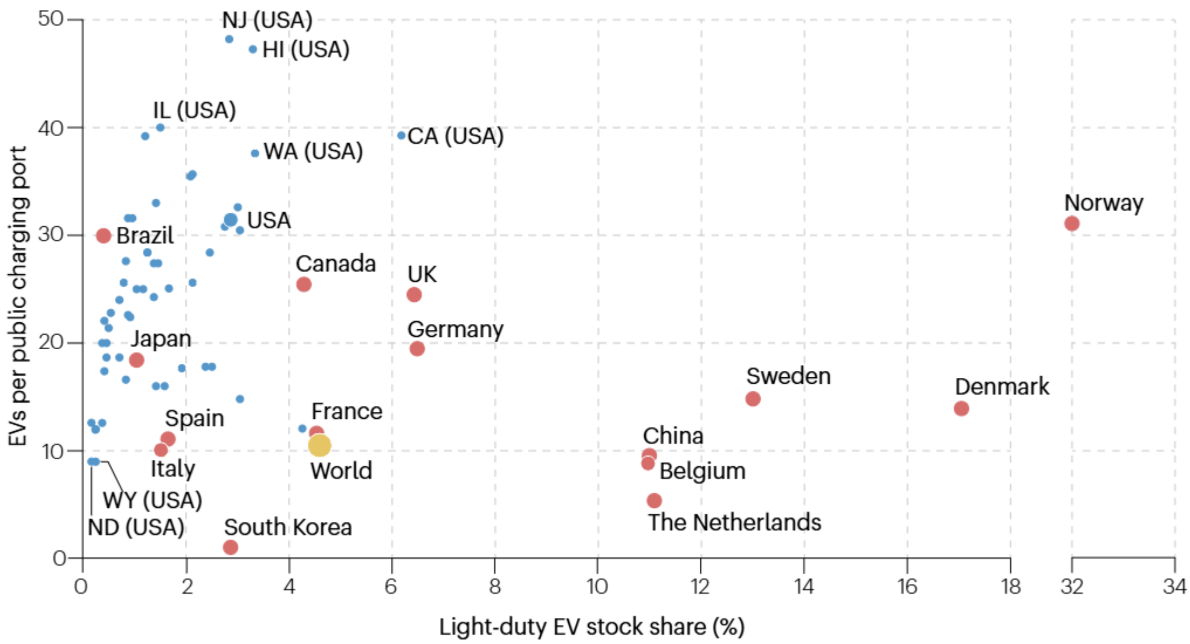
Figure 5 illustrates the current number of light-duty EVs supported per publicly accessible charging port across several world regions. Differences reflect diverse mobility patterns, private charging availability, urban form, transport behaviour and other structural factors that influence reliance on publicly accessible charging. In practice, the demand for publicly accessible charging is largely conditioned by the availability of private charging options, yet limited and fragmented data on both public and private charging infrastructure make it difficult to capture the full picture, with most existing research focusing primarily on publicly accessible networks (Xylia et al., 2025). As a result, observed differences should be interpreted with caution and reinforce a core planning reality: infrastructure requirements are not uniform. Moreover, these requirements change over time as markets mature. Academic research suggests that higher ratios of publicly accessible chargers per EV are required during early adoption phases to maintain user confidence and avoid “range anxiety”, but that these ratios can decline as EV markets mature (Muratori et al., 2025). This finding underpins policy frameworks, such as the EU’s AFIR (European Parliament and Council of the European Union, 2023), which sets temporary fleet-based infrastructure targets and then allows those obligations to lapse once EVs reach 15% of the national fleet (“sunset clause”). After a certain level of EV adoption, chargers’ utilisation rates are generally assumed to be sufficient for market-driven deployment to take over (IEA, 2025).

Two key dimensions of planning data are critical for guiding investment and publicly accessible charging infrastructure deployment decisions: future EV fleet size and local grid capacity availability.

Future EV fleet size

Reliable projections of EV fleet size and spatial adoption patterns are essential to inform where, when and what type of charging infrastructure will be needed. Modelling tools that integrate historical uptake trends, policy scenarios and demographic data support planners and investors in aligning infrastructure build-out with expected demand. Academic and policy studies have explored charging infrastructure demand using different metrics, such as EVs per charger, chargers per km, EVs per sqkm and KWh or KW per EV (Xylia et al., 2025). Some of these studies rely on simulation and optimisation methods to assess demand across different locations for publicly accessible infrastructure (Hipolito, Rich and Andersen, 2024; ITF, 2023; Zhang et al., 2015).

Figure 5. Number of EVs per public charger port and EV stock share for different world regions



Source: Trends and 2025 insights on the rise of electric vehicles in the USA (Muratori et al., 2025)

Despite the breadth of research literature, there are relatively few open data platforms of national or regional level that can support local authorities and charging operators in identifying optimal charging locations. One example, however, is Germany's Standorttool (BMV, n.d.), a web-based tool that incorporates traffic intensity, population density, land use and future projected demand of EVs together with existing infrastructure layers. By providing a transparent evidence base, such tools help reduce strategic uncertainty, target public support efficiently and support co-ordination between stakeholders.

Grid capacity availability

Equally important is transparent information on local electricity grid capacity and proximity to network infrastructure. The absence of detailed grid capacity data poses a significant challenge for municipal planning and charging operators, often leading to lengthy permitting procedures, repeated requests to verify grid connection availability and project delays. When grid availability data is accessible, charging operators can pre-screen sites with realistic connection prospects, reducing the administrative burden on grid operators and accelerating roll-out. Furthermore, granular insights into projected electricity loads enable proactive grid reinforcement planning and justify strategic investments where demand is expected to concentrate. This issue is particularly important for heavy-duty charging, where high power (e.g., megawatt charging) requirements can make grid constraints the binding factor in project feasibility.

The municipality of Stockholm has developed charging maps (*laddkartor*) identifying specific street locations where chargers can be installed following consultation with the local grid operator, thereby guiding operators towards sites with viable grid connections (Stockholms stad, n.d.) Similarly, the UK's Network Opportunity Map provides a unified view of possible connection opportunities using a colour grading feature map to guide users to areas of the network where connections are more likely to be achieved without requiring significant distribution grid reinforcement (UK National Grid, n.d.). While a few other national or regional capacity maps are available within the EU (Maarten Staats, n.d.), they mostly remain fragmented efforts without harmonisation or integration with other spatial datasets, such as traffic flows, renewable generation zones and land use, to support local planners and private investors. Looking further afield, Australia's national EV Charging Infrastructure Mapping Tool offers an instructive model by combining layers for existing and planned charging infrastructure deployment, demographic indicators, traffic data, ancillary services and grid capacity, providing a comprehensive decision support system for policymakers and industry alike (Department of Climate Change, n.d.).

"Smart" publicly accessible charging can reduce costs for users, the grid and the environment

As EV adoption expands, new demands will be placed on electricity grids, meaning that strategies for "smart" charging or managing how and when vehicles charge will become increasingly important. While EVs represent less than 1% of global electricity demand today, their contribution to power demand is heavily influenced by charging behaviour (IEA, 2025). Unmanaged charging patterns can have diverse implications, including overloading the grid and system instability, potentially leading to blackouts. They can even lead to the installation and use of expensive generators, resulting in higher costs, and the use of carbon-intensive power plants to meet peak demand (Dahiwale, Rather and Mitra, 2024; IEA, 2024b; IRENA, 2019; Tirunagari, Gu and Meegahapola, 2022).

In research and in practice, experts, industry and policymakers are increasingly recognising the advantages of managed, "smart" charging, which enhances grid resilience, reduces consumption of carbon-intensive electricity and improves affordability for end-users. The implementation of smart charging is a critical path to ensuring EVs are efficiently and cost-effectively integrated into the grid (Hildermeier et al., 2019; NREL, n.d.; Tirunagari, Gu and Meegahapola, 2022). Smart charging allows for a certain level of control over the charging process. This is achieved through at least one of the following (IEA, 2024b; IRENA, 2019):

- *Customers responding to price signal*s: There is no active control over users' decisions to charge; rather, price signals (dynamic pricing) prompt EV users to make behavioural changes to shift charging time to off-peak periods
- *The charger automatically responding to signals that react to the grid and market conditions*: Direct control over when and how vehicles charge is enabled, meaning charging can be stopped or started remotely and/or charging power can be modulated
- *A combination of the above*

The implementation and build-out of publicly accessible charging infrastructure that incorporates smart charging features can prevent overloading the grid by spreading out and more effectively stabilising charging demand (ITF, 2023). It can also encourage charging during periods with high renewable energy availability. This reduces environmental impact and potentially lowers charging costs, making publicly accessible charging more affordable for consumers while enhancing the flexibility and operation of grids (Bernard et al., 2025; European Commission, 2025a; Ferwerda and David Roldan, 2025). By 2030, total battery capacity from EVs on the road could be as high as 29 TWh and 186 TWh in 2050, providing a high potential for flexibility – taking advantage of this opportunity will be critical (IEA, 2024b).

Early interventions using smart charging are proving able to shape and manage consumer use of publicly accessible charging. The introduction of dynamic pricing during a large-scale field experiment in the UK demonstrated large demand responsiveness to price (Bernard et al., 2025). By procuring wholesale electricity at a lower cost and when high amounts of low-carbon electricity supply were available, reduced prices were offered to consumers. A 40% reduction in charging price caused a 117% increase in demand across the network of participating chargers, while a 15% price led to a 30% increase. Other experiments, such as in the city of Amsterdam, continue to investigate how smart charging influences use of publicly accessible charging infrastructure in ways that help EVs successfully integrate with the grid (IEA, 2025). A policy implication is that smart charging can lower the cost of public charging, closing the cost gap between public-based and home-based charging. This may make EV ownership more broadly affordable, especially for consumers who lack access to a garage or off-street parking. At the same time, CPOs can improve the utilisation of their assets, increasing their return on investment. The benefits of smart charging can be shared across EV drivers, CPOs and grid operators.

Over the longer term, more advanced smart charging approaches, such as enabling chargers to automatically respond to market and price signals or various forms of bi-directional charging (e.g. vehicle-to-grid) can have wider applications in energy management (Ferwerda and David Roldan, 2025). In the context of publicly accessible charging infrastructure, vehicle-to-grid technology can allow CPOs to access aggregated flexibility offered by EV users at public charge stations to stabilise the grid, optimise charging costs and generate discharge revenues. Users would also benefit from reduced costs through specific pricing models. The application of vehicle-to-grid in public settings may, however, be limited to slow charging, as fast charging is generally unsuitable for vehicle-to-grid services due to limited demand response flexibility (Funke et al., 2024; IEA, 2024b).

