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Toward healthy competition in the European public charging market

STAKEHOLDER DYNAMICS AND PRICING TRENDS

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The International Zero-Emission Vehicle Alliance is a network of leading national and sub-national governments demonstrating their deep commitment to accelerating the transition to zero-emission vehicles within their markets and globally. Its members include Austria, Baden-Württemberg, British Columbia, California, Canada, Chile, Connecticut, Costa Rica, Germany, Maryland, Massachusetts, the Netherlands, New Jersey, New York, New Zealand, Norway, Oregon, Québec, Rhode Island, Switzerland, the United Kingdom, Vermont, and Washington. The members collaborate through discussion of challenges, lessons learned, and opportunities; hosting events with governments and the private sector; and commissioning research on the most pressing issues in the ZEV transition.

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Executive summary

The public charging infrastructure market in Europe is undergoing rapid development, driven by the growing adoption of electric vehicles (EVs) and the push for sustainable transportation solutions. This development has entailed considerable changes in market composition and pricing trends, with important implications for industry competition and the overall EV driver experience. In this context, this paper aims to answer three main questions:

1. Who are the key players in the European public EV charging infrastructure market and how does the European market compare with that of North America?

2. What are the charge point operator (CPO) market concentration levels in Europe and North America, and do they cause competition concerns?

3. How do market players set prices for public EV charging, and is there a correlation with their market coverage?

Based on an examination of the public charging infrastructure market across Europe, including five indicator markets—France, Germany, the Netherlands, Norway, and Poland—as well as in the United States and Canada, this assessment arrives at the following conclusions.

Key market players

Charge point operators and mobility service providers (MSPs) are typically categorized into two types of companies: pure players that focus exclusively on the EV charging sector and sector-leaping players such as oil and gas companies, auto manufacturers, and electricity utilities.

Top CPOs in Europe are emerging from adjacent sectors such as oil and gas, while in the U.S. and Canadian CPO markets, pure players such as ChargePoint play a major role. Veteran sector-leaping players may have a competitive advantage over pure players. For example, auto manufacturers have access to vehicle data, oil and gas companies have access to valuable land at petrol stations along highways that is well suited for fast charging hubs, and electricity utilities partly control electricity prices.

In Europe, among leading CPOs that operate direct current (DC) chargers, oil and gas companies have shown the fastest growth, while vehicle manufacturers hold the largest market share. Carmakers, however, have little representation among the top CPOs that operate alternating current (AC) chargers, which are dominated by oil and gas companies and electricity utilities. In Canada and the United States, pure players like ChargePoint operate more than 50% of the AC market while the DC market is dominated by Tesla, followed by pure players.

Like the CPO market, the leading MSPs in Europe also include a higher share of sector-leaping players compared with pure players. Six of the top 10 European MSPs are vehicle manufacturers, which typically operate closed MSPs reserved exclusively for drivers of their respective brands.

CPO market concentration

As of January 2024, the leading AC CPO in 42% of European NUTS 3 regions had a market share exceeding 40%, which the German Competition Authority considers a threshold for market dominance. The leading DC CPO had over a 40% market share in 34% of NUTS 3 regions. At the European level, market concentration in both the AC and DC CPO industries has steadily decreased

since January 2022. However, among the national markets surveyed in this study, AC CPO market concentration has not consistently decreased despite the rise in EV adoption. Concentration in the AC market in Norway has increased while it has remained steady in the Netherlands. Ongoing monitoring could provide regulators with the necessary information to identify any possible competition concerns stemming from these market concentration trends.

Among the European public DC charging markets analyzed, Poland ranks highest in terms of market concentration, with 52% of its regions having a top DC CPO that operates more than 40% of chargers installed. Among AC markets, the Netherlands stands out with 50% of its regions having a top CPO with over 40% market share. Eastern Europe generally exhibits slightly higher market concentration levels than the rest of Europe, but there is no clear trend.

While fewer than 50% of regions in Europe have a leading AC or DC CPO with a market share above 40%, the picture looks considerably different in North America. Approximately 99% of municipalities in Canada and 80% of counties in the United States have a leading CPO operating more than 40% of AC chargers, while 96% of municipalities in Canada and 95% of counties in the United States have a top CPO operating over 40% of DC chargers installed.

Pricing strategies

Energy-based charging rates are widely considered to be the easiest to understand by consumers and ensure all drivers pay a consistent rate for the electricity they use. Charging rates based on energy fees (cost per kWh) are dominant among European charging products, with shares of 88% as of January 2024 for both AC and DC products. The recently enacted EU Alternative Fuels Infrastructure Regulation (AFIR) requires CPOs to deploy chargers with smart charging capabilities to optimize costs for both the grid and users. As CPOs transition to dynamic pricing to guide consumer behavior, ongoing monitoring will be essential to ensure that prices remain understandable and comparable for drivers.

Ad hoc charging prices are generally similar to MSP prices excluding subscription costs. Moreover, no clear correlation was observed between average ad hoc prices and regional market concentration, indicating that leading CPOs have so far not exhibited signs of abusing local market power. When taking subscription fees into account, average MSP prices tend to be higher than ad hoc prices. For frequent drivers, though, the per-kWh cost of the subscription fee decreases, making these plans more cost effective. So far, despite ad hoc prices being comparable to MSP rates on average, drivers have rarely opted for ad hoc payments. However, this may shift due to the AFIR requiring all chargers to support ad hoc payments and accept widely used payment methods.

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Introduction

Public charging infrastructure is a key component for enabling the widespread adoption of electric vehicles (EVs). Sufficient deployment of public chargers can ensure universal access, alleviate range anxiety, and enable longer journeys. For countries intending to phase out combustion engine vehicles, the development of a user-centric public charging network is essential. As governments increasingly help to finance public charging infrastructure deployment, it is important to better understand market dynamics to help determine if investment decisions are fostering healthy competition with fair and transparent prices.

This report provides a comprehensive analysis of the public EV charging infrastructure market in Europe. The first part details the role of charge point operators (CPOs) and mobility service providers (MSPs) in this market and identifies the leading companies in each industry. It also includes information on the Canadian and U.S. markets as points of comparison. The report then presents a quantitative assessment of CPO market concentration in select markets. The final part focuses on how these market players set charging prices.

This report is split into three sections, each answering a specific set of questions:

1. Who are the key players in the European public EV charging infrastructure market and how does the European market compare to that of North America?

2. What are the CPO market concentration levels in Europe and North America, and do they cause competition concerns?

3. How do these market players set prices for public EV charging, and is there a correlation with their market coverage?

The market analyses in this paper are presented at both the European level and the national level for France, Germany, the Netherlands, Norway, and Poland. These countries were selected to capture markets at different stages of EV adoption. Norway and the Netherlands rank first and fourth among European passenger car markets in terms of new plug-in hybrid and battery electric vehicle registration shares in 2023, at 90% and 44%, respectively. Germany and France have new plug-in hybrid and battery electric registration shares close to the European average and together with the Netherlands make up the three leading markets for public charging infrastructure deployment, collectively accounting for around 55% of all public chargers installed in Europe as of the end of 2023. In contrast, Poland's market is still nascent, with plug-in hybrid and battery electric registrations accounting for approximately 6% of total new car registrations in 2023.[1] Poland hosts roughly 1% of the public chargers installed in Europe, though it has taken steps to accelerate charger deployment and, since 2018, has supported EV adoption through tax incentives, purchase subsidies, and other measures.[2] The North America analysis covers Canada and the United States, both of which have seen increasing EV sales shares and substantial public and private sector

1 Michelle Monteforte et al., *European Car and van Market and Charging Infrastructure Development: January–December 2023* (International Council on Clean Transportation, 2023), https://theicct.org/publication/eu-car-and-van-market-development-quarterly-december23-mar24/.

2 European Alternative Fuels Observatory, "Poland: Incentives and Legislation," updated April 23, 2024, https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road/poland/incentives-legislations; Magda Furmanek, "The Budget for Grants for the Fastest Charging Stations Was Fully Allocated in Less than an Hour," PSNM - New Mobility Association, January 9, 2023, https://psnm.org/2023/information/the-budget-for-grants-for-the-fastest-charging-stations-was-fully-allocated-in-less-than-an-hour/?lang=en.

investments in public charging infrastructure.[3] Mexico was not considered for this analysis due to insufficient data.

This paper provides a snapshot of public charging infrastructure as of January 1, 2024, and compares it with the previous two years for Europe; pre-2024 data were unavailable for Canada and the United States. Charging infrastructure and pricing data for Europe cover public and semi-public chargers installed in the 27 Member States of the European Union, the four European Free Trade Association countries (Iceland, Liechtenstein, Norway, and Switzerland), and the United Kingdom, unless otherwise stated.[4] Data for Canada and the United States also cover public and semi-public chargers.[5] The term "charger" in the paper refers to a device that provides power to charge only one vehicle at a time, though it may have multiple connectors to accommodate different connector types. The term "charging station" refers to a cluster of chargers at a single location.

Charge point operators and mobility service providers

As entities responsible for managing and operating chargers, CPOs are regarded as the backbone of the public charging ecosystem, while MSPs engage directly with drivers and focus on delivering a user-friendly charging experience. This section summarizes the roles of CPOs and MSPs in the European public charging infrastructure market and reviews the leading companies in each sector. It also provides a comparison with the North American market to offer context for the subsequent market concentration and charging pricing analyses. The guiding questions for this section are: *Who are the key players in the European public EV charging infrastructure market, what are their roles, and how does this market compare to that of North America?*

The roles of CPOs and MSPs

The EU Alternative Fuels Infrastructure Regulation (AFIR) defines a CPO as the entity responsible for the management and operation of a charging point, including on behalf of an MSP.[6] CPOs may own the chargers they operate or operate them for third parties. Further, CPOs typically set the tariffs paid by end users for ad hoc charging, although these can also be determined by charging station owners if they are a separate entity. Ad hoc charging allows users to pay the CPO directly at a charging station without an MSP contract or membership. Instead, payments are made via a credit card reader installed at the charger or by scanning a QR code for web-based payment.

An MSP can partner with one or more CPOs to provide users with access, sometimes via subscription, to a large network of chargers through a single platform, a practice known as roaming. MSPs normally offer drivers streamlined payment options through charging cards or mobile applications and access to data related to charging progress as well as on the location, availability,

3 Logan Pierce and Peter Slowik, "Up to Speed: Why the Pace of U.S. Public Charging Deployment Is Set to Heat Up," *ICCT Staff Blog* (blog), September 12, 2024, https://theicct.org/why-the-pace-of-u-s-public-charging-deployment-is-set-to-heat-up-sept24/; "Zero Emission Vehicle Infrastructure Program," Natural Resources Canada, July 2, 2024, https://natural-resources.canada.ca/energy-efficiency/transportation-alternative-fuels/zero-emission-vehicle-infrastructure-program/21876.

4 Semi-public chargers are located on private property and typically have access restrictions, such as specific opening and closing times.

5 All data are sourced from Eco-Movement, https://www.eco-movement.com.

6 Regulation (EU) 2023/1804 of the European Parliament and of the Council of 13 September 2023 on the Deployment of Alternative Fuels Infrastructure, and Repealing Directive 2014/94/EU, OJ L 234 (September 22, 2023), https://data.consilium.europa.eu/doc/document/PE-25-2023-INIT/en/pdf.

and pricing of chargers. Further, MSPs tend to offer their customers predetermined charging rates that are relatively uniform across CPO networks and regions.[7] Agreements between CPOs and MSPs can be established either bilaterally or via roaming service platforms, which are third parties that facilitate connections between CPOs and MSPs by aggregating many participants across different regions. An individual charger can be part of many MSP networks simultaneously.

Some large CPOs (e.g., Ionity, Allego, and Recharge) function as their own MSPs, providing services such as mobile applications, subscriptions, and customer support but limiting these offerings to their own networks. In other cases (e.g., EnBW, Be Charge, and Shell Recharge), CPOs are vertically integrated with full-range MSPs and also offer roaming services. Generally, the level of vertical integration in the public charging market is high. For example, electric utilities, which are companies that produce, transmit, and/or sell electricity, can act as both CPOs and MSPs, and carmakers can act as MSPs.[8]

CPOs and MSPs can also play important roles in optimizing the integration of EVs into the power grid by supporting smart charging at public charging stations. Smart charging—which the AFIR defines as adjusting the intensity of the electricity delivered to the vehicle in real time to minimize costs for the driver and the grid—can be employed to manage power demand and avoid overloading the electricity grid while efficiently integrating renewable energy. CPOs are increasingly required by regulations such as the AFIR to deploy chargers that are capable of smart charging. By setting tariffs that vary based on the time of day, demands on the grid, and/or related considerations, CPOs can incentivize charging at times of renewable energy production peaks or low grid power demand. MSPs can also enable drivers to opt for smart charging by offering such services in their mobile applications. Smart charging is not yet feasible in the case of anonymous, ad hoc charging sessions.[9]

Further, MSPs are integral for the implementation of Plug and Charge, an emerging technology that facilitates automatic and secure authentication and authorization of charging sessions. To enable Plug and Charge, drivers must have at least one MSP contract, as MSPs issue the contract certificates that need to be installed in the vehicle.[10]

Market interactions between CPOs and MSPs and the role of roaming services

Europe

In Europe, it is common for MSPs to enter into agreements with many CPOs to expand their network coverage. This allows CPOs to increase their charger utilization rates and grants drivers access to networks operated by various CPOs through their preferred provider's mobile application. As of January 2024, the number of active MSPs across the five European countries examined in this paper ranged from 80 to 140, while the number of CPOs showed a much wider variation (from 74 in Poland to 973 in Germany; see Table 1). On average, as of January 2024,

7 Niko Waxmann et al., *eMobility Excellence Report* (eMobility Excellence, June 30, 2023), https://emobilityexcellence.com/en/report-june-2023.

8 European Commission: Directorate-General for Competition et al., *Competition Analysis of the Electric Vehicle Recharging Market across the EU27 + the UK – Market for the Provision of Publicly Accessible Recharging Infrastructure and Related Services* (Publications Office of the European Union, 2023), https://data.europa.eu/doi/10.2763/396082.

9 ChargeUp Europe, *The Importance of Including EV Roaming in AFIR* (February 23, 2023), https://www.gireve.com/wp-content/uploads/2022/02/The-importance-of-including-EV-roaming-in-AFIR-.pdf.

10 V2G Clarity and Hubject, *Secure and User-Friendly EV Charging. A Comparison of Autocharge and ISO 15118's Plug & Charge*, June 12, 2019, https://cdn.prod.website-files.com/62fffb2b98e777c73cdd625c/6458b0680be9f8b9ebff9e4d_AutoCharge-VS-PnC.pdf.

a single European charging station was covered by 25 MSP networks. The Netherlands had the highest average number with 36 MSPs per station, about three times higher than the average in Poland. Further, MSPs partnered with 88 CPOs across Europe, on average, although half of the MSPs covered nine or fewer CPO networks.