Smart charging will not "just happen" without the right regulatory foundations, standards and incentives. For smart charging to be effective, governments and industry should work together to identify and implement measures that enable EV charging to be actively controlled, traded as flexibility and safely integrated within energy systems. This is taking place with key actors coming together to discuss requirements for successful integration (EV TCP, 2025). Key considerations include:

- *Mandating or encouraging that EVs, charging infrastructure and the energy system use common communication protocols:* Standards and protocols are necessary to enable secure exchange of data and signals between the electricity grid, charger, vehicle and various actors involved (e.g. operators, aggregators, etc.) for optimised charging. In the Netherlands, OCPP and OCPI are required standards in tendering guidelines for publicly accessible charging points, while the EU AFIR requires chargers to be digitally connected and support ISO 15118 (European Parliament and Council of the European Union, 2023; IEA, 2024b).
- *Implement mechanisms that compensate operators and EV owners for providing flexibility:* Designing charging tariffs (e.g. real-time pricing, time-of-day tariffs) in such a way that prices reflect system conditions (peaks, congestion, renewables) is one way to compensate users for providing flexibility. Users are financially rewarded with cheaper charging rates during low-grid-stress periods. Other options include flexibility markets and enabling aggregators to enter EVs into bulk electricity markets (IEA, 2024b).
- *Update grid codes to recognise vehicle-to-grid capabilities:* This legal and technical recognition is essential for enabling smart charging, as it allows chargers and vehicles to respond to grid signals without risking non-compliance. Without this, chargers and vehicles cannot legally respond to grid signals. New grid code requirements are currently under review in Europe (Preci et al., 2025).

Measures to support grid integration of EVs can be completed by proactive grid planning, including modelling the impact of electromobility on energy systems and developing a comprehensive understanding of where specific issues may lie within network capacity. An emphasis can also be placed on co-ordinated deployment of charging infrastructure, with smart technology alongside renewable energy developments (IEA, 2024b; IRENA, 2019). How policymakers choose to navigate this process will depend on local conditions. However, the implementation of smart charging policy even in early market stages can allow for sufficient time for grid planning and reinforcement (Kok and Rajon Bernard, 2025b).

Anticipatory land reservation and grid reinforcement minimises bottlenecks

The roll-out of publicly accessible EV charging infrastructure is increasingly constrained by two structural bottlenecks: scarce availability of land in high-demand locations and the slow, reactive nature of electricity grid upgrade:

- Land scarcity is most critical in dense urban areas, multi-family neighbourhoods without off-street parking and strategic highways or service-area nodes where real-estate competition drives up costs for charging sites and reduces the number of viable publicly accessible charging locations. When land is not proactively identified and reserved for EV charging, the rolling-out of infrastructure risks being opportunistic and fragmented: longer negotiation cycles for sites, risk of infrastructure concentration in prime locations and market dominance by a single or a few providers (Ghosh, 2022; IEA, 2022). reduces the risk of market dominance by a single provider
- At the same time, the electricity grid often becomes a limitation even when land is available. New charging points can utilise the existing grid network; however, fast and ultra-fast chargers impose localised, high-power loads that can require new grid connections and grid reinforcement (IEA, 2022). At present, typical grid upgrading processes are reactive and can take years to be completed (Utility Dive, 2019). National and sectoral assessments emphasise that reactive reinforcement of the electricity grid leads to significant delays, additional costs and deployment uncertainty for EV charging projects (ACER and CEER, 2024; US DOE, 2024).

Only co-ordinated land and grid planning that proactively secures land and enables anticipatory grid investment will enable the deployment of publicly accessible charging networks at the speed, scale and geographic coverage needed. Reserving sites without ensuring power availability will shift the bottleneck, while upgrading the grid without pre-identifying sites risks under-utilised assets. Public authorities can change this dynamic by including EV charging in urban planning using a vision-led approach (ITF, 2026).

Jurisdictions can explicitly incorporate EV charging in zoning and land use code updates to smooth rolling out publicly accessible charging infrastructure (Alternative Fuels Data Center, n.d.; IREC and RMI, 2023). Authorities can also play a crucial role in unlocking access to publicly owned land. For example, London's EV Infrastructure Strategy identified land unlocking as the public sector's most significant contribution to building charging infrastructure, estimating that public-owned land in London could house a quarter of the fast chargers needed by 2030 (Transport for London, 2021; WEF, 2024). Delhi is another example of where authorities have taken steps to make land available. They have done so through concessional agreements. Land packages consisting of several sites to install publicly accessible charging infrastructure were secured from land-owning agencies and offered through a competitive bidding process. Land for publicly accessible charging infrastructure may be publicly- or privately-owned. In the latter, for example, in universities, parking lots and shopping malls, governments can act as convenors. Germany has developed a digital platform that enables federal states, municipalities, companies and private landowners to list and find properties suitable for installing publicly accessible EV charging, the FlächenTOOL. Investors and CPOs can search for potential sites, view key characteristics (e.g. size, parking spaces, accessibility), and connect with site owners (BMV, n.d.). As a first step in identifying suitable land for heavy-duty vehicle charging sites, Germany's HoLA project piloting megawatt charging along the Berling-Ruhr corridor aims to establish site selection criteria, including required grid connection capacity, space and facility requirements to inform future deployment (GmbH, n.d.).

Streamlining processes for charging infrastructure roll-out can reduce soft costs

Stakeholders have raised the issue that compliance with a multitude of diverging permitting regulations and the involvement of numerous administrations leads to lengthy permitting and approval processes (Sustainable Transport Forum, 2023a). Overall, lack of clearly defined timelines and standardised procedures, limited transparency on costs and a lack of co-operation and joint planning among public authorities, CPOs, DSOs and TSOs create bottlenecks in the deployment of publicly accessible charging infrastructure and add significant costs (Sustainable Transport Forum, 2023a).

To support timely public charging infrastructure roll-out and reduce soft costs due to site development and permitting delays, public authorities should minimise administrative bureaucracy and streamline current processes (European Commission, 2025b). The following upstream actions (Figure 6) could facilitate the rolling-out process (Rajon Bernard and Hall, 2021a).

Figure 6. Upstream actions to streamline EV charging infrastructure roll-out

Source: Adapted from (Rajon Bernard and Hall, 2021b)

- *Bring together relevant stakeholders*: Dialogue between institutions, jurisdictions and sectors (energy, transport and urban planning) needs to be encouraged. Public authorities can convene an EV infrastructure stakeholder working group. The Netherlands Knowledge Platform for Charging Infrastructure (NKL) is a knowledge-and-collaboration platform that helps local governments, private stakeholders and technical experts align on common standards, tools and objectives (NKL, n.d.). It may be beneficial to adapt institutional structures to create a joint office responsible for managing the building of publicly accessible EV charging. For example, the United States created in 2021 the Joint Office of Energy and Transportation to facilitate collaboration between the Departments of Energy (DOE) and Transport (DOT) on rolling out EV charging infrastructure (US DOT, 2021).
- *Define specific roles for stakeholders:* Develop partnerships between transport and urban planners, DSOs and CPOs to identify suitable locations for charging infrastructure backed by data on grid capacity, land availability and projected future demand. Designate contact people within each institution, provide them with the means to build their expertise (see Section 5) and assign them to a specific role in the rolling-out process.
- *Select a deployment strategy:* Choose a strategy for deployment and define the workflow. Most common strategies are planning-oriented (where the jurisdiction selects targeted locations for charging sites) and demand-driven (where deployment decisions are made in response to EV drivers’ requests) (Rajon Bernard and Hall, 2021a). Planning-oriented strategies are well suited to

avoid concentration of infrastructure and the creation of underserved areas. However, demand-driven strategies have proven useful in some places to accelerate infrastructure deployment in sites with not enough chargers and ensure higher-utilisation rates of existing chargers.

- *Provide clear guidelines*: Develop a guide or checklist that displays all steps, costs and amount of time to install AC and DC chargers. Guidelines should ideally be established at a national or regional level for local authorities to align and standardise requirements (as the EU has done through AFIR (European Parliament and Council of the European Union, 2023)). This guide should clearly and effectively outline permit application processes and define timelines to ensure transparency and predictability (OECD, 2025).
- *Implement regulations* that ensure new constructions are charging-capable and enable interoperability of charging stations (China- Development and Reform Commission, 2022).

To maximise efficiency and minimise excessive bureaucracy, a unique and reliable communication channel could be established between CPOs and public authorities following a "one-stop-shop" model. Like EV charging, the telecom and fibre sector have in the past faced similar fragmentation problems (many local authorities, multiple agencies, varied fees and technical checks) with drastic differences in requirements by municipalities. By implementing the "one-stop-shop" model, the telecom and fibre sector in many countries (European Parliament and Council of the European Union, 2014; PIB Delhi, 2022) has manged to consolidate approvals, standardise requirements, and reduce uncertainty for private actors. Typical components of the one-stop-shop model that could be applied to the EV charging sector include:

- *Digital single-window portals for Right-of-Way (RoW) and permit requests:* Operators submit one application that is routed to all relevant authorities (road authority, utilities, municipalities, etc.). The portal should include data models and geospatial layers so that the application covers location (GIS), proposed equipment, planned civil works, DSO connection request, parking and traffic impact, and subsidy application. This would reduce duplicating filings. The portal is either the co-ordinating body or forces multiple agencies to respond through a single workflow.
- *Statutory timelines:* Legally binding review times established by a legislative act or formal statute to limit unpredictable delays. Timelines could be tailored to the technical complexity of charging sites.
- *Transparent charging and fee caps for civil works:* Standardised road works and grid upgrade fees so operators have predictable costs.
- *Standardised technical templates and pre-approved designs:* Pre-agreed terms (in concession agreements or access contracts) for access to public land and grid connections reduce negotiation time. Pre-approved charger types or "fast track" for low-impact installations (for example, for on-street slow chargers, lamp-post chargers) can reduce processing time.

Box 2. Innovative charging solutions: battery swapping

While cabled charging is expected to remain the predominant technology for EV charging, battery swapping is developing in several markets. Deployment remains concentrated primarily in contexts with growing electrification of two- and three-wheelers, while applications for passenger cars and trucks largely confined to China.

Scaling deployment faces some challenges that mirror those of cabled charging, alongside distinctly different ones. Standardisation and interoperability are equally critical, but for battery swapping these extend to the physical standardisation of battery packs and vehicle designs- requirements unmet by most vehicles on the road today. Upfront investment costs are high, and stations require significant land and storage space for battery inventory. Securing sufficient grid connection capacity for battery charging facilities remains a constraint. Some of the planning and policy approaches discussed in this report, including demand forecasting, land identification, permitting streamlining and grid connection planning are likely relevant to battery swapping deployment. However, given the nascent state of the market, whether these approaches are sufficient or whether distinct frameworks are needed requires further research and evidence as the technology and its application develops.

Source: (IEA, 2026; Alhazmi, 2025).

Financing and ensuring long-term competitive markets

Public authorities often aim to deploy charging infrastructure, while maximising broader policy outcomes, and limiting cost and risk to the public sector. Public-private co-operation has, in many countries, been an essential lever for mobilising private resources and bridging financing gaps. The way in which public authorities structure infrastructure deployment and market access, allocate risks between the public and private sector, and define obligations has a direct impact on investment incentives, financing costs and the long-term fiscal exposure of the public sector. This chapter illuminates different deployment models from a financing angle. It discusses how they impact competition, together with other factors, such as price transparency and non-discriminatory market access. Finally, it discusses different revenue streams that could be used to fund charging infrastructure in developed and emerging markets.

Public financing needs vary with different deployment models

Deployment models differ significantly in how they allocate risk and control between the private and public sector. This, in turn, determines investment incentives, access to private capital, financing costs and revenue streams. This makes the choice of model a strategic financial decision that shapes market access, competition and the long-term financial exposure of public authorities.

The permitting model is the simplest for municipalities to manage. However, they have limited control over the location, specifications and strategic deployment of chargers. Local authorities mainly focus on administrative checks, granting permits on a first-come, first-served basis, without typically evaluating economic factors. While it might be tempting to start with a permitting model since it is entirely privately financed, public authorities relinquish all control, leading private capital to flow typically to the most economically attractive sites. As a result, “white spots” may remain on the map, with limited mechanisms to cross-subsidise low-demand areas. At the same time, authorities may have limited ability to mandate or ensure high service quality. Market-led deployment of publicly accessible charging infrastructure tends to concentrate investments in high-demand locations, leaving low-income and rural areas with limited coverage (Varghese, Menon and Ermagun, 2024). Public costs are initially low; however, authorities face necessity for repeated subsidy programmes in underserved areas (WRI, 2024). A purely market-driven approach based on a permitting model minimises short-term public spending, but risks shifting long-term systems costs of achieving widespread coverage to the public sector.

In the public operator model, public authorities maintain full control over the charging network, including procurement, location decisions, pricing and revenue collection. This can ensure good access and widespread coverage, but requires significant upfront investment. However, not all public authorities have the expertise and resources to procure, deploy and operate charging infrastructure in the rapidly evolving landscape of e-mobility. There is also the risk of installing chargers in politically advantageous areas rather than those economically or strategically needed. This model is typically more viable for larger cities or where there is a big municipally-owned utility company. While there have been a few successful examples (C40 Cities, 2023), it is unlikely that this model is scalable across all markets and geographies with different governance structures without resulting in a lack of competition that creates high end-user prices (ITF, 2024). Rather than deploying all infrastructure themselves, local municipalities can focus on deployment on municipal parking premises to support uptake at highly visible locations. In some countries, such as

Greece, local authorities are not allowed to exercise business activities as CPOs. In this case, they would build, own and maintain the equipment, but must have a contract with private CPOs to operate it and share a portion of the revenue.

Concessions are public contracts where authorities grant a private partner (the concessionaire, usually a CPO) the right to install, operate and maintain charging infrastructure on public land for a defined period of time. Unlike the simpler permitting model, concessions are more administratively complex. Authorities must define the terms and conditions, including the locations of charging points, and can bundle profitable locations with less profitable ones. While in most cases, the land subject to concessions for publicly available charging infrastructure is under public ownership (EU TED, 2025a, 2025b, 2025c; Government of Belgium, 2025), some concessions, for example, as part of the *Deutschlandnetz*, include land acquisition (Vinci, 2023). In this case, the concession guarantees exclusivity rights within a certain region, with a 2km radius (BMV, 2021)

Predicting demand can be difficult, especially early in the transition when EV adoption is low and uncertain. The concession model partially shifts utilisation and revenue risk to the private sector, converting fragmented, high-risk investments into bankable portfolios. The concessionaire gains exclusive rights for a given period, which increases investment certainty and unlocks private finance, while delivering public policy objectives. This can be more financially sustainable for governments than purely relying on subsidies. Other policy tools like government-backed residual value guarantees for vehicles and long-term concession contracts for charging infrastructure can lower financing costs, attract private investment and ensure cost-effective, co-ordinated deployment even in less profitable areas (ITF, 2025). Longer contract durations reduce the risk for the concessionaire (CPO) as it extends the time horizon, in which case the CPO can monetise its upfront investment. Typical contract durations vary with the capital intensity of the infrastructure (e.g. urban low-power vs highway high-power charging) and the maturity of the EV market, ranging between 7-15 years (La Gazette, 2024; ITF, 2024; Luxembourg Ministry of the Economy, 2025). Although concessions require greater upfront planning and administrative effort, they allow authorities to structure the market, ensure high service standards, reduce long-term subsidy dependence and ensure resilient, competitive and accessible charging networks. For these reasons, public authorities should prioritise concession models when planning large-scale deployment of publicly accessible backbone charging infrastructure on public land, especially in countries where long-term coverage, quality, and financial sustainability and competitive markets are priorities.

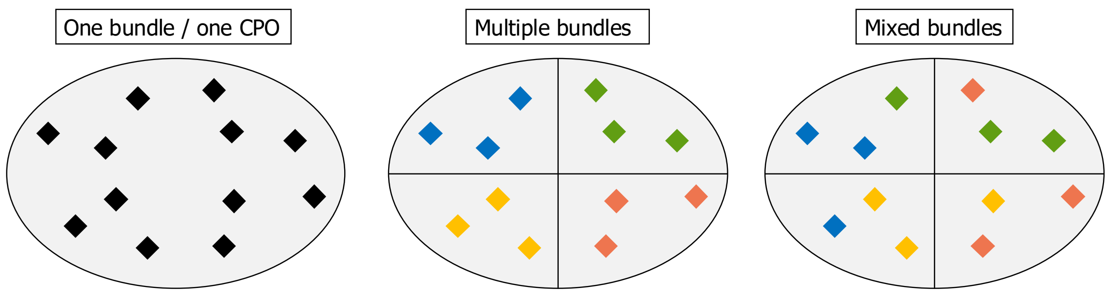
Healthy competition relies on, but goes beyond, deployment models

Different deployment models for publicly accessible charging infrastructure not only influence public financial involvement, but play an important role in ensuring long-term competitive markets (see Section 2). While concession models are often well suited to deliver on these objectives, as laid out in previous sections, they must be carefully designed and adapted to local needs and market structures. Key factors to take into account when designing concessions are outlined below.

Overlapping bundles increase competition and reduce market dominance

To promote long-term competition in EV charging markets, concessions should be designed to prevent a single "winner-takes-all" award. Authorities can structure the contract portfolio (across a country, region or at city level) into multiple lots or bundles, allowing multiple CPOs to compete and win in distinct, comparable segments. Figure 7 illustrates schematically how a concession portfolio can be organised into bundles. In the "standard case" (left) all sites within the concession are awarded to one CPO, whereas the "multiple bundles" example (middle) splits the available sites to four bundles of equal size. In the "mixed bundling" (right), the individual sites of the four bundles overlap geographically. In the latter, the sites allocated to one CPO are only distributed over two adjacent regions, which, depending on the size of concessioned area, can facilitate operation and maintenance of sites. The German government adopted this approach to organise the infrastructure portfolio of the high-power charging *Deutschlandnetz* across Germany (see Section 5).

Figure 7. Schematic illustration of site bundling.



Source: ITF illustration

It should be noted that bundling *itself* does not guarantee competition. Instead, *how* bundles are defined, their geographic mixture and the balancing of economic attractiveness determines whether a concession effectively promotes competition and reduces the risk of market dominance by a single provider (Autorité de la concurrence, 2025).

Assess competition within a given market rather than across whole networks

Market dominance generally occurs when one actor controls a significant share of charging infrastructure in a *relevant market*. Evaluating market dominance first requires defining the relevant market in terms of charging power (AC or DC) and vehicle type (light- or heavy-duty) within a given geographic area and then assessing the extent to which EV drivers have sufficient substitutable choices in this relevant market. For example, if an EV driver needs to recharge along the highway on intercity trips, slow charging options along the highway over multiple hours are unlikely to be a realistic substitute for high-power charging. However, a high-power charge point at the next rest area along the highway is likely a reasonable substitute if it is within the geographic market. A relevant geographic market is thus defined by the distance or travel time the consumer would consider driving to recharge at a competitor's charge point if the price was lower. In some cases, travel time may provide a more accurate representation of spatial competition than distance-based (such as a radius around a charge point), as it accounts for traffic conditions in urban environments, road network structure and topological barriers (such as rivers), and better reflects actual substitutability from a user's perspective (Monopolies Commission, 2025). In empirical competition assessments for long-distance travel on motorways, a distance-based definition of 50-60 km in one direction of travel has been used as a proxy to define a relevant geographic market for substitutable high-power charging alternatives and a radius of 20 km for fast charging on regional roads (Bundeskartellamt, 2024b). In an urban or suburban context, the relevant geographic market corresponds to the distance that can be covered in 15 minutes' driving time, a distance of five and eight km, respectively, in urban and suburban environments (Monopolies Commission, 2025). The German Competition Authority suggests a threshold for market dominance of 40% within a *relevant market* in the context of EV charging infrastructure (Bundeskartellamt, 2024b).

Early concession design influences long-term market dynamics

The way in which concession terms are specified also impacts private sector business models and is a key enabler of long-term competition. Firstly, big bundles combined with the requirement of simultaneous and timely deployment may require significant upfront capital. This can undermine the CPO's business case, especially when some charging sites are in areas with foreseeably lower charging demand, e.g. where EV penetration is still low. Authorities may, therefore, allow staggered deployment of sites within one bundle, providing CPOs with greater flexibility in capital prioritisation without compromising long-term competitive pressure (ITF, 2024). Secondly, the size of tendered bundles can impact competition, but involves important trade-offs and needs to be carefully defined. Big bundles can enable economies of scale for deployment, operation and maintenance if they are not overly dispersed geographically. This can help prevent fragmented markets. However, big bundles entrench incumbents and favour companies with appropriate financial and human resources (OECD, 2022a). Smaller bundles may increase the number of bidders and are more likely to attract SMEs and new market entrants. This may increase the number of market players in the short and long term, widening participation, also for bigger lots (OECD, 2022a). In many cases, SMEs drive innovation in the energy-transport ecosystem (EIT Urban Mobility, 2025). This makes it even more key to facilitate market entrance for smaller players.