Table 1. Number of MSPs per charging station, number of CPOs per MSP network, and total number of active MSPs and CPOs in select European countries as of January 2024

Country	Number of MSPs	Number of CPOs	Number of MSPs per charging station		Number of CPOs per MSP network	
			Mean	Median	Mean	Median
France	124	184	25	26	26	10
Germany	140	973	24	19	56	22
Netherlands	123	146	36	32	29	25
Norway	82	124	15	12	7	4
Poland	81	74	11	10	8	4
Europe	238	2,301	25	23	88	9

Notes: Calculations regarding the number of CPOs per MSP network and the total number of MSPs only include MSPs that had agreements with two or more CPOs in a given country as of January 2024. That is, MSPs that cover a single CPO (i.e., CPOs that act as their own MSPs) are excluded from the calculations. These CPO-MSPs accounted for 74% of the 911 European MSPs included in the dataset and are typically entities with a low number of chargers such as hotels, shops, and building owners.

Historically, payments to MSPs have largely outpaced ad hoc transactions. According to a 2022 report by ChargeUp Europe, 95% of payments on public chargers were made using an MSP account, while a 2023 analysis published by the German Monopolies Commission indicates that MSP payments amounted to at least 90% of such payments.[11] This is likely due to the fact that MSPs tend to offer convenient payment methods for multiple CPO networks and greater price transparency through upfront online information and fixed tariffs across the MSP network compared with CPOs. In addition, it is possible that service providers prefer the subscription model to ensure steady revenues in light of low charger utilization rates in emerging markets.[12] Despite the convenience of MSP services, limitations in roaming coverage have often meant that drivers have had to maintain multiple contracts to ensure access to a broad charger network, an issue exacerbated by the unreliability of ad hoc charging as a fallback option.[13] Additionally, differences across MSP pricing models, for example regarding subscription fees or special prices within networks, has made it difficult for drivers to compare charging prices.[14]

Given the lack of comprehensive ad hoc price information, consumers have only been able to compare MSP tariffs and ad hoc prices to a minimal extent. Thus, in some cases, MSP prices have not competed with CPO rates. The 2023 analysis by the German Monopolies Commission indicates

11 ChargeUp Europe and P3 Automotive, *State of the Industry. Insights into the Electric Vehicle Charging Infrastructure Ecosystem* (2022), https://cdn.motor1.com/pdf-files/il-report-state-of-the-industry-2022.pdf; Monopolkommission, *Energie 2023: Mit Wettbewerb Aus Der Krise* [Energy 2023: Out of the Energy Crisis with Competition] (2023), https://www.monopolkommission.de/images/PDF/SG/9sg_energie_volltext.pdf.

12 Sarah LaMonaca and Lisa Ryan, "The State of Play in Electric Vehicle Charging Services – A Review of Infrastructure Provision, Players, and Policies," *Renewable and Sustainable Energy Reviews* 154 (February 1, 2022): 111733, https://doi.org/10.1016/j.rser.2021.111733.

13 European Alternative Fuels Observatory, Avere, and Fier Automotive, *Pricing of Electric Vehicle Recharging in Europe* (February 9, 2022), http://old.avere.org/wp-content/uploads/2021/07/EAFO-Report-Pricing-of-Electric-Vehicle-Recharging-in-Europe.pdf.

14 Monopolkommission, *Energie 2023: Mit Wettbewerb Aus Der Krise*.

that CPOs have rather relied on negotiating attractive MSP-facing prices, potentially leveraging their local market power.[15] That is, a CPO with a dominant position in a region may have charged MSPs higher prices, as MSPs heavily relied on the CPO to serve that region. Conversely, MSPs have likely paid lower prices to CPOs when CPOs had a high dependance on the MSP. The same study assessed that MSPs' fixed pricing across CPO networks favors CPOs with market power to set excessive MSP-facing prices, which may have led to an increase in MSP price levels for drivers. Regional competition at the CPO level has thus possibly played a key role in setting charging prices, particularly in regions where leading CPOs have had leverage.

Tackling the lack of price transparency and payment barriers associated with public charging, such as the need to register or enter into contract with a provider to access chargers, is among the core objectives of the AFIR.[16] Adopted in 2023 and effective from April 2024, this regulation is expected to alter dynamics between CPOs and MSPs. The AFIR mandates that ad hoc payments be available at all charging points installed in the European Union after April 2024 and that all chargers with a power output above 50 kW be retrofitted to offer ad hoc payment before 2027. It further obligates the acceptance of widely used payment methods. The regulation also requires CPOs to make ad hoc prices available at no cost on National Access Points (e.g., public databases and web portals) from April 2025. In addition, CPOs must not discriminate in pricing between drivers and MSPs (or among different MSPs), but price differences are allowed if they are "proportionate and objectively justified."

With the AFIR supporting ad hoc charging, CPOs may play a more prominent, user-facing role in public charging and the share of ad hoc payments could grow in the future. CPOs have incentives to promote direct payments considering the higher price margins of ad hoc rates, which are exempt from potential MSP fees, and the investments required to equip chargers with credit card readers to comply with the AFIR. Further, CPOs are likely to increasingly adopt pricing models that vary by site to balance charger congestion as well as by time to reflect peak and off-peak energy costs. For MSPs, a shift to site-specific and dynamic pricing entails technical challenges and a deviation from their relatively simple pricing models to date. Some argue the cost premium of this new scheme might be unsustainably high for many MSPs.[17]

The European Commission decided not to include a roaming mandate in the AFIR, deeming it an unnecessary interference with the contractual freedom of CPOs. Since the AFIR is an EU regulation, it supersedes national laws, meaning Member States cannot legally mandate roaming services for all public chargers installed. However, the Netherlands and Malta include roaming in tenders and contractual agreements, while Portugal encourages nationwide roaming by supporting CPOs and MSPs to integrate with the national roaming platform MOBI.E through implementation of the Open Charge Point Interface (OCPI) roaming protocol.[18], France also promotes roaming by linking charging infrastructure funding to connectivity with the roaming platform Gireve for certain types of chargers.[19]

15 Monopolkommission, *Energie 2023: Mit Wettbewerb Aus der Krise*.

16 European Parliament and Council, "Regulation of the European Parliament and of the Council on the Deployment of Alternative Fuels Infrastructure, and Repealing Directive 2014/94/EU."

17 Janek Metzner et al., "Why MSPs Must Adapt to Survive," *Electric Avenue*, August 28, 2024, https://www.readelectricavenue.com/p/msps-must-adapt.

18 A roaming protocol is a set of rules for CPO-to-MSP communication to enable automated charging session authorization, billing, price information exchange, and charger reservations, among other services. Commonly used roaming protocols include OCPI, the Open Clearing House Protocol (OCHP), and Open Intercharge Protocol (OICP). On Portugal, see MOBI.E, *MOBI.E OCPI - CEME (EMSP) and OPC (CPO) Integration: OCPI Implementation Within the Context of MOBI.E and PT* (May 20, 2024), https://www.mobie.pt/documents/42032/143944/20230620_MOBIE_OCPI_Phase2_Internal_v1_6.pdf/fdb-22f6a-3ffc-529d-8f9f-d27706875de7?t=1716289763105.

19 "Advenir Services. Data Consumption Reports and Interoperability," Gireve, accessed November 20, 2024, https://www.gireve.com/advenir/.

Another factor that could impact CPO and MSP dynamics in favor of CPOs is a potential increase in the convenience of credit card payments for both CPOs and drivers. This could be driven by emerging software solutions for handling ad hoc payments or by simpler user authentication via a PIN pad exemption considered in the proposed revision of the Payment Services Directive II (PSD II).[20] Such developments may reduce the relevance of charging cards.

North America

Roaming has potentially been less relevant in North America due to the significantly higher concentration of the CPO market compared with Europe (see next section). The first North American roaming hub was founded in 2021, while large roaming platforms in Europe, such as Gireve and Hubject, have been active since 2013.[21] Additionally, the OCPI and Open Clearing House Protocol (OCHP), two widespread CPO-to-MSP communication protocols—fundamental for realizing roaming agreements—were both first established in Europe.[22]

In North America, the MSP and CPO have typically been the same entity, requiring drivers to create a network account to use their chargers without necessarily establishing roaming agreements with other networks.[23] Some of the largest North American CPOs have offered services such as mobile applications and streamlined payment options, but they have been less likely to offer the pricing plans and network-wide tariffs offered by several European MSPs. These CPOs typically do not control pricing themselves but rather pass site-specific prices set by charging point owners on to drivers.[24]

In recent years, both North American regulators and the industry have increasingly embraced roaming, with OCPI having established itself as the de facto standard for communication across networks. Since 2020, California has required all public alternating current (AC) and direct current (DC) chargers installed to be capable of providing roaming services using OCPI.[25] Similarly, the U.S. National Electric Vehicle Infrastructure (NEVI) Formula Program includes an OCPI mandate that applies to all NEVI-funded chargers.[26] Like the AFIR, NEVI and California do not require CPOs to establish roaming agreements with other operators, but the California Energy Commission may consider requiring such agreements for publicly-funded chargers in the 2025–2026 timeframe.[27] At the same time, CPOs that receive funding from NEVI may not charge a subscription fee or require membership for use of their public charging stations, a requirement that also applies to CPOs operating chargers in California.

20 Von Christoph M. Schwarzer, "AFIR mit Payment-Terminals: So wird Ad hoc zur Konkurrenz fürs Roaming [AFIR with Payment Terminals: How Ad Hoc Becomes Competition for Roaming]" *Electrive*, July 10, 2024, https://www.electrive.net/2024/07/10/afir-mit-payment-terminals-so-wird-ad-hoc-zur-konkurrenz-fuers-roaming/; Avere, *The Upcoming Proposal for a New Payment Services Directive (PSD II)* (April 15, 2023), https://www.avere.org/l/library/download/urn:uuid:2aeace4a-bd28-4728-8291-45792423f06c/avere+position+paper+on+the+upcoming+proposal+for+a+new+payment+services+directive+%28psd+ii%29.pdf.

21 "About Us," ChargeHub, accessed November 20, 2024, https://solutions.chargehub.com/about-us; "Hubject – eRoaming-Plattform für eine vernetzte Elektromobilität" [Hubject – eRoaming Platform for Networked Electromobility], Deutscher Mobilitätspreis, accessed November 20, 2024, https://land-der-ideen.de/wettbewerbe/deutscher-mobilitaetspreis/preistraeger/best-practice-2016/hubject; Renault Group, "Creation of GIREVE SAS_Roaming Services for Electric Vehicle Charging," press release, July 22, 2013, https://media.renaultgroup.com/creation-of-gireve-sas-roaming-services-for-electric-vehicle-charging/.

22 Netherlands Enterprise Agency, *Electric Vehicle Charging: Definitions and Explanation* (January 2019), https://nklnederland.nl/wp-content/uploads/2021/12/Electric_Vehicle_Charging_-_Definitions_and_Explanation_-_january_2019.pdf.

23 Jeffrey Lu, "Statement on Charging Interoperability (ADA)," statement concerning the Vehicle-Grid Integration project, California Energy Commission, November 14, 2023, https://efiling.energy.ca.gov/GetDocument.aspx?tn=253106.

24 LaMonaca and Ryan, "The State of Play."

25 Electric Vehicle Supply Equipment Standards, 13 CCR 2360 (2023), https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2019/evse2019/fro.pdf.

26 National Electric Vehicle Infrastructure Standards and Requirements, 88 F.R. 12724 (2023), https://www.federalregister.gov/documents/2023/02/28/2023-03500/national-electric-vehicle-infrastructure-standards-and-requirements.

27 Lu, "Statement on Charging."

Likely driven by these requirements, the number of roaming agreements among North American CPOs appears to be growing.[28] Further, in late 2023, the Canadian-U.S. industry initiative Agora was established with financial support from Natural Resources Canada's Zero Emission Vehicle Awareness Initiative to advance roaming in the Canadian public charging network.[29] The initiative offers a tool for finding charging networks compatible with mobility services in Canada and the United States.

Types of CPOs and MSPs

CPOs and MSPs are typically categorized into two types of companies: pure players that focus exclusively on the EV recharging sector and veteran sector-leaping players such as oil companies and utilities. Additionally, CPOs and MSPs can be classified based on their ownership structure as either state-owned or privately-owned companies.[30]

These categorizations can be valuable for identifying potential competition concerns. On the one hand, sector-leaping players may have a competitive advantage over pure players due to their access to relevant resources and existing customer relationships. Vehicle manufacturers have access to valuable vehicle data, while oil and gas companies own or control land along highways at rest areas, which are ideal locations for fast charging hubs. Retail establishments can also own or lease strategically located land, and EV charging is a natural extension of the core services of electric utilities, which in some cases also control the electricity distribution grid. On the other hand, the ownership structure of CPOs is important, as there is a risk that state-owned CPOs may receive preferential treatment from local authorities, such as when awarding grid access permissions or concession contracts for installing chargers in public land.[31]

CPOs

Europe

While pure players and state-owned companies have been more prevalent in the early stages of Europe's EV markets, large companies from adjacent sectors have later gained market share after acquiring existing companies.[32] For example, in 2023, Compleo, a pure player established in 2009, was acquired by Kostal Group, a century-old electronic and mechatronic product manufacturer.[33] Similarly, in 2021, Freshmile, a French pure player founded in 2010, was acquired by Rexel Group, a distributor of electrical supplies founded in 1967.[34]

Figure 1 illustrates the market shares of the 10 leading CPOs in Europe between January 2022 and January 2024 by charger power output type and CPO category. AC chargers are considered slow or semi-fast chargers, delivering up to 50 kW of power in the form of alternating current from the

28 Charles Morris, "Greenlots, ChargePoint, EV Connect and FLO Expand Roaming Cooperation," *Charged EVs*, June 28, 2021, https://chargedevs.com/newswire/greenlots-chargepoint-ev-connect-and-flo-expand-roaming-cooperation/; EVCS, "EVCS Partners with ChargeHub to Simplify Access to Public Charging for EV Drivers," press release, March 30, 2023, https://www.evcs.com/blog/evcs-partners-with-chargehub-to-simplify-access-to-public-charging-for-ev-drivers.

29 Agora, "Industry Launches Agora to Drive Electric Vehicle Adoption Through EV Roaming," press release, November 17, 2023, https://www.newswire.ca/news-releases/industry-launches-agora-to-drive-electric-vehicle-adoption-through-ev-roaming-828513069.html.

30 Marie Bonnefous, "Beyond EV Charging #5 - CPO Segmentation," Gireve, March 6, 2024, https://www.gireve.com/beyond-ev-charging-5/; European Commission: Directorate-General for Competition et al., *Competition Analysis*.