Lastly, concession contract durations and sequencing of subsequent tenders impacts competition. In general, concessions should be long enough to allow investment recovery under demand uncertainty, but short as possible to avoid lock-in of specific CPOs for indefinite periods. While periodic re-tendering refreshes competitive pressure, optimal contract length varies with market maturity and should be re-evaluated for each new tender. The temporal sequencing for new concessions has been recently discussed in the context of tenders for public transport contracts. Empirical evidence indicates that the number of simultaneous tenders is a key factor in determining how many operators participate in the bidding, with a greater number of simultaneous tenders associated with fewer bidders, as the process for submitting a bid is resource-intensive (OECD, 2022a). However, the relative merits of staggered tenders, where bundles are reissued on a rolling schedule, versus synchronous tendering, where multiple contracts are opened at the same time, depend on the market structure and risk of monopolisation (Iossa, Rey and Waterson, 2022). More concretely, in cases of monopolistic market structure, synchronous tendering can enhance competition because new market entrants increase pressure on incumbents through more aggressive bids. Inversely, when several competitors remain active in the market, staggered tendering can generate stronger competition among existing bidders (Iossa, Rey and Waterson, 2022).

Payment models and price transparency can boost competition

EV charging and payment mechanisms rely on the interaction between several actors across the charging ecosystem, notably CPOs, EMSPs, energy suppliers and EV drivers (see Figure 8). While CPOs own and operate the physical charging infrastructure, including the underlying back-end systems for the charging station, EMSPs acts as an intermediary, providing access, authentication, tariffs and billing to the EV driver. CPOs and EMSPs connect via bilateral roaming agreements that set the commercial and technical conditions under which an EMSP can access a CPO's network. These connections allow EV drivers to access one or multiple CPO networks, while holding a single subscription with an EMSP and typically paying through its mobile application or Radio Frequency Identification (RFID) card. This combination enables various payment mechanisms.

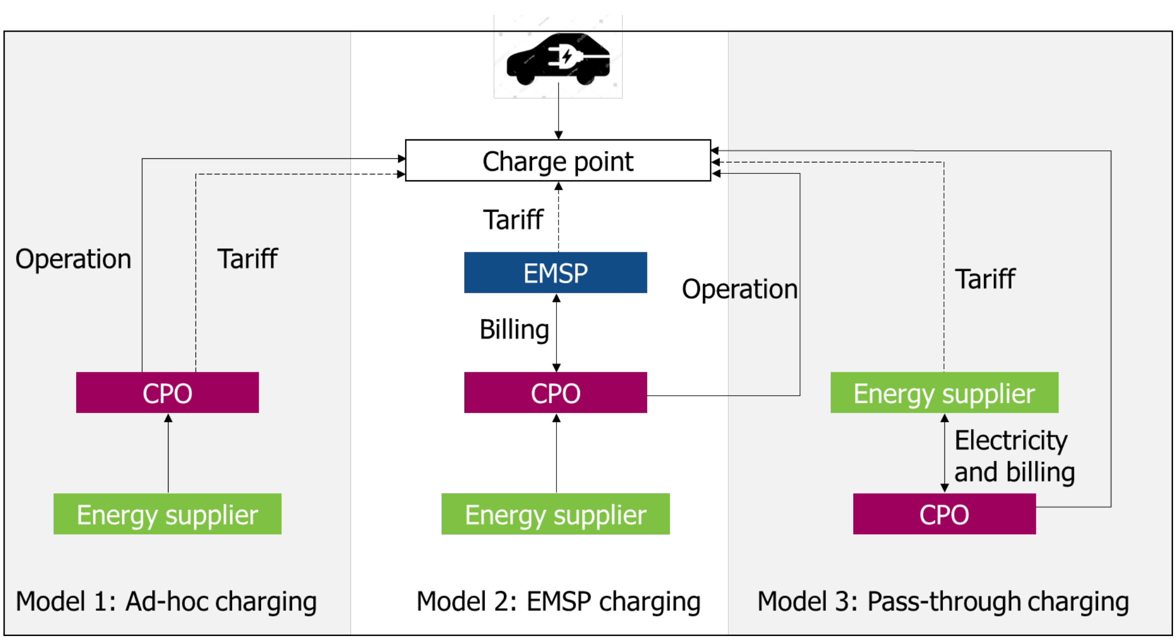
Payment models and how they organise the involvement of these various actors within the system has implications on the development of a competitive publicly accessible charging network.

Types of payment models

There are two commonly used payment mechanisms: (i) ad-hoc charging, (ii) charging through an EMSP and (iii) "pass-through", a currently evolving third model. Figure 8 shows, schematically, how different actors interact under different payment mechanisms. In the first case, EV drivers either settle their accounts directly and without registration (ad hoc) with the CPO through a credit card or other digital payment mechanisms, such as through a QR code. Ad-hoc payment mechanisms have been made compulsory for all publicly accessible charge points in the EU through AFIR (European Parliament and Council of the European Union, 2023). In the second case, the end-user interacts and pays through an EMSP. This involves a contractual relationship with the EMSP, often in the form of a subscription, which can include monthly base rates and reduced prices per kWh.

In the "pass-through" model, the end-user settles the charging event directly with the electricity provider of their choice for the consumed electricity ("bring-your-own-power"). The CPO, who operates the physical charging infrastructure, receives a regulated infrastructure fee to compensate for construction and operation, which constitutes a known and transparent component of the end-user price. This model decouples energy supply from charging infrastructure provision and reinforces the CPO's role as infrastructure operator rather than an energy retailer or re-seller (as in the case of ad-hoc charging or contract-based EMSP charging). This model is being implemented for the first time in the ongoing concession tender for the German high-power truck charging network in unmanaged rest areas as an obligatory payment mechanism (see Chapter 5) alongside ad-hoc and contract-based EMSP charging (Autobahn GmbH, 2024). A "pass-through" model is already commonly used in liberalised electricity and gas markets, where the underlying infrastructure is a regulated natural monopoly, characterised by very high fixed costs, low marginal costs and where duplication of infrastructure would be very inefficient. This approach is widely accepted in economic theory (Shapiro and Varian, 1999), regulatory practice (European Commission, 2024) and policy institutions practise (OECD, 2022b).

Figure 8. Different EV payment mechanisms and key actors involved



Note: CPO = Charge point operator, EMSP = e-mobility service provider

Payment mechanisms can reinforce existing incumbents or intensify competition

In principle, CPOs should grant non-discriminatory access to EMSPs, which promotes competition by allowing users at publicly accessible charging stations to choose between ad-hoc charging offered by the CPO and contract-based charging through an EMSP. Roaming agreements between CPOs and EMSPs, which determine the access conditions of an EMSP to a CPO's charging network, are typically negotiated bilaterally. By extending access to their networks to EMSPs, CPOs can increase utilisation of their infrastructure and generate additional revenue through roaming fees, which contribute to covering investment and operational costs.

However, a vertically integrated CPO can also act as an EMSP and offer contract-based services at their own charge point. A CPO with local market dominance, therefore, poses a dual competition risk. First, such a CPO can charge higher ad-hoc prices, as alternative charging options are not available within a reasonable driving distance. Second, the CPO could use its market power to structure access conditions for competing EMSPs in a way that prevents them from offering competitive retail prices or earning sufficient margins (so-called margin squeeze). This can lead to market foreclosure, reinforce the CPO's market power and result in higher prices and reduced customer choice set (Bundeskartellamt, 2024b). The Italian anti-trust authority recently fined a leading CPO in Italy EUR 2.3 million for "abusing their market dominance" and hindering competitors from accessing the market, explicitly mentioning market-squeezing practices (Autorità Garante della Concorrenza del Mercato, 2025).

If vertically integrated CPOs charge competing EMSPs ad-hoc prices to access their network, the prices of competing EMSPs are necessarily higher than CPOs' ad-hoc prices and even higher than those of EMSPs that are vertically integrated into operating CPOs. This is problematic since neither ad-hoc nor EMSP prices display individual price components, including external EMSPs' roaming fees. Recently, there have been more reports of lack of price transparency. For example, the 2025 price transparency benchmark report in the Netherlands found that only 50% of all invoice prices matched advertised prices and that there was no price information at all in 20% of all invoices (NKL, 2025). While there are contradictory views on the impact of price transparency on end-user prices, experiences from fuel transparency and recent evidence show that price-lowering effects outweigh risks (see Box 2.).

High-power charging for trucks along highways could particularly benefit from an obligatory pass-through payment model, as its deployment is highly capital-intensive and infrastructure utilisation is expected to remain low during the market ramp-up phase. Furthermore, truck-charging infrastructure along highways is subject to strong spatial constraints. As a result, distances between truck charging sites may be large, with users having only one or very few charging options along a given route. Given the high investment costs and limited site availability, duplication of physical charging infrastructure by multiple CPOs is economically inefficient (Monopolies Commission, 2025). In such contexts, effective competition between physical charging locations may fail to emerge on its own. The obligatory pass-through model provides a mechanism to ensure competition *within* the infrastructure rather than *between* infrastructures by enabling multiple electricity providers to compete for the same end-users. Electricity providers, with their large portfolios and experience in wholesale electricity markets, are typically better positioned than individual CPOs to procure electricity at competitive wholesale rates and pass these lower prices on to end-users, for example, during periods of abundant supply of renewables. This could reduce charging prices by up to 20% (Electrive, 2025a). Lowering charging costs is particularly important in commercial freight transport, which is highly cost-sensitive. Refuelling prices strongly influence total cost of ownership. High charging prices can, therefore, jeopardise the business case for electric trucks (ITF, 2022, 2025).

By contrast, passenger car charging typically involves lower site-specific investment costs, greater location density and higher substitutability between charging options. Users place greater value on convenience and proximity, and competition between physical charge points is more likely to emerge organically. In this context, measures such as increased price transparency and strengthened roaming conditions may address competition concerns without adding regulatory complexity.

Box 3. Does price transparency really increase competition and lower prices?

Transparent prices can have positive impacts on competition and result in lower prices, but can also have unintended consequences. Existing fuel markets provide a useful reference for understanding the competitive effects of price transparency. Since 2013, fuel stations in Germany have had to report their fuel prices to the Market Transparency Unit in real-time through a digital reporting system maintained by the federal competition authority (Bundeskartellamt, 2013). Comparable, though less frequent, reporting regimes exist in other European countries, including France (French Ministry of Ecological Transition, 2025) and the Netherlands (Statistics Netherlands, 2025a).

A persistent concern has been that publicly available, real-time price information may facilitate tacit co-ordination, allowing a fuel station to adjust prices in response to those of an adjacent competitor without explicit collusion. In fuel markets, this has been associated with very high fuel price fluctuations – on average, 20 times per day in 2025 (Bundeskartellamt, 2025). As a result, some countries have introduced regulatory safeguards to limit the allowed number of price increases. For example, Austrian fuel stations can only increase their prices once a day – typically around noon – and then only decrease prices afterwards (Fasoula and Schweikert, 2018).