31 European Commission: Directorate-General for Competition et al., *Competition Analysis*.

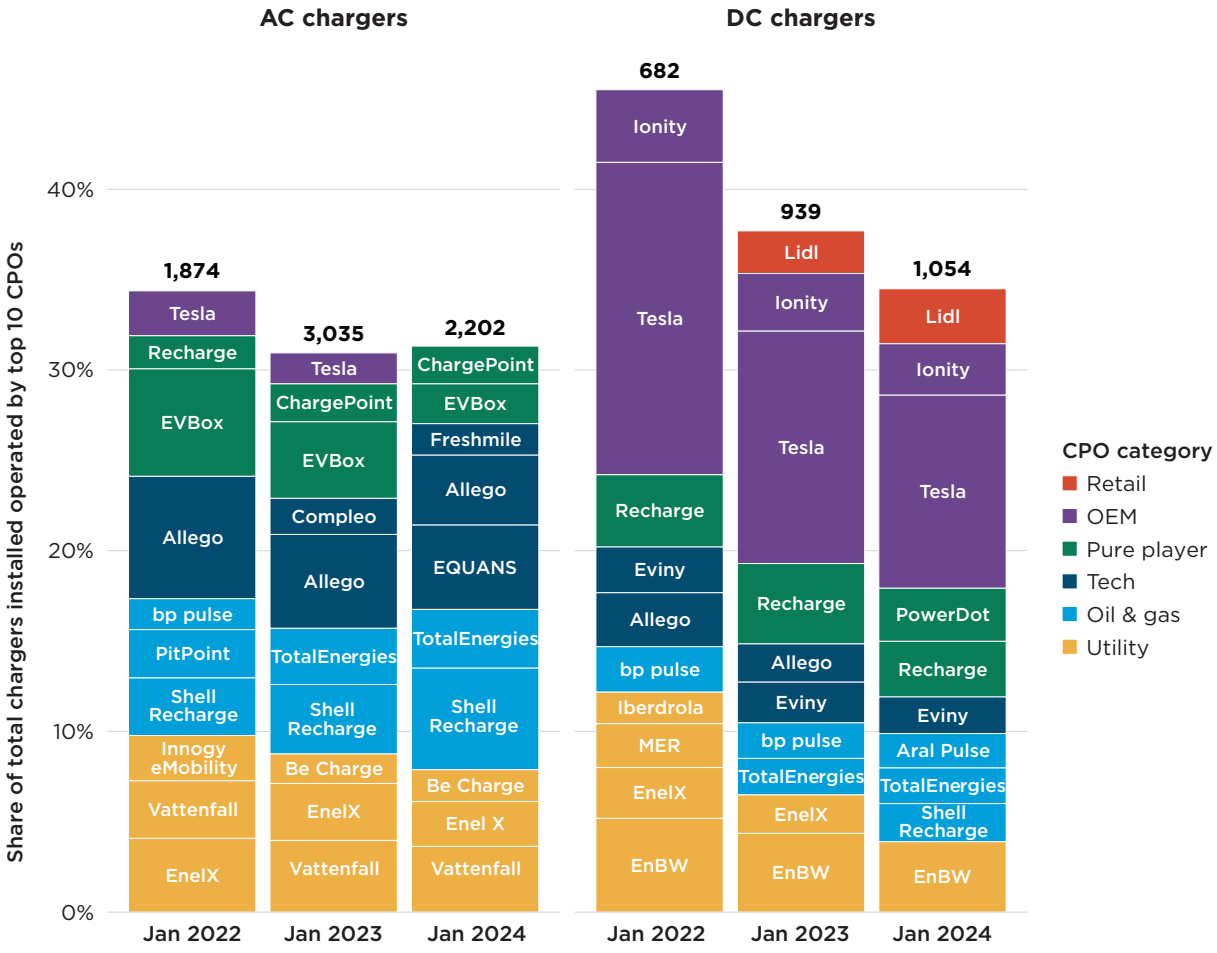
32 European Commission: Directorate-General for Competition et al., *Competition Analysis*.

33 "Pioniere Der Elektromobilität" [Pioneers of Electromobility], Compleo Charging Solutions, accessed November 26, 2024, https://www.compleo-charging.com/unternehmen/geschichte.

34 "About Freshmile," Freshmile, accessed November 26, 2024, https://www.freshmile.com/en/about/.

electrical grid. In contrast, DC chargers, often referred to as fast chargers, supply power directly to the vehicle's battery, bypassing the onboard converter. They typically supply power above 50 kW, enabling faster charging speeds. The total number of CPOs active in Europe is shown at the top of each bar. CPOs are classified as pure or sector-leaping players, and the latter are further subdivided into (1) electric utilities, (2) oil and gas companies, (3) original equipment manufacturers (OEMs) or OEM partnerships, (4) retail companies, and (5) companies in technology-related sectors (referred to as "Tech" in the figure), including renewable energy technologies, public infrastructure projects, or electrical equipment supply.[35] There are no state-owned companies among the leading CPOs, but Vattenfall InCharge, EnBW, MER, and Eviny are part of fully or partially state-owned utilities.[36]

Figure 1. Share of total public chargers installed in Europe operated by top 10 CPOs by CPO category, power output type, and date. The total number of active CPOs is indicated at the top of each bar.



We observe that the share of AC chargers managed by the top 10 CPOs in Europe dropped from 34% to 31% between January 2022 and 2024, while the decrease in DC market concentration was more pronounced, dropping from 46% to 34%. There was no company with a market share above 10% except the OEM Tesla, which had a DC charger share of 11% as of January 2024 (down from 17%

35 "Wat we doen" [What We Do], Equans, accessed November 26, 2024, https://equans.nl/over-ons/wat-we-doen/; Freshmile, "About Freshmile"; "About Us," Allego, accessed November 26, 2024, https://www.allego.eu/about-us/.

36 Sören Amelang and Felix Bieler, "Germany's Largest Utilities at a Glance," *Clean Energy Wire*, March 14, 2018, https://www.cleanenergywire.org/factsheets/germanys-largest-utilities-glance; "E-Mobility Solutions," Statkraft, accessed November 26, 2024, https://www.statkraft.com/what-we-offer/e-mobility-solutions/.

at the beginning of 2022). None of the other companies captured a charger share of more than 7% in these years.

As shown in the figure, sector-leaping players have outnumbered pure players among the leading AC and DC CPOs in Europe. As of January 2024, the dominant sectors among the top 10 CPOs offering AC charging were oil and gas companies and technology-related companies, with the latter showing a significant increase compared with January 2022. In the DC market, OEMs led due to Tesla's large network.

While oil and gas companies entered the CPO market relatively late, they are now the fastest growing sector, amid numerous acquisitions by energy and oil companies in recent years.[37] For example, in 2018, BP acquired the pure player Chargemaster, the United Kingdom's largest CPO at the time.[38] Shell, meanwhile, has acquired several pure players, including Cable Energía, active in Spain and Portugal, in 2022 and Swiss CPO evpass in 2023.[39] Oil and gas companies are also forming partnerships with OEMs for the installation of public chargers. For example, Shell and BYD reached an agreement in 2023 to install 100,000 chargers in Europe that will give BYD drivers preferential access.[40] Outside of the oil and gas sector, the retail company Lidl joined the DC CPO top 10 list in 2023 and 2024.

North America

Figure 2 shows the shares of public chargers managed by the 10 largest CPOs in Canada and the United States as of January 2024 by charger type and CPO category. These markets differ greatly from the European market in terms of market concentration and category shares. In Canada, the 10 leading CPOs operated over 90% of public chargers installed in both the AC and DC charger markets. The DC CPO market in the United States featured similar concentration levels, while the 10 largest AC operators in the United States covered a slightly lower share of chargers (83%). In Canada, there were fewer than 30 CPOs active in either the AC or DC market. In contrast, in the United States, there were about 60 AC and 70 DC CPOs—still far fewer than the few thousand active companies in Europe. Notably, there is significant overlap among CPOs operating in the AC and DC markets.

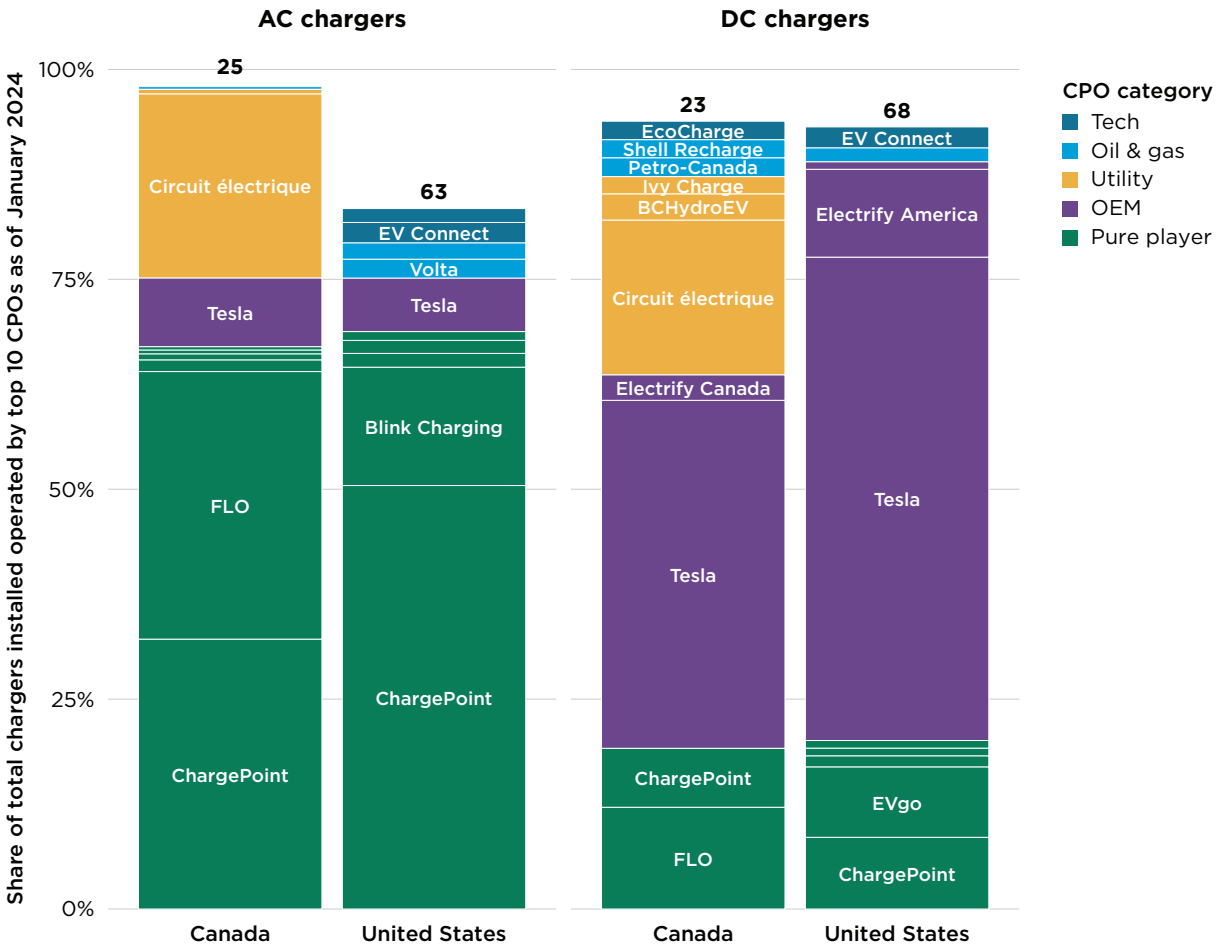
37 Lorenzo Chiavarini et al., "The Electric Vehicle (EV) Charging Infrastructure Startup Landscape," *Dealroom*, November 4, 2024, https://app.dealroom.co/lists/18703.

38 BP, "BP to Acquire the UK's Largest Electric Vehicle Charging Company," press release, June 28, 2018, https://www.bp.com/en/global/corporate/news-and-insights/press-releases/bp-to-acquire-uks-largest-electric-vehicle-charging-company.html.

39 Shell Global, "Shell Acquires 100% of Cable Energía to Expand EV Charging Network to Spain and Portugal," press release, June 8, 2022, https://www.shell.com/what-we-do/mobility/mobility-news/shell-acquires-hundred-percent-of-cable-energia-to-expand-ev-charging-network-to-spain-and-portugal.html; Shell Global, "Shell Expands Swiss EV Charging Network with Acquisition of Evpass," press release, February 27, 2023, https://www.shell.com/what-we-do/mobility/mobility-news/shell-expands-swiss-ev-charging-network.html.

40 BYD, "BYD and Shell Partner on Charging for 100,000 Electric Vehicle Customers," press release, April 13, 2023, https://www.byd.com/eu/news-list/BYD_and_Shell_Partner_on_Charging_for_100,000_Electric_Vehicle_Customers.html.

Figure 2. Share of total public chargers installed operated by the top 10 CPOs by CPO category and power output type in Canada and the United States as of January 2024. The total number of CPOs is indicated at the top of each bar. Only the names of CPOs with a market share above 2% are shown in the figure.



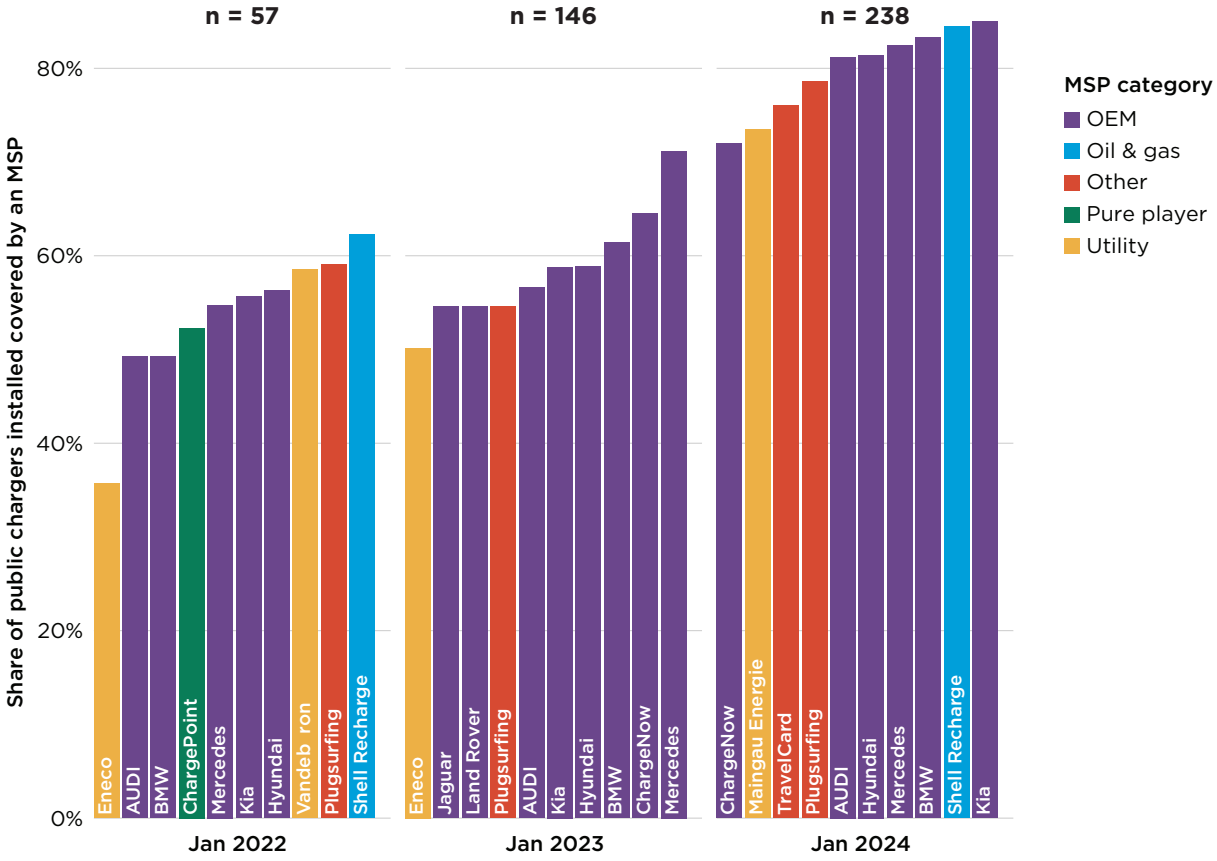
Pure players are key in the Canadian and U.S. public AC charging infrastructure markets, with ChargePoint leading in both countries with market shares of 32% (Canada) and 50% (United States). The second-largest CPO in Canada, Flo, operates a network virtually as extensive as ChargePoint, while the second-largest CPO in the United States, Blink Charging, had a market share of 14%. These three CPOs serve as aggregators connecting independent station hosts that set charging tariffs. All three also act as MSPs offering mobile applications, charging cards, and access to partner networks, while direct, anonymous payments are only partially available.[41] In Canada, the utility Le Circuit électrique (Electric Circuit) stands out with AC and DC market shares of 22% and 18%, respectively. DC infrastructure was dominated by Tesla in both countries, especially in the United States, where the OEM operated 58% of all public DC chargers installed. ChargePoint and Flo were the leading DC pure players in Canada, while ChargePoint and EVgo were the top two DC pure players in the United States.