While initial studies indicated price-increasing effects from transparency (Dewenter, Heimeshoff and Lüth, 2016), there is now increasing consensus that it is competition-promoting, with price-lowering effects prevailing (Arkhangelsky et al., 2021; Becker, Pfeifer and Schweikert, 2021; Bernhardt, Breiderhoff and Dewenter, 2025; Horvath, 2019).

Applying these insights to EV charging infrastructure highlights that price transparency is necessary, but not sufficient when it is limited to ad-hoc charging. The European Alternative Fuels Observatory reports dynamically ad-hoc charging prices across European Member States (European Alternative Fuels Observatory, 2024), as required by Article 5 in AFIR (European Parliament and Council of the European Union, 2023). However, most charging events typically take place via contract-based EMSP charging, so current obligations only cover a subset of the market. From a competition perspective, transparency of EMSP tariffs is equally important, but not required by AFIR. This is especially important when users rely exclusively on the prices displayed in their EMSP app, without visibility of alternative offers. Allowing users to directly compare EMSP tariffs with ad-hoc prices and reducing information asymmetries between user and CPO further enhances competition.

Looking ahead, price transparency and dynamic reporting is likely to become even more relevant as the energy and transport sectors become more closely coupled. Greater shares of renewable electricity increase variability in wholesale prices and can lower prices when supply is high, even making prices negative. This can only be effectively passed onto the end-user when made dynamically and easily accessible, with transparency design covering all relevant charging regimes.

From concessions to blended finance: Financing charging infrastructure in emerging and developed markets

Concessions are particularly well suited to mobilise private capital when commercial or economic fundamentals are sufficiently mature and the private sector's risks manageable. However, concessions do not fully crowd in private finance when key risks remain, particularly in early and capital-intensive segments. In these cases, governments can absorb additional risk and often provide complementary financing, such as anticipating or covering big grid connections, bearing utilisation risk or some capital expenditures. In France, up to 75% of grid connection costs were covered as part of broader CAPEX support on public highway charging (AFRY, 2023). Germany provides a subsidies scheme of EUR 1.6 billion for electric heavy-duty vehicle (e-HDV) truck megawatt charging infrastructure along national highways (Autobahn GmbH, 2024) that has been approved by the European Commission (EAFO, 2025). The European Union's Alternative Fuels Infrastructure Facility (AFIF) has also provided hundreds of millions of euros in direct grants to support both truck and light-vehicle charging deployment across 24 member states (European Commission, 2025c). These examples underscore that concessions are not a universal solution on their own to finance publicly accessible charging infrastructure. Rather, they are most effective when complemented by targeted public support and risk mitigation mechanisms, especially in applications at early stages of market maturity, where strategic deployment precedes predictable cashflows.

In developed economies, these public funds come from a variety of revenue sources. This could include, but not be limited to, general national budgets (transport, climate, recovery funds), such as the LEVI fund in the United Kingdom (DoT, 2023) or support from infrastructure banks, such as the European Investment Bank (EIB, 2024). In other cases, carbon pricing revenue streams (e.g. the emissions trading system (ETS) in Europe) are explicitly used to fund vehicle or infrastructure subsidy schemes. Germany has implemented a CO_2-component on truck tolls of EUR 200/tCO2 since 2024. This is estimated to create an additional revenue of around EUR 30 billion from all commercial road freight activity between 2024 and 2027 (Bundesregierung, 2023). This additional revenue will be used to cover costs for EV purchase and infrastructure subsidy schemes, and highway infrastructure improvements. It will also benefit broader mobility objectives, including the rail sector (Deutscher Bundestag, 2023). Supporting the broader transition, however, often requires additional revenue not directly related to the physical charging infrastructure. This includes investments in grid upgrades, which are usually covered and socialised through grid tariffs on the cost of electricity. Consequently, low-income households could disproportionally be affected, requiring additional compensation or redistribution mechanisms.

However, in emerging and developing markets, mobilising private capital for building publicly accessible charging infrastructure is more challenging. EV uptake is at a nascent stage, making charging demand even more uncertain, and the cost of capital is typically high due to macroeconomic and currency risks. Even if concession models shift investment responsibilities to the private sector, these structural constraints often prevent concessions from crowding in sufficient private financing, particularly for capital-intensive publicly accessible charging infrastructure beyond captive or depot-based applications.

As a result, market creation frequently requires layered public and multilateral risk absorption, combining concessions with concessional finance, guarantees or direct public co-investment. Multilateral development banks (MDBs) have supported early charging infrastructure deployment through blended finance structures, risk-sharing instruments and technical assistance. This has been very successful, especially for urban city bus electrification, where MDB's investment would align with broader sustainable development goals (ITF, 2025). Examples that include publicly accessible charging infrastructure for private vehicles are still scarce compared to those from public transport, but would then be part of wider industrial policy developments. For example, a USD 100 million concessional loan for the building of publicly accessible charging infrastructure in the Philippines goes in tandem with the government's Electric Vehicle Industry Development Act that includes tax incentives for the EV industry (ADB, 2025). South Africa combines EV charging infrastructure support with off-grid solar PV subsidy in a USD 6 million investment from the national development bank, explicitly targeting the creation of green jobs (DBSA, 2025).

Even where direct subsidies are limited, stable regulatory frameworks and credible electrification pathways can reduce perceived risk and improve access to concessional and private finance. Many MDBs emphasise the importance of a solid enabling environment, which includes legal certainty, long-term strategies and nationally determined contributions (NDB, 2022). The Green Climate Fund has mobilised USD 1.2 billion of blended finance in their flagship India E-Mobility Financing Program to provide EV financing solutions, including publicly accessible charging infrastructure, in line with India's climate ambitions (GFC, 2022). While those ambitions do not substitute for financing, they are fundamental for concessional funds to be oriented towards countries with articulated decarbonisation strategies.

Best practices and overcoming challenges

As markets for publicly accessible electric vehicle charging continue to evolve, public authorities and private operators are adapting their approaches to planning, operation and governance. Across countries and cities, similar questions arise: how to sustain long-term competition, safeguard reliability, address vandalism, prioritise suitable locations and charging types, and build institutional capacity and expertise. This section highlights examples of good practice from around the world, showcasing how different actors have tackled these shared implementation challenges through various policy and deployment approaches. By drawing from lessons learned from diverse markets, policymakers and the private sector, players can inform future deployment efforts and potentially leapfrog common challenges in scaling publicly accessible charging infrastructure.

AMSTERDAM, NETHERLANDS – 16 November 2016. Electric car charging stations in the streets of Amsterdam, which has the second largest fleet of plug-in electric vehicles per capita in the world after Norway.

How and where to focus deployment?

Local realities, from land availability to housing typology, shape the roll-out of charging infrastructure. Jurisdictions adopt diverse approaches to tailoring deployment, with each telling their own story.

Building out a robust and effective publicly accessible charging network requires more than accelerating deployment to keep pace with electric vehicle sales. Matching real-world charging needs with a focused approach that considers the location and types of charging needed is essential.

When determining how much, what type and where to place charging, various local conditions inform the approach a given region will take, including housing stock, density, land availability, grid capacity, commuting patterns, and car ownership (Hall and Lutsey, 2020; IEA, 2025). Policy goals and local, regional and national planning priorities will also shape the strategy taken to deploy charging infrastructure. While some general approaches exist for where certain types of charging may be best suited, no single "one-size-fits-all" approach exists for building out publicly accessible charging networks. Lessons can be drawn from approaches taken across various markets in conjunction with local conditions and stakeholder input.

Case study

Amsterdam

As of 2024, Amsterdam has approximately 39 000 public charging stations, up from 12 700 in the region at the end of 2019 (Hall and Lutsey, 2020; Rui et al., 2025). Meeting the needs of a population that predominantly resides in multi-unit residential buildings has significantly influenced the deployment of publicly accessible charging infrastructure in Amsterdam. The housing stock primarily consists of apartments – over 480 000 dwellings – many of which (87.3%) are multi-residential unit (Statistics Netherlands, 2023, 2025b). Like other major Dutch cities, Amsterdam has promoted public charging to accommodate urban drivers lacking private home charging options (IEA, 2025). This has translated into a targeted partnership with the power company Nuan to build an urban network of curbside charging stations designed specifically for local resident use (Rajon Bernard & Hall, 2021a).

The city has employed a demand-driven strategy in deploying publicly accessible charging infrastructure: electric vehicle owners can request a public charging point and requests are evaluated based on distance to existing or planned infrastructure (Rajon Bernard & Hall, 2021a; Van Den Hoed et al., 2019). Because a large share of drivers depend on public charging infrastructure, Amsterdam has focused on a dense network of AC chargers for residential use rather than fast-charging hubs; as of 2024, DC chargers make up just 3% of public charging infrastructure (Cui et al., 2024; Rui et al., 2025). Projections indicate that Amsterdam will have over 103 000 chargers by 2030, with 4% being DC fast chargers (Hall and Lutsey, 2020).

With a strategy that has established a dense network of AC chargers to serve residential consumers, Amsterdam is exploring the integration of smart charging to optimise use of the electricity grid and is targeting deployment of DC fast chargers in key hubs and corridors to support fleet vehicles and heavier transport (European Commission, 2025a; gridX, 2025).

Black Cab Electric vehicle charging at public charging station in LONDON, UNITED KINGDOM – January 2023. New energy vehicles, eco-friendly alternative energy for cars. Electric cars used as taxis and hackney carriage.

Case study

London

London has pursued a mixed-speed public charging strategy that reflects diverse neighbourhood needs and the city's strong fleet presence. By 2025, London's public network had grown to around 25 000 chargers, up from 9 000 in 2021, with roughly 80% slow and lower-power chargers and 20% fast, rapid and ultra-rapid units (Transport for London, 2025).

93% of households in inner London and 64% in outer London lack access to off-street parking ([Transport for London, 2025](#)). Many drivers rely heavily on slower, overnight public chargers to meet some, if not all of their charging needs. At the same time, London has a strong presence of fleet vehicles, including taxis and private hire vehicles (PHV) that require fast turnaround charging to meet operational needs (Transport for London, 2022).

The interplay of housing type, fleet activity, transportation patterns and other factors shows up in the different charging needs in London's boroughs: dense inner boroughs, such as Westminster, with low private car ownership but intensive taxi and PHV activity, require more fast and rapid charge points, while outer boroughs like Redbridge, with higher car ownership and less public transport use, depend more on a combination of public and private residential charging (Bernard et al., 2020). Transport for London (TfL) projects that 43 000–51 000 public charge points will be needed in 2030, of which 3 500 need to be higher powered (TfL, 2025).