41 "Driver FAQ: Answers to Common EV Charging Questions," Blink Charging, accessed November 26, 2024, https://blinkcharging.com/charge/driver-faq; "How Much Will It Cost to Charge My Car? Who Sets Prices for Charging?," ChargePoint, May 8, 2023, https://www.chargepoint.com/en-gb/drivers/support/faqs/how-much-will-it-cost-charge-my-car-who-sets-prices-charging; "Leading the way," Flo, accessed January 8, 2025, https://www.flo.com/about/.

MSPs

Figure 3 shows the charger coverage of the top 10 MSPs in Europe from January 2022 to 2024 by MSP category. The total number of active MSPs is indicated at the top of each bar chart.[42] Information for the United States and Canada is not included due to data limitations.

Figure 3. Share of public chargers installed covered by the top 10 MSPs in Europe by category and date. The total number of active MSPs is indicated at the top of each bar chart.



The share of installed chargers served by the top 10 MSPs increased considerably from a maximum of about 60% as of January 2022 to a maximum of roughly 85% two years later. Like the CPO market, the leading MSPs also featured a higher share of sector-leaping players compared with pure players. Most of the top 10 MSPs were OEMs, which tend to restrict their services to drivers of their own automobiles.[43] As of January 2024, the open MSP with the largest network was Shell Recharge, with a coverage of 84% of all public chargers installed in Europe.[44]

Competition in the CPO market

This section dives into the evolution of CPO market power dynamics. The underlying research questions are: *What are the CPO market concentration levels in Europe and North America; how*

42 As in Table 1, the MSP tallies included in Figure 3 exclude MSPs that cover a single CPO (i.e., CPOs that act as their own MSPs). These CPO-MSPs accounted for 74% of the 911 European MSPs included in the dataset.

43 Waxmann et al., *eMobility Excellence Report*.

44 As of January 2023, Shell Recharge was not ranked among the top 10 MSPs, likely due to limitations or inaccuracies in the raw data used for the analysis.

have they evolved in recent years; and do the levels of concentration warrant competition concerns? A summary of existing competition analyses of European markets and their findings is provided at the beginning of this section, followed by an overview of key measures of market competition. The section then proceeds into an analysis of historical market share trends of leading CPOs in the European, U.S., and Canadian markets at the national and local levels to provide insight into the levels of concentration within these markets. This section does not assess the MSP market due to data availability; for a general overview of MSP charger coverage in Europe, see Figure A1 and Table A1 in the appendix.

Review of EV public charging competition analyses

Amid concerns about a possible lack of competition in the emerging EV public charging market and its negative impact on EV adoption, authorities and researchers in several countries have conducted analyses of competitiveness in the sector. An extensive 2023 competition report on behalf of the European Commission found no evidence of major competition issues in the European Union and the United Kingdom but highlighted that such concerns may arise as the sector grows.[45] The report identified five key areas of concern:

1. The potential abuse of local market power to impose unfair conditions on consumers

2. Positive density and/or indirect network effects—whereby the value of a charging service increases as the provider's network coverage grows—leading to an increase of national market concentration levels (a process known as market tipping)

3. Practices that prevent competitors from accessing the market resulting from vertical integration (e.g., an electricity grid operator acting as a CPO limiting grid access for rival CPOs to favor its own charger network)

4. Practices that restrict market access due to coordinated conduct resulting from horizontal cooperation agreements (e.g., exchange of commercially sensitive information between CPOs placing competitors at a competitive disadvantage)

5. Concerns related to public funding (e.g., exclusive, long-term concessions by local authorities for AC chargers or for DC chargers along highways).

Regarding country-level analyses, the 2023 edition of a report series published by the German Monopolies Commission found a higher increase in ad hoc AC charging prices in postal codes with higher CPO concentration levels between 2021 and 2023.[46] The report pointed to a lack of transparency regarding ad hoc charging prices as one of the most detrimental factors to market competition. It also highlighted the potential for anticompetitive practices, such as OEMs that act as MSPs installing their own MSP digital certificates into their vehicles; as these certificates are required for authenticating and authorizing Plug and Charge charging sessions, this could hinder access to rival MSPs. Additionally, it found that the current lack of compatibility of Plug and Charge with ad hoc payments, which is unnecessary from a technical point of view, restricts competition in the market.[47] Further, the study stressed the importance of distributing public funds for charging infrastructure among several players at a regional level, as well as of eliminating entry barriers to fast charging locations at rest stops along highways. A 2024 report by the German Federal

45 European Commission: Directorate-General for Competition et al., *Competition Analysis*.

46 Monopolkommission, *Energie 2023: Mit Wettbewerb Aus Der Krise*.

47 Monopolkommission, *Energie 2023: Mit Wettbewerb Aus Der Krise*.

Cartel Office largely supported the findings of the German Monopolies Commission, emphasizing that regional authorities often allocate public land and incentives for charger deployment in a discriminatory manner. However, the report cautioned that increasing ad hoc price transparency could facilitate price coordination across EV service providers, potentially resulting in higher charging prices.[48]

A 2023 report published by the Austrian Federal Competition Authority analyzing competition in the Austrian public charging market found high CPO market concentration levels across the country, with regional public utilities operating the largest charger shares. While the study did not consider high concentration levels to be a cause for concern at a time when the Austrian market is in an early stage of development, it did emphasize the importance of taking regulatory measures to ensure non-discriminatory access to newcomers in order to prevent long-term competition issues, especially considering that public utilities are owned by municipalities that control the allocation of charging sites. Further, the report identified a concerning widespread lack of transparency of charging prices in general and of roaming fees in particular, though it expected this situation to improve significantly with the adoption of the AFIR.[49]

In 2022, the Delft University of Technology carried out a competition analysis of the Dutch public charging market. Consistent with the analyses mentioned above, the study identified two major barriers to competition: long-term exclusive government concessions for facilities at highway locations and exclusive AC charging infrastructure concessions granted by municipalities. These practices hinder the entry of new companies and risk creating technology or vendor lock-in when the concession period ends. Policy recommendations in the report include allowing new market entrants to take over charging infrastructure along highways for a fee and requiring compliance with interoperability measures to avoid lock-in dynamics and reduce switching costs.[50]

In 2024, the French Competition Authority published a report examining competition in the public and private charging infrastructure markets. A lack of price transparency was among the major issues identified. To address this, the Authority proposed maintaining a public database with real-time CPO and MSP rates, noting that consumer benefits of increased transparency outweigh the potential risk of collusion. While the report found no significant market entry barriers, it warned of potential abuses of competitive advantage by sector-leaping players, such as oil and gas companies. The Authority also emphasized the role of local authorities in fostering competition by encouraging the presence of multiple CPOs and discouraging the use of exclusivity clauses that favor specific CPOs. Further, it recommended allowing all French interoperability platforms to issue the interoperability certificates required for CPOs to access public subsidies.[51]

48 Federal Cartel Office, *Wettbewerbsschädliche Strukturen beim Angebot von Ladestrom – Abschlussbericht der Sektor-untersuchung zur E-Ladeinfrastruktur* [Anti-Competitive Structures in the Supply of Charging Power – Final Report of the Sector Inquiry into E-Charging Infrastructure] (October 1, 2024), https://www.bundeskartellamt.de/SharedDocs/Meldung/DE/Pressemitteilungen/2024/01_10_2024_Ladesaeulen.html.

49 Austrian Federal Competition Authority, *Sector Inquiry: EV Charging Infrastructure* (March 2023), https://www.bwb.gv.at/fileadmin/user_upload/Final_Bericht_der_BWB_zur_Branchenuntersuchung_E-Ladeinfrastruktur_EN_MP_JG_2023_02_17__002_.pdf.

50 M.L. van der Koogh and Rishabh Ghotge, "State of Competition in the Dutch EV Charging Sector: Emerging Issues in a Developing Market," *Mededingingsrecht in de Praktijk*, no. 4 (October 2022): 19–27, https://research.tudelft.nl/en/publications/state-of-competition-in-the-dutch-ev-charging-sector-emerging-iss.

51 French Competition Authority, "Charging Stations for Electric Vehicles: The Autorité Issues its Opinion on the Competitive Functioning of Electric Vehicle Charging Infrastructure (EVCI)," press release, June 11 2024, https://www.autoritedelaconcurrence.fr/en/press-release/charging-stations-electric-vehicles-autorite-issues-its-opinion-competitive

Measuring market concentration

The German Competition Administration has provided a list of criteria to assess whether a company holds a dominant position in a given market or sector and may have the potential to abuse its market power.[52] This section focuses on the first two criteria:

1. Its market share and the market shares of its competitors (the threshold value for assumed market dominance is a market share of 40%)
2. The number and size of its competitors

Market concentration measures the extent to which market shares are dominated by a small number of companies and is commonly used as a factor when assessing competition within a market. High levels of market concentration are considered a cause of concern as they can be related to high market power which, from the consumer perspective, can lead to higher prices and lower quality services.[53] Still, high market concentration levels can benefit the consumer by eliminating the need for multiple membership cards in the absence of roaming. However, in that scenario, strong regulations may be needed to avoid abuse of power by a dominant company.

There are two widely used market concentration indicators: the concentration ratio (CR-N) and the Herfindahl-Hirschman Index (HHI). As shown in the equations below, CR-N corresponds to the sum of the market shares (*ms* in the equation) of the *n* leading companies within a market, while the HHI is the sum of squared market shares of all companies in the market.[54]

Equation 1. Concentration ratio

$$CR\text{-}N = ms1 + ms2 + \cdots + msn$$

Equation 2. Herfindahl-Hirschman Index

$$HHI = ms1^2 + ms2^2 + \cdots + msn^2$$

The main disadvantage of the CR value is that it does not give any indication of the market share distribution among companies excluded from the ratio, nor does it provide insight into the distribution among the top companies. These considerations are taken into account by the HHI, which describes the relative size distribution of all companies in a market.

For both indexes, a value close to zero implies perfect competition, in which many firms offer nearly identical goods or services. A CR1 of 100% and HHI of 10,000 imply the market is controlled by a single player. The HHI increases both when the number of companies in the market decreases as well as when the size disparity among those companies increases.

For this analysis, we primarily use CR1, consistent with many of the competition analyses of the public charging sector described above, and we include HHI values for comparison. CR-N and HHI value ranges used to classify market concentration levels vary across jurisdictions. This analysis is guided by the CR-N threshold levels outlined in the German Act Against Restraints of Competition, alongside HHI threshold levels established by the U.S. Federal Trade Commission and Department

52 "Control of Abusive Practices," Federal Cartel Office, accessed November 26, 2024, https://www.bundeskartellamt.de/EN/Tasks/AbuseControl/AbuseControl_DS/AbuseControl_DS_node.html.

53 Executive Office of the President, "Promoting Competition in the American Economy," Executive Order, 86 F.R. 36987 (July 9, 2021), https://www.federalregister.gov/documents/2021/07/14/2021-15069/promoting-competition-in-the-american-economy.

54 Ivan Pavic, Fran Galetic, and Damir Piplica, "Similarities and Differences between the CR and HHI as an Indicator of Market Concentration and Market Power," *Journal of Economics, Management and Trade* 13, no. 1 (March 21, 2016): 1–8, https://doi.org/10.9734/BJEMT/2016/23193.

of Justice guidelines.[55] These thresholds are shown in Table 2 and define levels above which companies are deemed market dominant.

Table 2. Market concentration indicators and value ranges used to determine if companies hold a dominant position

Indicator	Range	Market state
CR-1	≥ 40%	Market dominated by 1 company
CR-3	≥ 50%	Market dominated by 3 or fewer companies
CR-5	≥ 66.66..%	Market dominated by 5 or fewer companies
HHI	1,000–1,800	Market moderately concentrated
HHI	> 1,800	Market highly concentrated

CPO market concentration analysis

To analyze concentration within a market, the first step is to define the relevant product and geographical market. For the present analysis, we define the market based on access type, power output type, and geographic segmentation of EV chargers. In terms of access, we focus on public and semi-public charging infrastructure, considering that it generally does not compete with private chargers: due to the lower costs associated with private charging, drivers typically rely on (semi-)public charging stations when private charging is not an option. Regarding power output type, we differentiate between AC and DC charging markets based on their distinct use cases and infrastructure investment costs.[56] In terms of geographic segmentation, we focus on concentration at the national, NUTS 3 region, and postal code levels for the Europe analysis and on the national and county levels for the U.S. and Canada analyses.[57]

The section begins with an overview of national CPO market concentration levels as of January 2024 for the United States, Canada, and select European countries. The focus then shifts to a detailed analysis at the NUTS 3 region level for Europe based on data from January 2022 to 2024. For comparison, some information is also provided for the United States and Canada at the county level based on a January 2024 snapshot of data. For ease of reference, we use the term "region" in this section to refer to both European NUTS 3 regions and North American counties and municipalities.

Supranational and national market concentration trends as of January 2024

Figure 4 and Table 3 summarize national CPO market concentration trends. Figure 4 displays the cumulative charger share of CPOs by country and power output type as of January 2024, with CPOs sorted by decreasing market share. Each colored line represents a jurisdiction, and the vertical dashed lines highlight the market share of the leading CPO (CR1) as well as the combined market share of the top three CPOs (CR3) and top five CPOs (CR5). The top graph shows the results

55 Gesetz Gegen Wettbewerbsbeschränkungen in Der Fassung Der Bekanntmachung Vom 26. Juni 2013 (BGBl. I S. 1750, 3245), Das Zuletzt Durch Artikel 25 Des Gesetzes Vom 15. Juli 2024 (BGBl. 2024 I Nr. 236) Geändert Worden Ist [Act Against Restraints of Competition in the Version Announced on 26 June 2013 (Federal Gazette I S. 1750, 3245), Last Amended by Article 25 of the Act of 15 July 2024 (Federal Gazette 2024 I No. 236)] (2005), https://www.gesetze-im-internet.de/gwb/__18.html; U.S. Department of Justice Antitrust Division, "Herfindahl-Hirschman Index," updated January 17, 2024, https://www.justice.gov/atr/herfindahl-hirschman-index.