Most slow and fast charge points have been installed through borough contracts, including different central government funding schemes. TfL and the boroughs have also delivered the majority of rapid charge points in parking bays, while delivery of hubs has been driven by the private sector (Transport for London, 2025). Ongoing collaboration between TfL and the boroughs to understand the changing landscape of charging needs will continue to inform infrastructure delivery.

Case study

Beijing

In China's major cities, dense urban form and high-rise housing have led to a strong reliance on public charging, particularly DC fast charging. Major Chinese cities have a substantially greater public charger stock than European and U.S. cities; for example, Beijing alone had approximately 90 000 chargers in 2024, more than twice the number in Amsterdam, the leading European city (Rui et al., 2025).

Urban density and housing type have driven the choice of charger technology: in Beijing, approximately 50% of public chargers are DC fast chargers, compared to only 12% in Boston and 15% in Barcelona (Rui et al., 2025). The distribution of these public charging stations is highly concentrated in Beijing's central ring roads, particularly in urban districts with high population density and mixed land use. This concentration reflects spatial constraints that limit the feasibility of dispersed, low-power AC curbside chargers and favours centralised hubs with DC fast chargers (Lin and Kang, 2020).

National and municipal planning, and policy priorities have heavily shaped deployment. China's *2025 Action Plan* set nationwide targets to further expand fast-charging networks, emphasising the need to upgrade urban fast charging (The People's Republic of China, 2025). This followed earlier strategies like *China's Electric Vehicle Infrastructure Development Guidelines (2015-2020),* which outlined regional targets for fast-charging infrastructure in high-density urban centres and emphasised the provision of fast charging for fleet vehicles (e.g. taxis) (China Energy Portal, 2015). In line with this, Beijing aims to build 700 000 charging points by 2025 and targets a 2:1 ratio of public fast-to-slow charging piles in central areas. The dense core will have chargers spaced within 0.9 km, ensuring fast chargers serve neighbourhoods where slow curbside chargers are less feasible (CarNewsChina, 2022).

BEIJING, CHINA – 6 November 2024. View of the EV charging stations in Beijing. EV charging stations support the city shift towards sustainable electric transportation.

How to ensure long-term competition?

How authorities procure public charging infrastructure today shapes the competitiveness and durability of the market in the future. Well-designed concessions foster resilience and prevent consolidation.

Long-term competition in public EV charging markets helps sustain affordable prices, ensures reliability and service quality, and encourages ongoing innovation. Yet without public guidance, there is the risk of uneven deployment and downstream problems with coverage and competition, i.e. market dominance of a single operator.

Concession-based tenders foster *competition to the market* and enable authorities to better guide deployment and promote multi-operator networks. Designing tenders in which charging sites are bundled into packages that are balanced in their economic attractiveness and overlap geographically (multiple CPOs compete within the same region) creates and sustains *competition in the market*. Competition extends from initial procurement to the ongoing delivery phases, as operators must maintain high service availability and user satisfaction in a multi-operator network.

Payment models and how they organise interaction between multiple actors across the charging ecosystem (notably CPOs, EMSPs, energy suppliers and EV drivers) also shape the development of a competitive publicly accessible charging market.

Case study

Germany (light-duty vehicles)

The *Deutschlandnetz* in Germany is a model for how public authorities actively guided the deployment of publicly accessible charging infrastructure, while ensuring competition and avoiding market concentration. This was achieved by tendering bundles of individual charging sites with balanced economic attractiveness that overlapped geographically, combined with limits on how many bundles any one CPO could be awarded (BMV, 2021).

In 2021, the installation and operation of approximately 1 000 locations with high-power charging points to build out a nationwide charging network (*Deutschlandnetz*) were publicly tendered in two calls:

The first tender concerned the installation and operation of stations along federal motorways. A total of approximately 200 locations were grouped into four bundles covering government-owned, unmanaged rest areas. Each bundle contained pre-defined sites where the successful CPO was to install charging infrastructure.

The second tender involved deployment away from motorways, across rural, urban and suburban areas. The country was divided into six regions, each further subdivided to contain three to four bundles, with a total of 23 bundles tendered across the regions. The bundles contained "search areas" in which no exact charging site was fixed. A total of 900 search areas were tendered. CPOs had to identify a feasible site for installation in the given search area, allowing them the flexibility to identify and propose specific locations to deploy charging.

The tenders were structured explicitly to prevent the formation of local monopolies. That is, they were designed to avoid very few bidders being awarded contracts and to ensure that no one CPO could build a dominant position in any given area (BMV, 2021; Bundeskartellamt, 2024) . In the regional tender, bundles were drawn so that they overlapped geographically, meaning different CPOs would operate sites along the same travel corridors and within the same broader catchment areas. To reinforce this, the tenders also capped the number of bundles that could be awarded to a single bidder: no one bidder could win more than one bundle along federal motorways, plus three regional bundles in total. Finally, bundles were divided among 10 operators (Electrive, 2025), ensuring that drivers moving through a given region have access to stations from multiple providers rather than relying on a single dominant operator. Drivers benefit from choice, competitive pricing and greater reliability across the network.

Case study

Germany (heavy-duty vehicles)

The ongoing German tender for truck charging on federal highways (*Lkw-Schnellladenetz an Bundesautobahnen*) is notable in how it layers additional mechanisms to create long-term competition *in the market* among operators and energy providers. This is achieved through tendering bundles of charging sites that overlap geographically, but most uniquely through mandating sites to offer the option of a pass-through payment model (see Section 4).

The first truck-charging tender, launched in September 2024, covers approximately 130 unmanaged rest areas structured into five bundles of roughly 25 sites each (see figure below). The bundles are deliberately designed to overlap geographically, ensuring that no single concessionaire can dominate a given area. Bidders are allowed to bid on all bundles, but are restricted to winning a single bundle unless a specific bundle receives no eligible bid (Autobahn GmbH des Bundes, 2025).

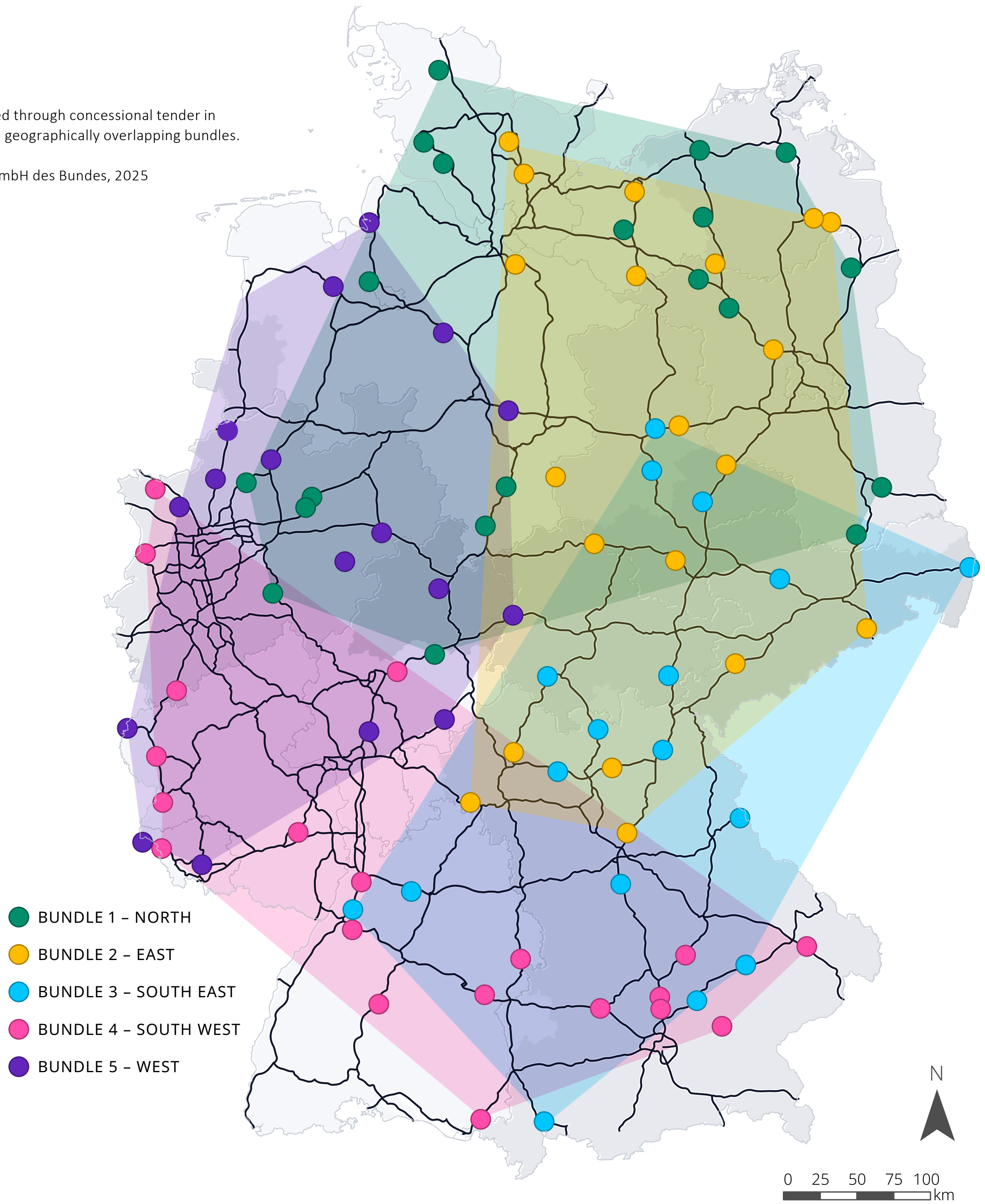
Awarded concessionaires are required to offer users a choice of payment options, including ad-hoc payment, contract-based EMSP charging and the pass-through model (Autobahn GmbH des Bundes, 2025). The mandatory inclusion of the pass-through model is an additional mechanism in which the tender reinforces competition in the market. Under this model, a truck driver arrives at any charging site with their own electricity contract and simply uses the charger to refuel. This means that even a CPO holding concessions across many highway sites cannot use that position to lock in drivers or charge premium electricity prices. Electricity suppliers are also incentivised to offer competitive rates to customers across the network, knowing that drivers are free to switch suppliers at any time.

Suitable locations for highway truck-charging stops are typically scarce, distances between truck-charging sites large and users may have only one or very few charging options along a given route. The pass-through model provides a mechanism to ensure competition even when infrastructure itself is limited, as multiple energy suppliers can compete for the same end-users.