56 LaMonaca and Ryan, "The State of Play."

57 The NUTS (Nomenclature of Territorial Units for Statistics) is the official geographic division of the European Union and the United Kingdom for regional statistics. NUTS 3 regions are relatively small regions with a population size between 150,000 and 800,000.

for AC chargers, while the bottom graph corresponds to DC chargers. Chargers with unknown CPO are not included in the figure.[58]

Figure 4. Cumulative share of total public chargers installed of top 20 CPOs by country and power output type as of January 2024. CPOs are sorted by decreasing market share. The value ranges for CR1, CR3, and CR5 that are considered indicative of concerning market concentration levels are highlighted with solid black lines. Chargers with unknown CPOs are not included in the figure.

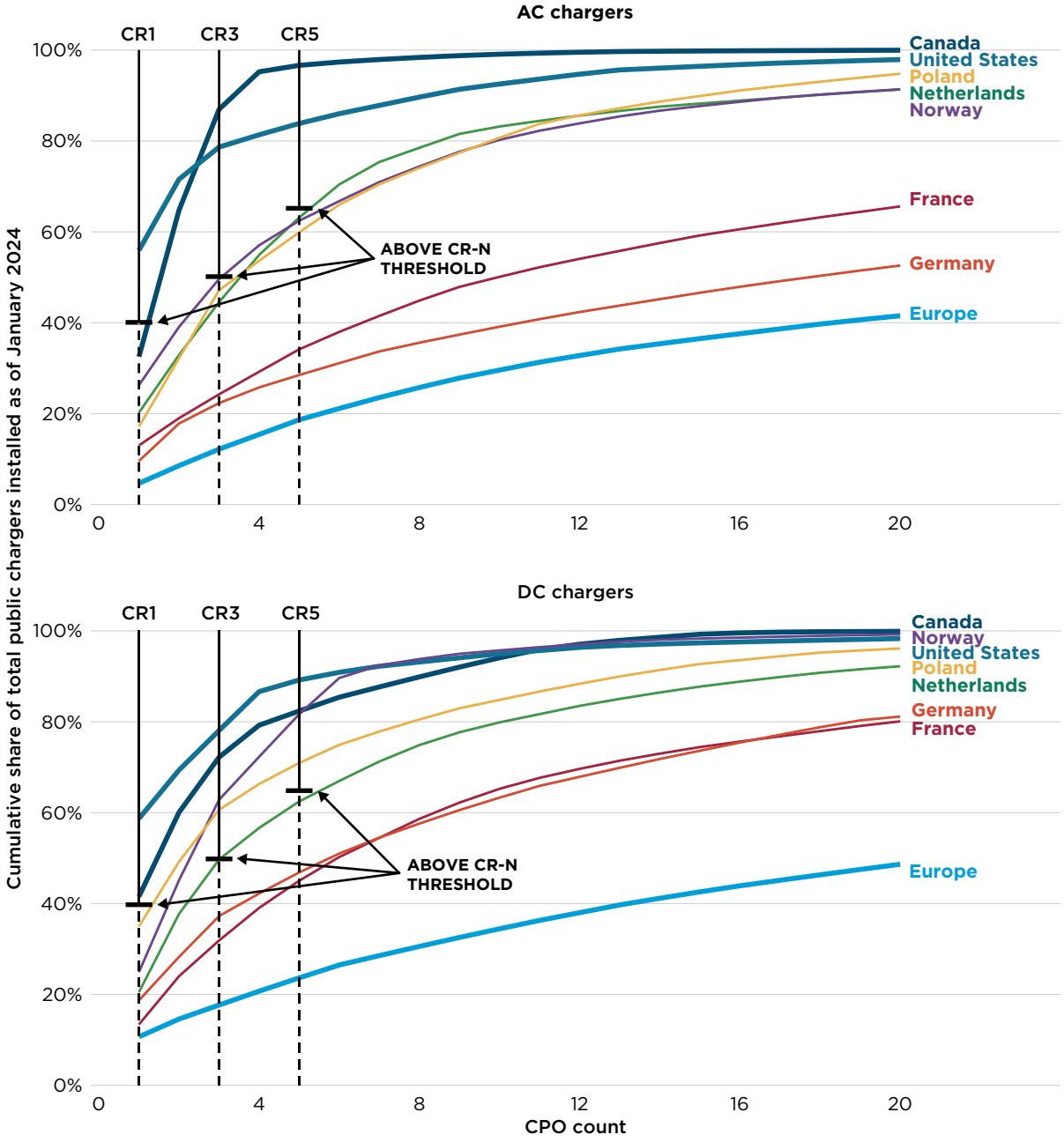


Table 3 below details the number of public chargers installed, the number of active CPOs, the average and median CPO network size values, and the CR1 and HHI concentration indicators by power output type and country as of January 2024. For each output type, countries are listed

58 Among surveyed countries, Norway had the highest share of AC chargers with unknown CPO (15%), followed by France (11%), the United States (10%), Germany (8%), Poland (3%), and Canada (1%). France had the highest share of DC chargers with unknown CPO (4%), followed by Germany, Poland, and the United States (2%) and Norway (1%), with negligible shares in the Netherlands and Canada.

in descending order of total number of CPOs. Cells are highlighted in red when the CR1 is above 40% or the HHI is above 1,800, indicating high concentration. Cells are highlighted in light red when the HHI is between 1,000 and 1,800, indicating moderate market concentration.

Table 3. Number of public chargers installed, active CPOs, and average and median CPO network size by power output type and country as of January 2024.

Power output	Country	Number of chargers installed	Number of CPOs	Number of chargers per CPO		Concentration indicators		
				Mean	Median	Country (or Europe) level CR1	Average regional CR1	Country (or Europe) level Herfindahl-Hirschman Index
AC	Europe	652,940	2,202	229	11	5%	39%	93
	Germany	99,254	947	97	8	10%	37%	260
	France	91,705	181	449	100	13%	37%	380
	Netherlands	140,757	129	1,091	47	20%	41%	989
	Norway	19,889	116	145	14	26%	32%	1,131
	Poland	4,573	67	66	6	17%	40%	942
	United States	138,814	63	1,986	91	56%	65%	3,457
	Canada	18,740	25	741	29	33%	78%	2,661
DC	Europe	124,280	1,054	87	8	11%	37%	80
	Germany	25,860	387	65	4	19%	32%	662
	France	20,130	112	173	29	13%	26%	560
	Netherlands	4,559	71	64	7	21%	30%	1,026
	United States	37,998	68	548	15	59%	77%	3,724
	Poland	2,152	45	47	6	35%	42%	1,667
	Norway	9,956	37	266	16	25%	31%	1,597
	Canada	4,704	23	204	54	42%	80%	2,311

Note: Chargers with unknown CPOs are not included in the CPO network mean and median size calculations.

A key observation from Figure 4 and Table 3 is that North American CPO markets are considerably more concentrated than those in Europe. Indeed, while no European country, nor Europe as a whole, had a CR1 value exceeding 40% as of January 2024, the United States had a CR1 above 40% for both the AC and DC networks, and Canada surpassed this threshold for DC stations. This is related to the United States and Canada having fewer CPOs than European countries. Further, we observe similar levels of market concentration between the AC and DC markets, with the same countries (highlighted in red and light red) standing out in both: Canada, the Netherlands, Norway, Poland, and the United States.

Germany stands out with a high number of CPOs operating a rather small number of chargers. As of January 2024, the total number of AC CPOs in Germany was about 950, with a median of 8 chargers per CPO. Approximately 33% of these CPOs were identified as regional utilities in the dataset.[59] Indeed, compared with other European countries, Germany's electricity utility market is particularly decentralized and features around 700 municipally owned utilities managing local grids.[60]

59 CPOs categorized as municipal utilities include those with "Stadtwerke," "Gemeindewerke," "Energie- und Wasserversorgung," and "Energieversorgung" in their name.

60 Edith Bayer, *Report on the German Power System Version 1.2: Country Profile* (study commissioned by Agora Energiewende, October 2015), https://www.agora-energiewende.de/fileadmin/Projekte/2014/CP-Deutschland/CP_Germany_update_1015_web.pdf.

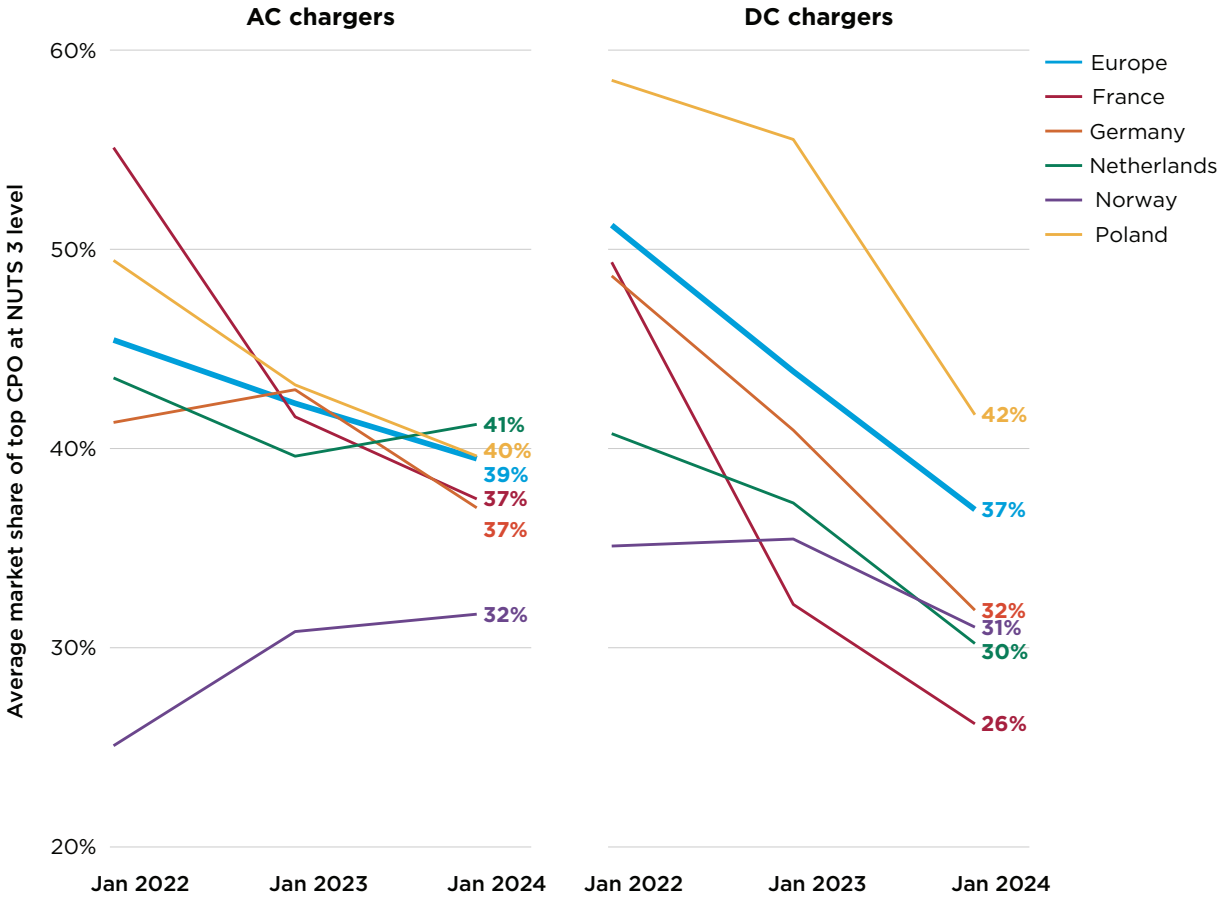
One could postulate that, as EV adoption increases, an increasing number of CPOs would enter the market. This would result in countries with high BEV sales shares having relatively low concentration ratios. However, this does not seem to be the case. In Europe, Norway and the Netherlands have stronger EV adoption than France and Germany but also had higher CR1 and HHI values. Poland, which lags the other markets in EV adoption, featured relatively high HHI and CR1 ratios in the DC market but a lower AC market concentration than Norway and the Netherlands.

Lastly, Table 3 shows that based on the average market share of the leading CPOs at the regional level, multiple jurisdictions exceeded the threshold of 40%. Strong outliers are the United States and Canada, with average regional CR1 values ranging from 65% to 80% for the AC and DC markets. In Europe, Poland stands out with average regional CR1 values above 40% in both markets. It is important to note that U.S. and Canadian counties and municipalities cannot be directly compared with European NUTS 3 regions due to their varying sizes, populations, and EV stock levels.

Evolution of regional market concentration levels between January 2022 and January 2024 in Europe

Figure 5 illustrates the historical evolution of the average market share of the leading CPO (CR1) at the NUTS 3 level by power output type and date for select countries. The same information at the postal code level is provided in Figure A2 in the appendix.

Figure 5. Average market share of the leading CPO at NUTS 3 region level by country, power output type, and date.



While Figure 5 shows regional trends aggregated at the national level, Figure 6 illustrates the annual evolution of CR1 values by NUTS 3 region in Europe since January 2022. The left column presents the AC market and the right column the DC market. From top to bottom, the maps depict data for January 2022, 2023, and 2024. The dark and light blue shades correspond to market concentration levels of the leading CPO that do not rise to a level of concern according to German Competition Administration standards—that is, with regional CR1 values below 40%. Regions shaded in green are those with CR1 values between 40% and 60%, while regions shaded in yellow and red are those with a leading CPO operating more than 60% or 80% (respectively) of chargers installed.

Figure 6. Market share of the leading CPO at the NUTS 3 region level by power output type and date

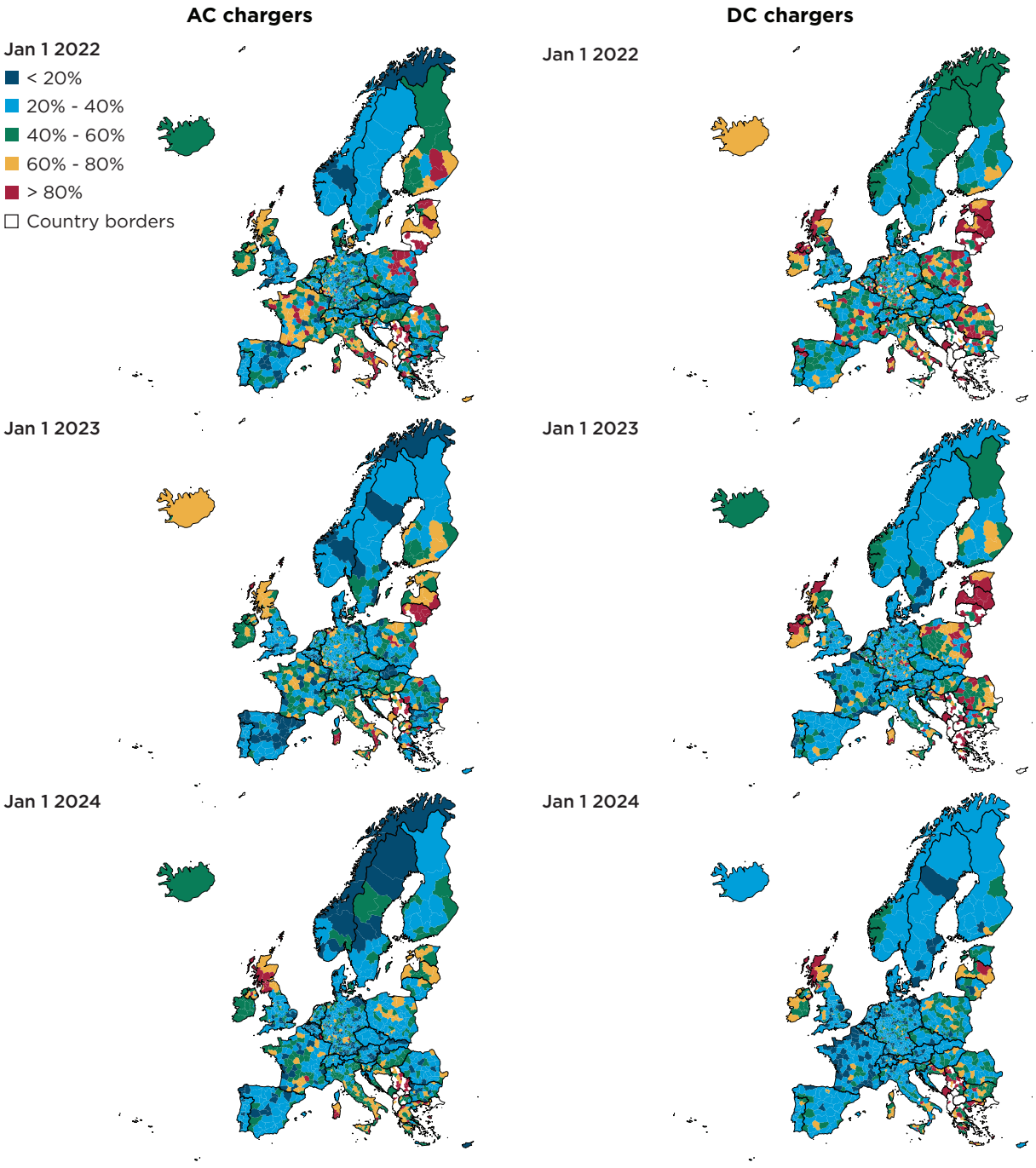


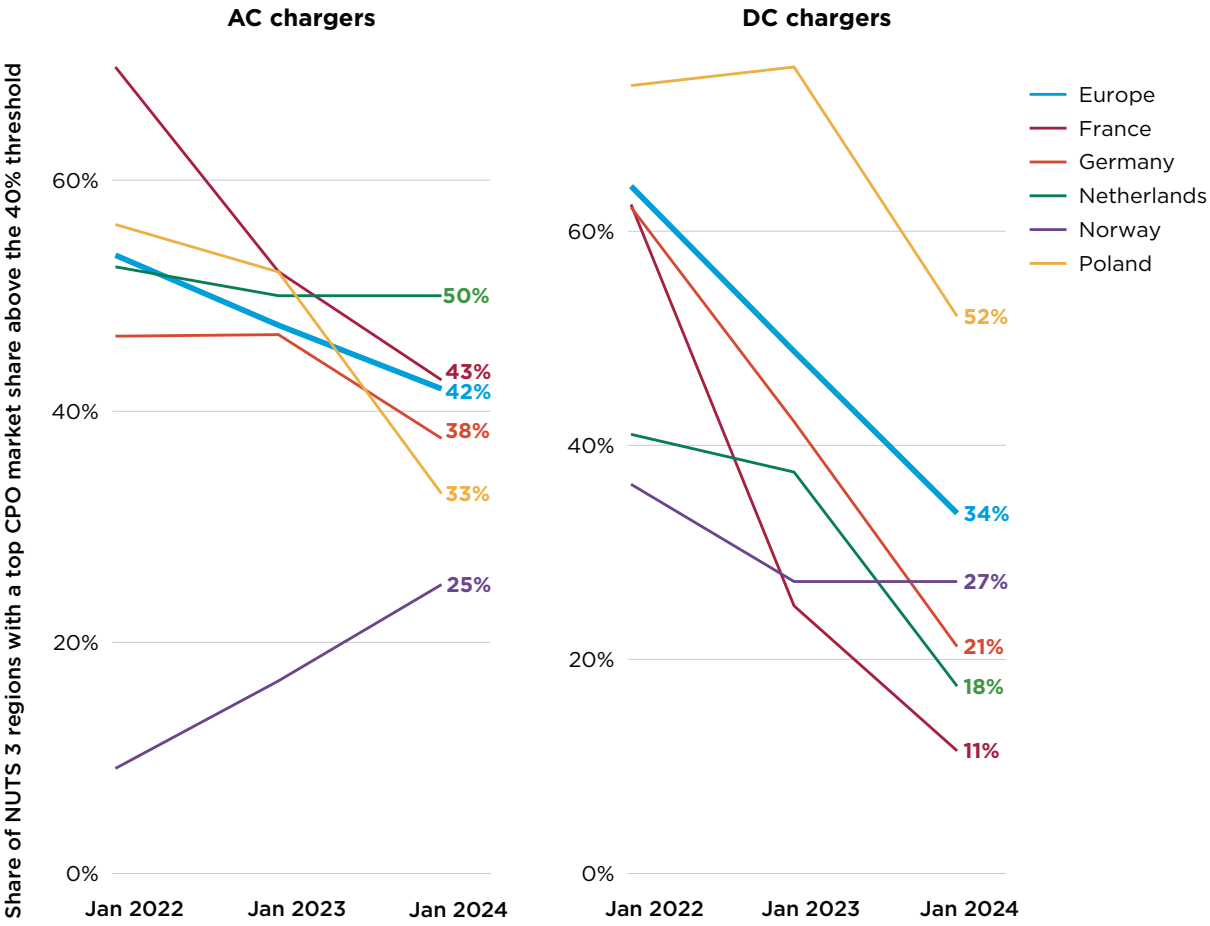
Figure 5 and the maps in Figure 6 show that, generally, the market share of the leading CPO at the regional level has decreased over time. However, there are a few exceptions, such as the Netherlands and Norway, which saw increases in average regional AC market concentration between 2023 and 2024. In terms of geographic differences, Eastern Europe seems to feature slightly higher market concentration levels than the rest of Europe, but there is no clear pattern.

As opposed to the national level, where the market concentration scores for DC and AC chargers were similar, the AC market at the regional level shows higher concentration than the DC market. This makes sense, since AC CPO networks tend to serve users near where they live, while DC networks, used more for long-distance trips, are developed across multiple regions.

Figure 7 illustrates changes in the percentage of regions with CPO market shares above 40% by country. The figure shows that, in the case of AC infrastructure, 42% of European regions had a CR1 value above 40% as of January 2024, down from 54% in January 2022. In all jurisdictions analyzed except Norway and the Netherlands, the share of regions with CR1 values exceeding 40% in the AC market decreased in the past two years. In Norway, the share of regions with a leading CPO operating more than 40% of AC chargers installed increased from about 9% at the beginning of 2022 to 25% at the beginning of 2024; in the Netherlands, the share remained relatively constant during this period. Thus, in these two countries, as EV adoption has grown, market concentration has not decreased consistently. It is therefore important to monitor the evolution of these markets to ensure that CPO market consolidation does not lead to competition concerns and potential unfavorable outcomes for consumers.

As for DC infrastructure, market shares of leading CPOs at the regional level were generally slightly lower than in the AC market, with 34% of regions featuring a CR1 value above 40% at the beginning of 2024, down from about 64% in early 2022. Poland stands out as the only jurisdiction analyzed with more than half (52%) of its regions having a CR1 value above 40% in the DC market. This means that, in more than half of Polish regions, the top DC CPO captured a market share above 40%, which could raise competition concerns.

Figure 7. Share of NUTS 3 regions with a market share of the leading CPO above 40% by country, power output type, and date



While fewer than 50% of regions in Europe had a leading CPO with a market share above 40%, the picture looks considerably different in Canada and the United States. In Canada, 99% and 96% of regions had a leading CPO operating more than 40% of AC and DC chargers installed, respectively. In the United States, 80% of regions had a leading AC CPO with a market share above 40%, while in 95% of the regions the top DC CPO exceeded this threshold.

Public charging infrastructure pricing

This section explores ad hoc and MSP charging rates in the European public charging infrastructure market. We first provide a description of common charging pricing models, followed by a summary of legislative measures aimed at ensuring transparent and fair pricing. We then assess the prevalence of various pricing models and compare the price per kWh charged across several factors: power output type (AC versus DC chargers), ad hoc and subscription-based payments, regional differences, and the level of regional CPO market concentration. The central research questions are: *How do market players set prices for public EV charging, and are ad hoc prices correlated with CPO market concentration?*

CPO and MSP charging pricing dynamics and pricing components

CPOs or site owners set the end-user charging rates for ad hoc charging at their stations, as well as the charging rates passed on to MSPs with which they have roaming agreements. MSPs then use CPO-to-MSP charging rates, also known as business-to-business (B2B) rates, to determine end-user charging rates. The MSP rates can be either CPO-specific or uniform across CPOs. Notably, complex B2B charging rates are often simplified before being passed on to drivers, either due to limitations in MSP communication protocols or to avoid driver confusion. However, simplified end-user rates are typically higher than the underlying CPO B2B rates.[61]

End-user and B2B charging rates may consist of multiple components or fees. However, there are three basic components: an energy fee, based on the amount of energy transferred to the vehicle, measured in euros per kWh; a time fee, based on the duration of the charging session and/or the blocking time, measured in euros per minute; and a flat fee per session, measured in euros. Other components include roaming fees (applicable to MSP prices only), parking fees, or start fees. In addition, MSP contracts often include a subscription fee.

The structure of CPO and MSP charging rates can vary depending on several factors, including the charger's location and capacity and the charging status. For instance, a penalty fee—often referred to as blocking, idle, or occupancy fee—may be applied when a vehicle is not charging to discourage drivers from blocking chargers longer than necessary. Additionally, rates can vary based on specific time or energy thresholds. For example, an energy fee may apply for the initial hour or two of charging, followed by a different, higher fee for subsequent hours. Further, rates may fluctuate depending on the time of the day, day of the week, or the real-time energy price. These time-variant rates are typically implemented to encourage charging at times of low energy demand, such as by offering different rates for peak and off-peak hours, or to align with real-time energy costs, which is known as dynamic or spot pricing.

Energy-based charging rates are widely considered the easiest for users to understand, and they ensure all drivers pay a consistent rate for the electricity they use, regardless of the charging speed. In contrast, charging rates based primarily on the duration of the charging session do not consider varying charging speeds across vehicle models, chargers, and ambient temperature levels. These rates can also result in higher costs for drivers when a charging session takes longer than required due to charger malfunctions or energy supply limitations designed to protect the grid from overload.

Review of legislative efforts to ensure transparent pricing

Pricing transparency can allow consumers to easily compare products or services, which can drive market players to offer better value through lower prices, higher quality, or improved service. In recent years, several studies have highlighted significant shortcomings regarding the transparency of public charging prices in European markets.[62] One major concern has been the difficulty drivers face in finding information on charging rates before initiating a session. Further, the complexity of pricing structures can make it difficult for drivers to predict the cost of a charging session, compare prices across different providers, or verify charging invoices after transactions are completed. In addition, even though CPO-to-MSP communication protocols

61 EVRoaming Foundation, *Issues and Solutions for Better Exchange and Understanding of EV Charging Tariffs* (February 2024), https://evroaming.org/app/uploads/2024/03/EVRoaming-White-Paper-Tariffs-in-EV-charging-world-v1_21.pdf.

62 French Competition Authority, "Charging Stations for Electric Vehicles"; European Alternative Fuels Observatory, Avere, and Fier Automotive, *Pricing of Electric Vehicle Recharging in Europe*.

generally support the exchange of charging pricing data, failures can occur, particularly when charging rates are not communicated in a standardized way or when complex pricing models are involved. More recently, the growing use of dynamic tariffs by CPOs has made price transparency more difficult, as these pricing models are often harder to understand and sometimes are not appropriately supported by CPO-to-MSP communication protocols.[63]

Europe

In Europe, the AFIR allows a maximum of two pricing components in ad hoc charging rates at public chargers with a power output above or equal to 50 kW: an energy-based component and an additional time-based blocking fee. For chargers with a power output below 50 kW, there is no limit on the number of pricing components, but the AFIR specifies the order in which these components should be presented to drivers. More broadly, the AFIR mandates that prices must be "reasonable, easily and clearly comparable, transparent, and non-discriminatory" and must be presented to users before the start of each charging session.[64] As mentioned above, the AFIR also requires CPOs to make ad hoc prices available on National Access Points (internet platforms set up by Member States) from April 2025 onward.

The AFIR does not regulate the structure of MSP charging rates, except to mandate that any roaming fees be consistent across Member States. However, as previously mentioned, the AFIR requires CPOs to not discriminate in pricing between end users and MSPs or between MSPs. Thus, limitations to the structure of ad hoc charging rates are likely to indirectly shape MSP rates.

Member States are responsible for monitoring compliance with AFIR requirements. France is drafting legislation that may require CPOs to provide up-to-date data for an online map of ad hoc charging prices, install clear signage of ad hoc charging prices, and disclose information on charging costs and the maximum real power output at the start of each charging session.[65] The French legislation may also mandate standardized public charging bills and require highway operators to install roadside signage displaying ad hoc charging prices. Further, it may require local authorities deploying public chargers to follow a standardized approach (known as *schema directeurs*) defined by the government.

North America

In February 2023, Measurement Canada gave a temporary dispensation to allow CPOs to bill based on energy consumption rather than time, provided chargers meet the agency's technical and metering standards.[66] The change addressed the advantage of time-based billing for drivers with faster-charging vehicles. As a result, the Government of Quebec amended its regulation for public fast-charging rates in March 2024, switching from time-based to energy-based pricing (see Table A2 in the appendix for an overview of the amended charging rates).[67] In Canada, some drivers have raised concerns about demand charges based on peak energy uses, which

63 EVRoaming Foundation, *Issues and Solutions*; European Alternative Fuels Observatory, Avere, and Fier Automotive, *Pricing of Electric Vehicle Recharging in Europe*.

64 Regulation (EU) 2023/1804, art. 5, §5.

65 The data to be provided by CPOs may include the number of chargers, connector types, real power output, current type, electricity costs (before and after tax), any additional fees, payment methods, and opening times.

66 Temporary Dispensation Program for Electric Vehicle Supply Equipment, October 31, 2022, https://ised-isde.canada.ca/site/measurement-canada/en/temporary-dispensation-program-electric-vehicle-supply-equipment.

67 Règlement Modifiant le Règlement sur les Tarifs d'Utilisation du Service Public de Recharge Rapide pour Véhicules Électriques [Regulation Amending the Regulation on Utilization Rates of the Public Fast Charging Service for Electric Vehicles], Gazette Officielle du Québec du 156e année, partie 2, no. 10 (March 6, 2024), https://www.publicationsduquebec.gouv.qc.ca/fileadmin/gazette/pdf_encrypte/gaz_entiere/2410-F.pdf.

can be problematic for certain DC chargers that occasionally have to provide high power to EVs.[68] Because DC chargers are regulated separately from those of other power outputs in the province, CPOs have removed this demand charge or factored it in their prices.

In the United States, NEVI-funded chargers are required to display charging prices before the start of each charging session. Prices must be based on the energy transferred to the vehicle measured in dollars per kWh. Charging rates cannot be altered during a charging session but may include additional fees, which must be "clearly displayed and explained" to users.[69] In California, charging rates for all public chargers must be based on a price per kWh or MJ.[70]

Prevalence of pricing models among charging products

Figure 8 shows the shares of charging products available at European public chargers by pricing model and power output type as of February 2023 and January 2024. The total number of products available is indicated at the top of each bar. The pricing model data displayed in the figure only cover the three basic pricing components mentioned above: energy fee, time fee, and flat fee. Other, additional fees such as parking fees or roaming fees are not shown.