The tender offers the awarded concessionaire financial support for construction and operation. The authority sets a uniform infrastructure fee across all sites based on submitted bids; operators are required to display this fee transparently and apply it to every charging event, irrespective of the payment method chosen by the user. The fee is transferred to the authority, meaning that utilisation risk is borne by the public sector. Revenue from ad-hoc and contract-based EMSP charging events exceeding the infrastructure fee remains with the operating CPO, providing an incentive to maximise site utilisation (Autobahn GmbH des Bundes, 2025).

Charging sites offered through concessional tender in Germany grouped in geographically overlapping bundles.

Source: Autobahn GmbH des Bundes, 2025



TINTON FALLS, NJ, USA – 8 March 2024. The electric vehicle charging stations in a suburban New Jersey shopping mall parking lot glow at dusk, beacons for drivers needing to recharge their cars.

How to ensure user experience and reliability?

When chargers fail to operate, drivers are left unsupported and trust in infrastructure erodes. Accessible charging infrastructure means reliability, not just presence.

Charging infrastructure reliability is improving in some markets (Utility Dive, 2025), yet persistent issues affect user confidence across China, Europe and the United States. Drivers continue to report both software- and hardware-related issues, including failed authentication, damaged connectors and payment system errors (Rajon Bernard et al., 2024); Keith & Womack, 2023). In the United States, average reliability stands at about 78%, meaning one in five do not work (Barbara DeLollis & Glen Justice, 2024). In Germany, 6% of charging attempts are unsuccessful due to technical failures (EcoG Charging Reliability Index, n.d.).

Charger uptime is one component of reliability. Industry and regulators have adopted this concept to track the amount of time that a charger is operational. Several jurisdictions have developed minimum uptime requirements to improve charging infrastructure reliability (ChargeUp Europe, 2025; Keith & Womack, 2023; Rajon Bernard, 2023; Rajon Bernard et al., 2024). Authorities have also looked to increase data transparency, mandating charging network operators to provide real-time data on charger location, type and availability (World Economic Forum, 2024; Rajon Bernard et al., 2024; van Bergen et al., 2021).

Case study

United Kingdom

In 2023, the United Kingdom adopted *The Public Charge Point Regulations* to strengthen reliability and user experience throughout its public charging network. The framework ensures that public charge points are functional, easy to locate and priced transparently, while supporting seamless payments across networks.

Operators of 50 kW and above, public chargers must maintain an annual 99% uptime averaged across their network. Downtime covers both hardware and software failures, but excludes incidents beyond operator control (e.g. grid or telecommunications outages) (Government of UK, 2024).

Other aspects of the regulation are that charge point operators provide customers with a free, 24/7 staffed telephone helpline for real-time assistance. Charge point operators must also clearly display the maximum price of a charging session either on the charge point or through a separate device and fixed charging fees, such as connection or transaction fees, must be displayed to the consumer. All new public charge points 8kW and above (deployed after 24 November 2024) and those 50kW and above must support contactless payment. Payment roaming is also a requirement that allows consumers to pay to charge across multiple charge point networks (Government of UK, 2024).

The UK regulation uniquely introduces penalties for failure to comply with requirements. Operators receive a compliance notice to remedy breaches; failure to act can result in fines of up to GBP 10 000 per charge point (Government of UK, 2024).

Case study

California

Since 2021, the California Energy Commission (CEC) has embedded reliability conditions within its EV charging infrastructure grants, mandating a 97% uptime target (California Energy Commission, 2025). To address ongoing data gaps, California has advanced a legislative framework aimed at improving transparency, reporting and accountability.

Assembly Bill 2061 (2022) required the CEC and the California Public Utilities Commission to establish performance reporting standards for all chargers installed after 2024 and to conduct biennial assessments of their uptime. Assembly Bill 126 (2023) then introduced broader data reporting rules, mandating:

- Inventory reporting to track the number of EV charging ports installed in California
- Record-keeping and reporting to track the reliability of publicly or ratepayer-funded DC fast charging ports
- A 97% uptime standard for publicly or ratepayer-funded DC fast charging ports
- Data sharing on the real-time availability and accessibility of publicly available charging infrastructure

Proposed regulations define uptime as the percentage of time a charging port (on a per-port basis) is operational, with the exception of excluded downtime periods. Regulations also propose that all publicly or ratepayer-funded AC level 2 and DC fast-charging ports share real-time data accessibility, availability and price data (California Energy Commission, 2025). The CEC is also directed to establish standards for how charging stations inform customers about the availability and accessibility of stations (California Energy Commission, 2025).

California's per-port accountability approach is among the most granular and rigorous globally, diverging from the average-based uptime methodologies used elsewhere (Rajon Bernard et al., 2024). The CEC also intends to rank EV network reliability publicly in biennial reports, thereby enhancing competition, operator accountability and consumer confidence.

COLUMBUS, GEORGIA USA – 6 February 2021.
Close up of backlit ChargePoint station in the USA.

How to address vandalism?

From cable theft to smashed screens, vandalism threatens charging networks worldwide. Smart policy, strategic siting and innovative design are essential countermeasures.

Increasing vandalism of publicly accessible charging infrastructure has been documented globally (Transport & Energy, 2025; J.D. Power, 2024). Authorities are now working to better understand the extent and severity of these events (California Energy Commission, 2025). Charger hardware, including display screens, are susceptible to vandalism and accidental damage, while cables are targeted for copper resale.

Aggregated policy reports in the United Kingdom show that theft and vandalism against charge points have cost millions of pounds since 2022, while in Germany, EnBW has recorded cable theft at 120 locations since the beginning of 2025 (Electrive, 2025b). One in five U.S. public charging attempts in 2024 ended in failure, with 10% due to vandalised or missing cables (Automotive News, 2024). The cost of repairs can be substantial, leaving chargers inoperable for extended periods and drivers stranded without charging access.

To deter vandalism, operators are introducing preventative measures, such as reinforced cables, surveillance measures and embedding GPS trackers or dye packs in cables (Automotive News, 2025; Kempower, 2025). Charging infrastructure with exposed cables are at higher risk of vandalism, leading to other innovative designs that minimise cord exposure. While more prominent in Europe, the "bring your own cable" (BYOC) model for curbside AC charging can limit cable theft and vandalism (Epstein et al., 2024). Strategic siting – installing chargers in well-lit, high-traffic areas – also enhances safety and discourages vandalism.

BARCELONA, SPAIN – 15 March 2025. Electric Car Charging at Graffiti-Covered Public Station in Urban Barcelona City.

Case study

Los Angeles

Vandalism of public charging infrastructure in Los Angeles has been of growing concern, prompting collaborative efforts between the City and private operators to reduce theft and damage. Through the City's streetlight EV charging programme, Los Angeles aims to install 150 chargers per year across city council districts. Leveraging municipal ownership of streetlight poles and wiring has enabled efficient deployment and oversight (Lamm & Johnson, 2024).

Vandalism of screens and cables has created maintenance costs that impede the programme's financial viability (Lamm & Johnson, 2024). To mitigate vandalism events, Los Angeles has partnered with AmpUP, a software platform and equipment provider that designs and manufactures retractable-cable charging stations (PR Newswire, 2024). These chargers are mounted on light-poles 10–15 feet (3–4.5 metres) above the ground; the cables descend upon activation and retract when disconnected, minimising cable exposure.

Similarly, start-ups such as Voltpost retrofit existing lampposts into charging stations with protective casings and retractable cables to reduce tampering (Canary Media, 2024).

Case study

California

In the midst of growing challenges related to vandalism and theft of critical infrastructure, California passed Assembly Bill (AB) 476 on 13 October 2025 (California State Legislature, 2025). Public infrastructure under threat includes not just communication network, electric grids and utility poles, but transportation infrastructure, including public charging stations. AB 476 aims to eliminate incentives to steal copper wire and strengthens enforcement through stricter reporting requirements placed on dealers and recyclers, expanding restrictions on scrap metal possession and increased penalties (California State Assembly Caucus, 2025).

Theft of copper valued at under USD 950 is prosecuted as petty theft (up to six months imprisonment), while higher-value thefts qualify as grand theft, chargeable as misdemeanours or felonies.
Vandalism of property, including damages to public utility infrastructure, are also punishable as a felony or misdemeanour. The bill also includes criminal statutes applicable to the receipt, purchase and sale of stolen copper wire. It requires that junk dealers who buy or receive copper wire obtain information from the seller, keep detailed written records of the sale, allow for periodic inspections and participate in reporting to law enforcement (California State Legislature, 2025).

HOLLYWOOD, LOS ANGELES, CALIFORNIA – 19 September 2018.
Electric Vehicle Charging Station in Hollywood on Sunset Boulevard

Burnt charging station for electric cars. The charging station was destroyed in the fire. Parking for electric vehicles

View out of order, not functional electrical car charging station wrapped in striped red white ribbon in Germany

JAKARTA, INDONESIA – 12 February 2024. State-owned company officials are inaugurating a place to refuel electric carsv

How to build capacity and develop internal expertise?

Without the expertise, data and co-ordination local authorities need to guide charging infrastructure roll-out, deployment stalls. Capacity building helps cut through bottlenecks.

For local authorities, barriers to the installation of publicly accessible charging infrastructure can include limited access to data and analytical capacity for demand modelling; unclear direction and guidance at the national level and limited clarity over the role authorities play in the provision of charging infrastructure (Local Government Association, 2021; Rajon Bernard & Hall, 2021b). In many cases, co-ordination with distribution network operators on energy planning and grid connection is limited and local governments report lacking the technical skills, information and staff capacity to guide investments (Local Government Association, 2021;Rajon Bernard & Hall, 2021b) .

Permitting and grid connection procedures are among the most common barriers cited by both public and private stakeholders (e.g. charge point operators, utilities, system operators). These challenges arise partly from administrative capacity constraints and the absence of clear, standardised procedures at the national level. Consequently, local authorities develop divergent approaches, generating uncertainty regarding costs, timelines and approvals. Addressing these inefficiencies requires enhanced national co-ordination, technical support for local governments and systematic knowledge transfer between jurisdictions to share best practices and ease administrative bottlenecks (Sustainable Transport Forum, 2023b).

Case study

Germany

With the National Centre for Charging Infrastructure, the Federal Ministry for Transport has set up anofficial expert hub for developing, planning and co ordinating charging infrastructure rollout in Germany. The Centre offers toolkits, guidance,templates and workshops to support municipaland state authorities in the planning and management of charging infrastructure coverage (National Center for Charging infrastructure, n.d.).