We observe that charging rates based exclusively on energy fees dominate AC and DC charging products with shares of 88% as of January 2024 in both AC and DC products. The shares of AC and DC products with rates based exclusively on time fees dropped between 2023 and 2024, while the availability of rates that combine energy and time fees increased, especially among DC products. In the case of these combined rates, time fees are likely to apply only after a certain amount of time to discourage drivers from blocking chargers. Charging rates based exclusively on time fees were most popular in France, where their share amounted to about 60% of AC products and 40% of DC products as of February 2023, decreasing to 4% and 3%, respectively, as of January 2024.

68 Electric Autonomy Canada, "Understanding Demand Charges Part 1: What are they and why they need to change," March 9, 2022, https://electricautonomy.ca/sponsored/2022-03-09/chargepoint-understanding-demand-charges/.

69 National Electric Vehicle Infrastructure Standards and Requirements.

70 Alternative Fuels Data Center, "Electric Vehicle (EV) Charger Billing Requirements," U.S. Department of Energy, accessed November 26, 2024, https://afdc.energy.gov/laws/12511.

Figure 8. Shares of charging products available at public chargers installed in Europe by pricing model and power output type as of February 2023 and January 2024. The total number of products available is provided at the top of each bar. The "all combined" pricing model refers to a combination of energy fee, time fee, and flat fee.

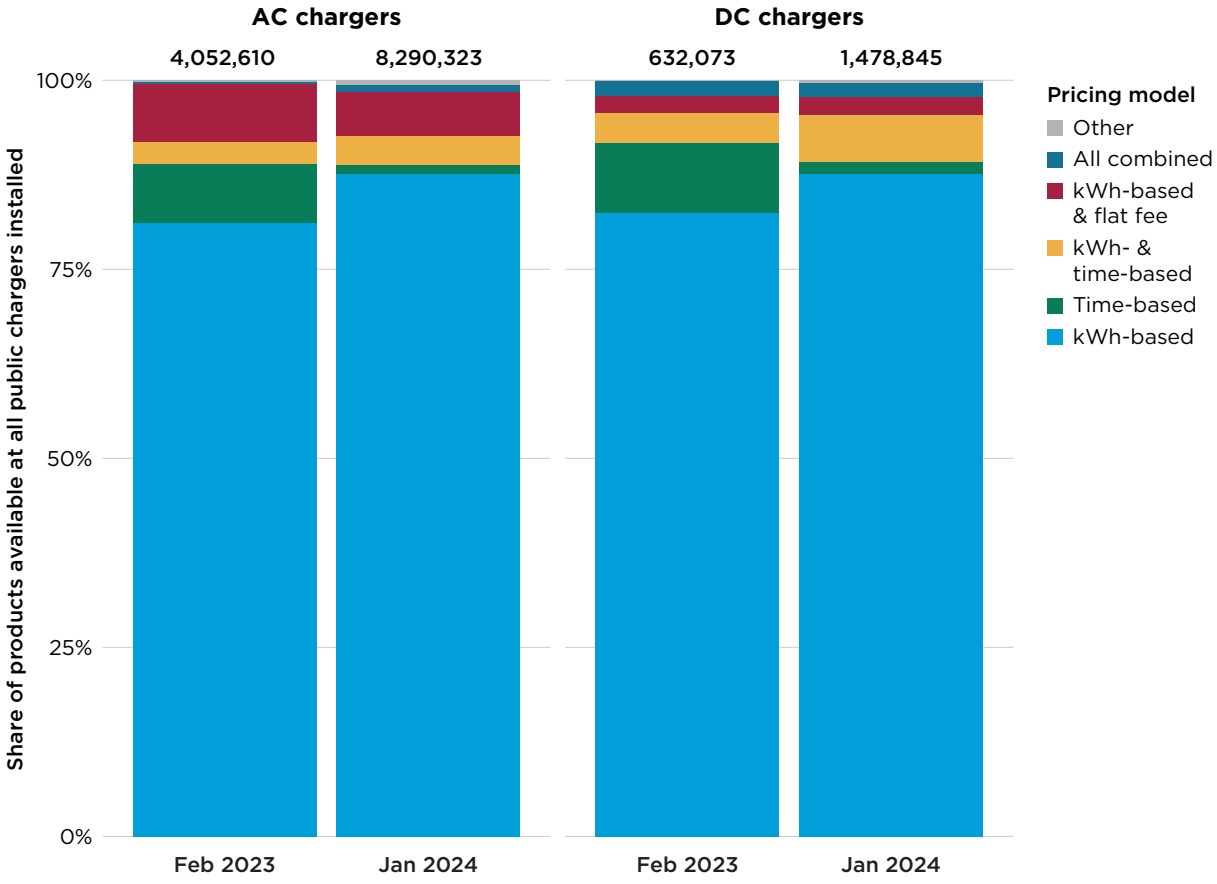
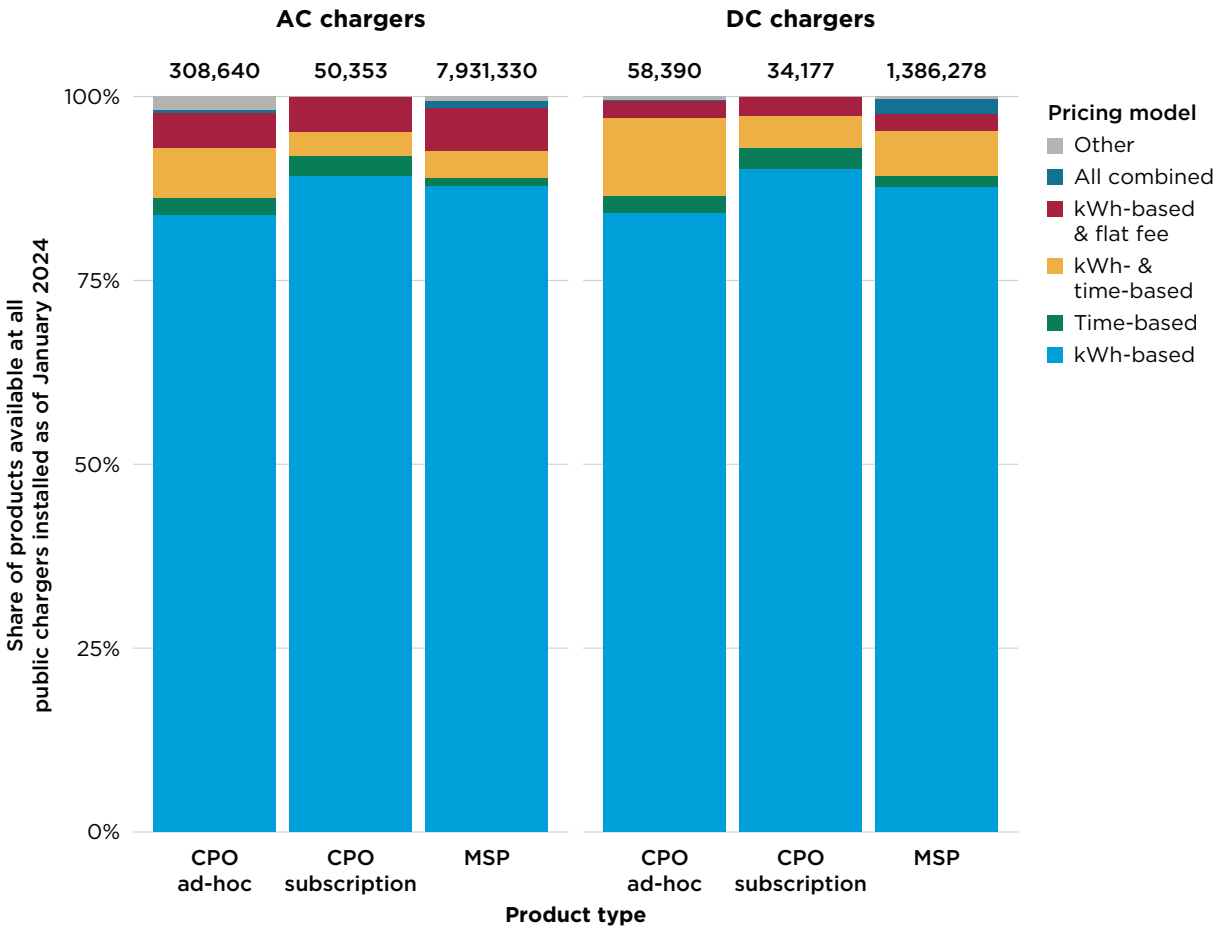


Figure 9 compares the prevalence of different pricing models in European public charging products across product types and power output type as of January 2024. Products are grouped into three categories: CPO ad hoc charging products, CPO subscription-based charging products, and MSP charging products. Each charger only features one ad hoc charging product, but multiple CPO subscription and MSP products can be offered. MSP products are often subscription-based, though this is not always the case. No major differences are observed across the different product types, except for the fact that the "all combined" pricing model is almost exclusive to MSP products. However, the share of this pricing model is limited to 1% of AC MSP products and 2% of DC MSP products.

Figure 9. Shares of charging products available at public chargers installed in Europe by pricing model, power output type, and product type as of January 2024. The total number of products available is provided at the top of each bar.



The increasing availability of the energy-based and the energy- and time-based pricing models among European public charging products aligns with the implementation of AFIR ad hoc pricing requirements. Although the AFIR does not regulate MSP prices, CPOs pass on their prices to MSPs, which could be the reason that MSP prices are also primarily kWh based. However, even pricing models with just two components can be complex due to the potential variations described above (e.g., by charger location or time of the day). As smart charging becomes more common, it is likely that dynamic pricing models will become more common, too.

Comparison of CPO and MSP charging prices

Figure 10 compares the average net prices per kWh for AC and DC public charging across countries as of January 2024, focusing on ad hoc charging and MSP monthly subscription-based products. CPO subscription-based products and MSP products with yearly or one-off subscription fees are excluded due to their limited availability compared with MSP products with a monthly subscription fee. MSP products without a subscription fee are also excluded from the analysis because the available data do not distinguish between MSP products that lack subscription fee information and those genuinely offered without such a fee. Further, to enable comparison across products, only those with energy-based charging rates were included; as noted above (Figure 8), these account for the majority of AC and DC products. We also excluded charging rates with a time component, as it is not possible to distinguish whether the time fee applies for the entire duration of the charging

session or is a blocking fee that takes effect after a certain period. Charging rates that include flat rates per session were also excluded due to their low availability.

To calculate MSP subscription fee costs per kWh charged, three driver profiles were considered based on the profiles defined in a previous ICCT publication: urban commuter, rural commuter, and long-distance driver.[71] These profiles differ in their total annual grid energy consumption and the share of public versus private (home or workplace) charging (see Table 5). The rural commuter and the long-distance driver have access to home charging, while the urban commuter lacks a home charger but has access to a workplace charger. Other differences between the profiles are not relevant to the scope of this analysis. Since the rural and urban commuter profiles consume nearly identical amounts of annual AC and DC public grid energy, Figure 10 presents results only for the urban commuter. Additionally, we consider an alternative urban commuter profile ("urban commuter public") that has no access to workplace or home charging and relies exclusively on public charging. The subscription fee costs per kWh charged for each driver profile are calculated by dividing the annual subscription fee costs by the total AC and DC annual grid energy charged at public chargers. We assume the same MSP contract can be used for AC and DC charging.

Table 5. Total and public annual grid energy charged by driver profile

Driver profile	Power output type	Total grid energy charged (kWh/year)	Public grid energy charged (kWh/year)
Urban commuter	AC	1,790	409
	DC	1,073	1,073
Rural commuter	AC	2,123	399
	DC	1,077	1,077
Long-distance driver	AC	3,909	410
	DC	6,153	6,153
Urban commuter public	AC	1,790	1,790
	DC	1,073	1,073

Before calculating the price per kWh charged for each product, all fees were converted to euros and products with missing currency codes, product types, or fee values were removed from the dataset.[72] Additionally, products with non-plausible fee values (flat fee values above €30 per session, time fee values above €50 per hour, subscription fee values above €50 per month, and energy fee values above €2 per kWh) were removed. About 14,850,000 out of roughly 17,340,000 products remained.

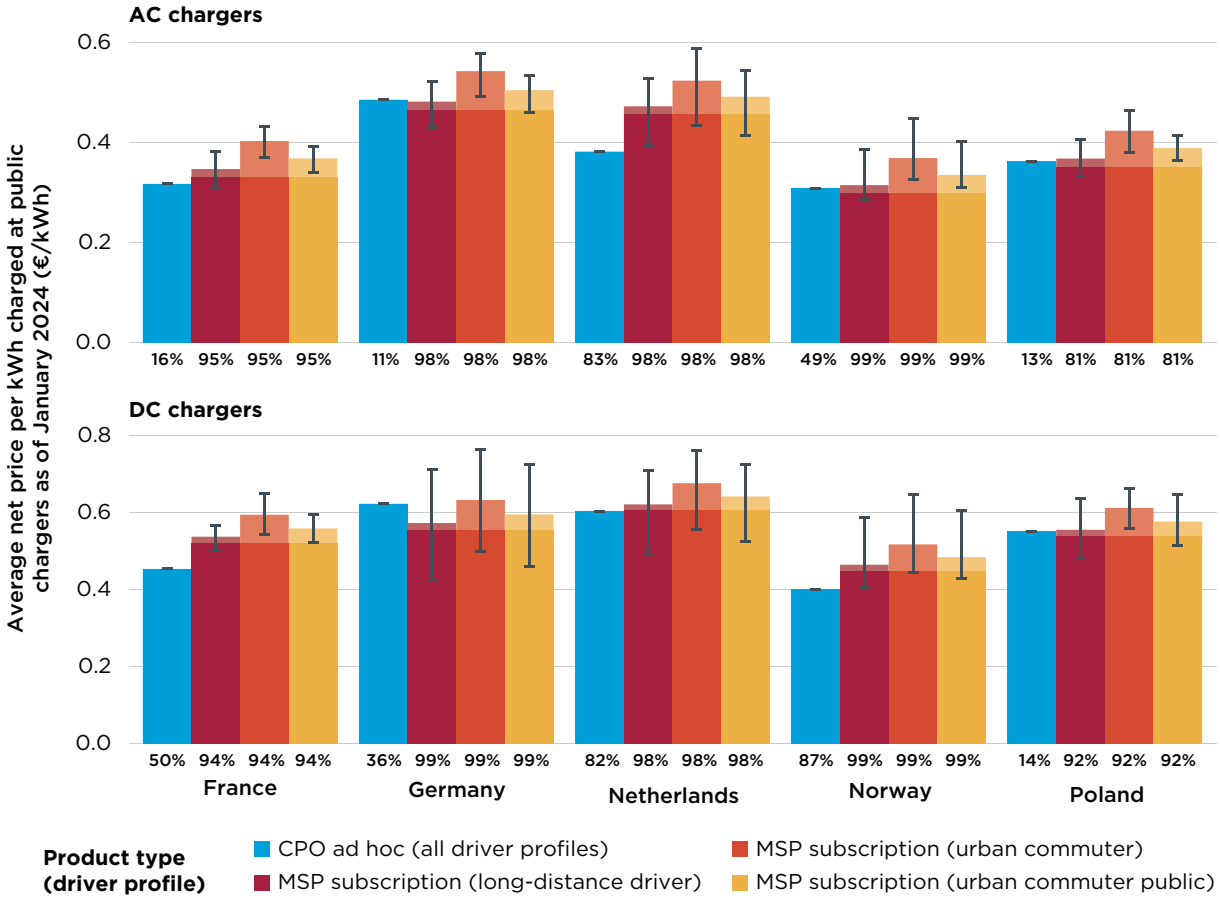
The percentage of chargers offering each product type is indicated at the top of each column in Figure 10. Generally, there is limited availability of ad hoc charging products, except in the Netherlands and Norway. For example, in France, as of January 2024, only 16% of AC chargers offered ad hoc charging based solely on energy fees. This is likely due to data quality issues rather than an accurate representation of actual ad hoc charging availability, especially considering that

71 Carolina Poupinha and Jan Dornoff, *The Bigger the Better? How Battery Size Affects Real-World Energy Consumption, Cost of Ownership, and Life-Cycle Emissions of Electric Vehicles* (International Council on Clean Transportation, 2024), https://theicct.org/publication/bev-battery-size-energy-consumption-cost-ownership-lca-ev-apr24/.