The LadeLernTOOL is geared toward municipalities, serving as a learning platform. It provides practical knowledge on the deployment of charging infrastructure through several courses, including modules on:

- Basic knowledge of charging infrastructure – Covering key actor roles, legal regulations, load management strategies , spatial planning and plug types
- Municipalities and charging infrastructure – Outlining legal frameworks, approval processes and relevant permits for public or semi-public space
- Electrification of the municipal vehicle fleet – Guiding fleet conversion, charging infrastructure and procurement considerations
- Planning and approval processes – Describing legal steps, from planning to operation

The LadeLernTOOL is complemented by the FlächenTOOL and StandortTOOL. The FlächenTOOL streamlines suitable site identification for charging infrastructure, while the StandortTOOL enables authorities, distribution system operators and operators of charging infrastructure to visualise and assess current and future demand for public charge points. Together, the three instruments form a TOOLbox providing foundational knowledge and data driven applications to help deploy infrastructure more effectively. By enabling the use of standardised maps, data and guidance for local procedures, the TOOLbox also addresses complex and layered jurisdiction over infrastructure deployment, allowing for a more co ordinated approach.

Case study

United Kingdom

The UK government and Energy Savings Trust's *Local Government Support Programme* provides local authorities with free and impartial advice on deploying public charging infrastructure (International Transport Forum, 2024). The programme aims to share knowledge and upskill municipal officers to accelerate deployment(Energy Savings Trust, n.d.).

A comprehensive suite of services is offered through the programme:

- Strategy development, including funding guidance and mentoring across delivery phases

- Technical and analytical assistance, such as site selection (map-based analysis), utilisation assessment, guidance on accessibility and EV grid integration

- Skills training on technical analysis and infrastructure design

Further support covers procurement processes, including identifying suitable delivery models, reviewing tenders and guidance on bid evaluation. The programme also hosts quarterly networking forums for municipalities and provides awareness-raising sessions for other local staff involved in parking, enforcement, transport planning, etc.

Several guidance frameworks complement the service, including a procurement guidebook outlining concession models, profit-sharing arrangements and approaches for site selection (Energy Savings Trust, 2020). A broader package of resources links to best practices and case studies on local strategy, energy planning, funding and grant schemes (Energy Savings Trust, 2021). Complementing this, a new UK government-funded electric vehicle infrastructure course launched in March 2024 provides 15-week training (Cenex, 2024).

Multiethnic group of business colleagues collaborating on a project in a conference room, with documents spread on the table.

A New York City government-owned electric car charging at Marcus Garvey Park in Harlem, New York City


Heavy-duty commercial trucks charging at a high power charging depot

How can the private sector mobilise investment?

Leveraging private investment to complement public resources is central to advancing charging infrastructure deployment at scale. First movers benefit from getting involved early.

A substantial share of charging infrastructure deployed to date has benefited from public financial assistance (ZEV Alliance, 2024). Governments can jumpstart charging infrastructure deployment through use of public funding; however, in the medium to long term, scaling expansive public charging networks depends on mobilising private investment (World Economic Forum, 2024b;Tankou et al., 2023;C40 Cities, 2023).

Where public budgets are constrained, the private sector can help to fill the gap. City governments may be able to fund only a limited number of chargers and when spread across numerous projects over an entire country, national funding can be insufficient (World Economic Forum, 2024). In practice, public and private initiatives typically co-exist in the development of publicly accessible charging infrastructure, with public funds de-risking early deployment and private capital enabling subsequent scaling. The coming together of private sector players through joint initiatives and partnerships makes large-scale deployments more feasible by pooling capital and enabling knowledge transfer (C40 Cities, 2023).

Private investors can capitalise on market opportunities where governments lack fiscal space by financing stations and services that complement public programmes. Investing in scalable pilot projects can be of particular importance (Tankou et al., 2023). Early movers can establish brand recognition, build consumer trust and secure strategic sites and partnerships.

Case study

Kabisa (Rwanda)

Launched in 2022, Kabisa is a Rwanda-based company specialising in advancing electric mobility across East Africa. While the company focuses on selling and leasing electric vehicles, it aims to build a comprehensive ecosystem to support the uptake of electric mobility, including through the deployment of public charging stations (Kabisa – Leading EV Ecosystem in Africa, n.d.).

As of October 2025, Kabisa has sold 200 cars and installed 21 charging stations in Rwanda, 27 in Kenya and 3 stations in Uganda. Government authorities have supported the development of a charging network by tendering locations for installation and offering access to land rent-free. With the aim to ensure EV owners are always within 100 km of a charger, Kabisa seeks to build out an electric highway with 31 charging stations stretching across Rwanda, Kenya and Tanzania.

Intentionally deferring reaching a return-on-investment with their charging stations, Kabisa has adopted a pricing model whereby charging is offered at a lower cost so as to increase adoption in the initial stages of market development. The company has had to overcome challenges with access to capital, seeking out strategic partnerships with other private actors. Following a successful pilot where Kabisa installed charging stations at selected gas stations, Kabisa and Societe Petroliere Ltd (SP) announced a partnership in 2024 to further install charging stations across Rwanda. The project received investment through the Rwandan Green Fund (Clean Technica, 2024).

Most recently, Kabisa established an ultra-fast-charging hub strategically positioned near Kigali International Airport and the Free Trade Zone, a high-traffic corridor for commercial transport (Clean Technica, 2025). This newly established station will assist commercial fleets operating electric buses, such as IZI Electric and BasiGO, deliver service in the region (Africa Sustainability Matters, 2025).

Case study

Milence

A joint venture between Volvo Group, Daimler Truck and Traton Group established Milence in 2022, an independent company with the aim to accelerate the deployment and operation of public charging stations across Europe serving electric trucks (Volvo Group, n.d.). The partnership represents a concerted effort among truck manufacturers to support freight electrification and the uptake of electric trucks by building out the infrastructure to support these vehicles.

Charging locations are strategically determined by analysing average annual and daily truck traffic. Milence aims to deploy charging stations every 300 to 400 km along main logistics routes on the European TEN-T network with the highest utilization rates. Locations are chosen for their strategic importance in logistics transport across Europe and ensure drivers can maximise the distance of their journeys (Drive to Zero, 2024).

Starting with its first fast-charging hub established in Venlo (Netherlands) in 2023, Milence has since deployed chargers in Belgium, Sweden and the United Kingdom. The company established its first electric corridor in 2025, connecting Barcelona and Lyon (Milence, 2025). With an initial funding of EUR 500 million and an investment of EUR 111 537 000 through the EU Alternative Fuels Infrastructure Facility (AFIF), Milence aims to deploy 1 700 publicly accessible charging stations by 2027 (Milence, 2025). Deployment is set to include 284 Megawatt Charging System (MCS) and 264 Combined Charging System (CCS) charging points in 71 locations across 10 EU member states (Volvo Group, n.d.).

Heavy-duty electric truck plugged into a charger

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Annex A. Roundtable participants

Last Name	First Name	Affiliation	Presence
FERWERDA (Chair)	Roland	NKL	In-person
CORRADI	Chiara	ChargeUp Europe	In-person
FORGET	Nicolas	Ministère transition écologique France	In-person
GOMEZ	Isabel	Iberdrola	In-person
HAYTON	Judith	Transport for London	In-person
HUISMAN	Mathilde	IEA	In-person
KOHLI	Sumati	ICCT India	In-person
KOPF	Andreas	ITF	In-person
LANN	Gustaf	Swedish Energy Agency	In-person
LORRAINE CHRISTOCHOWITZ	Virginia	NOW GmbH	In-person
MCBAIN	Sarah	ITF	In-person
MCCARTY	Orla	ITF	In-person
MENENDEZ MARTINEZ	Fernando	bpPulse	In-person
MERK	Olaf	ITF	In-person
PAPU CARRONE	Andrea	ITF	In-person
PARMAR	Hiten	South Africa Electric Mobility Alliance	In-person
SAMULON	Michael	City of Los Angeles	In-person
TEIGE KALSAS	Sara	City of Oslo	In-person
ALLEN	Zoe	C40	Online
BERRY	Aaron	UK Department for Transport	Online
ERIKSSON	Lisa	Transport Analysis, Sweden	Online
FABIAN	Bert	Asian Development Bank	Online
FICKER	Monica	Natural Resources Canada	Online
HASHIMOTO	Hiroyoshi	MLIT-NILIM Japan	Online
HASIBAR	Johannes	AustriaTech	Online
KAHRAMAN	Aslihan	Middle East Technical University, Türkiye	Online
KAYHAN	Burak	T.C. Ulaştırma ve Altyapı Bakanlığı, Türkiye	Online
KAYSI	Hakan	EPDK Türkiye	Online
KHAMRAKULOVA	Nadejda	UNECE	Online
KLENKE	Aleksandra	DG MOVE	Online
LIMA	Joana	IMT Portugal	Online
LINDGREN	Magnus	Swedish Transport Administration	Online

MUHOZA	Pophia	Kabisa	Online
NEZU	Yoshiki	MLIT-NILIM Japan	Online
ÖZMEN	Zehra	Enerji ve Tabii Kaynaklar Bakanlığı	Online
PADILLA	Marcelo	Ministerio de Energia Chile	Online
RANTANEN	Laura	Ministry of Transport and Communications Finland	Online
ROLDAN	Juan David	Greenbee	Online
SAWAMURA	Haruki	MLIT-PRILIT Japan	Online
SCHEFFER	Sacha	External Expert	Online
SCHEIN	Andrew	Centre for Net Zero	Online
TOZAKI	Hajime	Kyoto University, Japan	Online
VAN DER KAMP	Anna	Natural Resources Canada	Online
VAN GEELEN	Hinko	Belgian Road Research Centre	Online
WOOD	Eric	NREL	Online
WOODWARD	Amber	Centre for Net Zero	Online
YAZICI	Mehmet	Ministry of Transport and Infrastructure, Türkiye	Online

Building Publicly Accessible Electric Vehicle Charging InfrastructureWorks
Summary and Conclusions

As electric vehicles grow, publicly accessible charging must expand in parallel. Market-led deployment has been uneven, concentrating chargers in profitable locations and leaving gaps that undermine driver confidence and uptake. Permitting and grid-connection delays raise costs and slow roll-out, while reliable operation and long-term competition concern public authorities.

This report gives policymakers guidance on planning and delivering publicly accessible EV charging networks. It distils international experience across deployment models, land-use and grid planning, and policy frameworks that de-risk investment, and sets out measures to clear administrative bottlenecks, streamline roll-out and apply standards that keep networks accessible and reliable for users.*

Based on international case studies and ITF Roundtable discussions with governments, operators and researchers, it compares deployment models – from permit-based to concession and public-operator approaches – assessing their trade-offs for coverage, competition and affordability. It is designed for decision makers shaping public charging strategies in emerging and mature EV markets.

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