72 Euro foreign exchange rates were sourced from the European Central Bank on October 21, 2024.

the directive preceding the AFIR (Directive 2014/94/EU, adopted in 2014) mandated that ad hoc charging be available at all public chargers installed.[73] Figure 10 also includes error bars indicating the range between the average lowest and highest prices per kWh charged for each product type across chargers. Lastly, in each MSP bar, the darker color indicates the energy costs while the lighter shade represents additional costs from the subscription fee.

Figure 10. Average net price per kWh charged by product type, driver profile, country, and power output type as of January 2024. The share of chargers installed featuring a certain product type is indicated at the top of each bar. The lighter color shade at the top of each MSP bar indicates the additional cost attributed to the subscription fee. The error bars indicate the range between the average lowest and highest prices per kWh charged for each product type across chargers.



As shown in the figure, for AC infrastructure, ad hoc average prices per kWh charged tend to be similar to MSP prices excluding subscription costs. In the Netherlands, however, the average MSP price excluding subscription costs is around 20% higher than the average ad hoc price. The portion of the total MSP price per kWh charged attributed to the subscription costs is significant for both urban and rural commuters, ranging from about 13% in the Netherlands to 19% in Norway. For the urban commuter public and long-distance driver profiles, subscription costs make up a smaller percentage, reaching a maximum of 11% and 5% of the total average MSP price per kWh charged in Norway, respectively.

73 Directive 2014/94/EU Of The European Parliament And Of The Council of 22 October 2014 on the Deployment of Alternative Fuels Infrastructure, OJ L 307 (October 22, 2014), https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0094&from=EN.

Regarding DC infrastructure, average MSP prices per kWh charged excluding subscription costs are generally higher than ad hoc prices. However, in Germany and Poland, average ad hoc prices are slightly higher than MSP prices excluding subscription costs. The largest price disparity is observed in France, where the price per kWh charged with an MSP monthly subscription excluding subscription costs is, on average, around 15% higher than the average ad hoc charging price. For urban and rural commuters, the share of the total MSP price per kWh charged attributed to subscription fees is about 12% on average.

Average AC and DC CPO ad hoc charging prices per kWh charged are, therefore, generally similar to MSP prices excluding subscription costs. Taking subscription fees into account, average MSP prices tend to be the highest. For long-distance drivers, though, for whom the portion attributed to the subscription fee per kWh charged is lower, such products can be convenient and are broadly available.

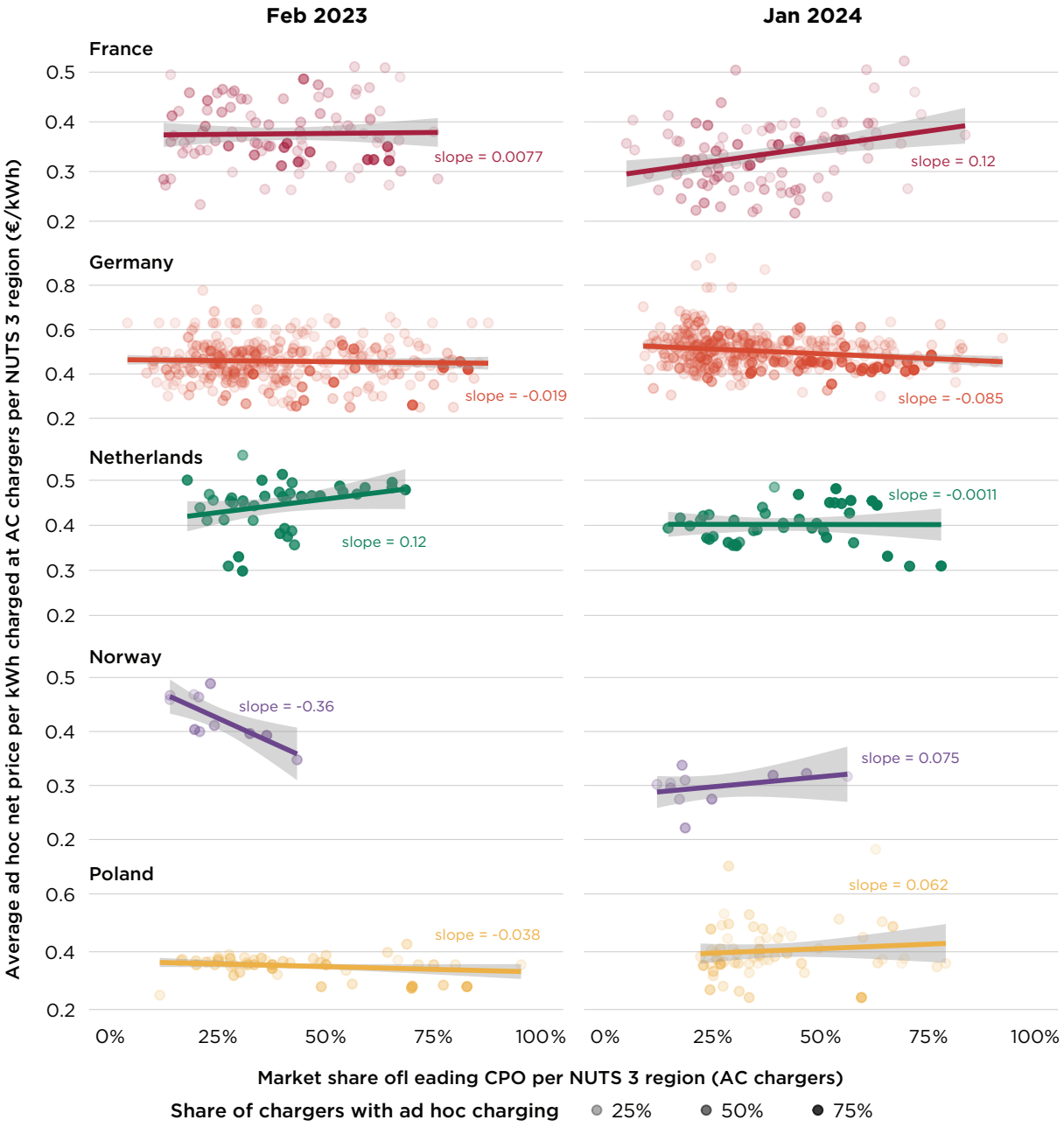
Correlation between local CPO market concentration and average ad hoc prices

Figure 11 and Figure 12 show the correlation between the market share of the top CPO and the average ad hoc net price per kWh charged for AC and DC charging, respectively, by NUTS 3 region, country, and date. Each dot represents a NUTS 3 region, with color opacity corresponding to the availability of ad hoc charging products. The more opaque the dot, the higher the share of chargers offering ad hoc charging. The figures include simple linear regression lines along with their corresponding regression coefficients. In February 2023 and January 2024 in Poland, and in February 2023 in Germany, about 20% to 30% of NUTS 3 regions had no charger that offered ad hoc charging. This is likely due to data quality issues rather than an accurate representation of actual ad hoc charging availability.

Regarding AC infrastructure, the correlation between the market share of the leading CPO and average ad hoc prices per NUTS 3 region was generally weak over this timeframe. In Norway, however, a relatively strong negative correlation was observed as of February 2023. That is, decreases in average ad hoc charging prices at the NUTS 3 region level were associated with increases in CR1 values. By January 2024, this trend had reversed and the relationship between average prices and CR1 values had weakened. In France, as of January 2024, the relationship appeared comparatively strong. However, ad hoc charging data for AC infrastructure is particularly limited in the case of France and, thus, definitive conclusions cannot be drawn. A similar observation can be made for DC infrastructure. As of February 2023 and January 2024, as the market share of the leading CPO increased at the NUTS 3 regional level, there was no clear tendency in average ad hoc charging prices to either increase or decrease.

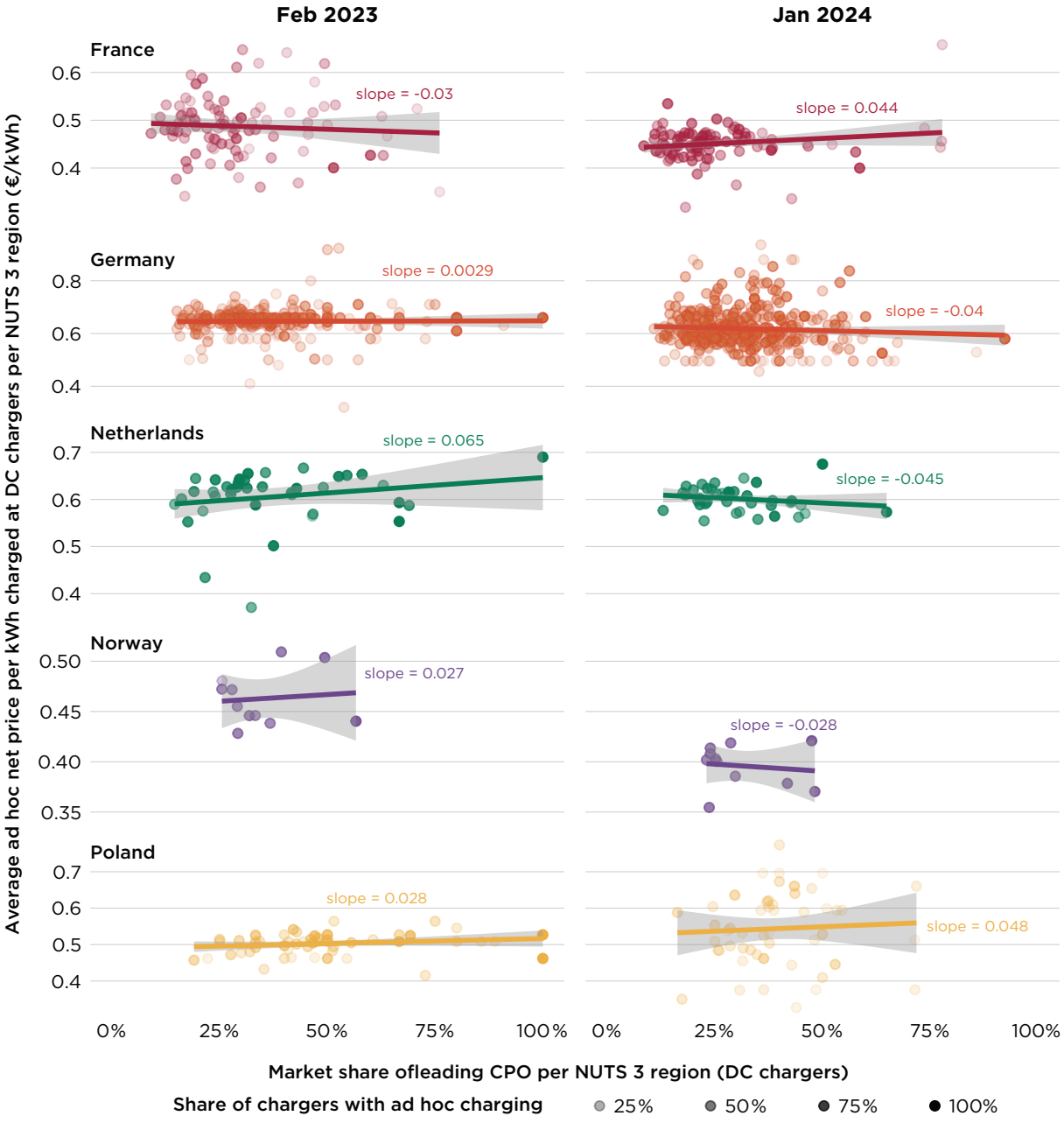
Future research could investigate whether the pricing strategies of CPOs and MSPs are influenced by local market concentration levels. Specifically, researchers could examine whether a given CPO or MSP sets higher prices in regions with lower competition compared with areas with a greater number of market participants. Additionally, it would be valuable to assess whether charging rates are higher in regions with sparse public charging infrastructure compared with those with relatively dense deployment. Lastly, future research could also explore whether pricing strategies vary across different categories of CPOs and MSPs. A forthcoming ICCT report tentatively scheduled to be published by the end of 2025 is slated to address some of these questions.

Figure 11. Average ad hoc net price per kWh for AC charging per NUTS 3 region versus market share of leading CPO per NUTS 3 region.



Notes: Solid lines correspond to simple linear regression lines. The gray ribbon behind each regression line corresponds to the 95% confidence interval.

Figure 12. Average ad hoc net price per kWh for DC charging per NUTS 3 region versus market share of leading CPO per NUTS 3 region



Notes: Solid lines correspond to simple linear regression lines. The gray ribbon behind each regression line corresponds to the 95% confidence interval.

Conclusions

The European public charging market consists of a vast number of charge point operators and mobility service providers. As of January 2024, the top 20 CPOs operate approximately 42% of AC and 49% of DC public chargers in Europe. However, the market remains highly fragmented, with over 2,000 CPOs offering AC charging, more than 1,000 offering DC charging, and about 240 MSPs in total. Widespread adoption of ad hoc charging and close coordination through roaming

agreements is thus essential to allowing EV drivers to find and use chargers across different CPO networks and countries with a single card, app, or membership. This also would help improve price transparency, a key factor in promoting healthy market competition. The share of chargers installed covered by the top ten MSPs has increased considerably, from about 60% in January 2022 to roughly 85% two years later, reflecting the growing availability of roaming agreements.

The U.S. and Canadian markets are much more concentrated than the European market. As of January 2024, Canada had fewer than 30 CPOs active in either the AC or DC market. In the United States, there were about 60 AC and 70 DC CPOs—significantly fewer than the number of market players in Europe. There was also considerable overlap among CPOs operating in the AC and DC markets. The greater market concentration in North America means there may be less of a need for roaming agreements. The first North American roaming hub was established in 2021, while major European roaming platforms have been operational since 2013.

While the U.S. and Canadian CPO markets are dominated by pure players or vehicle manufacturers, top CPOs in Europe are emerging from adjacent sectors such as oil and gas. In the early stages of European EV markets, pure players (companies focused solely on EV charging technologies) and state-owned companies have been more prevalent. However, as markets have grown, large sector-leaping players have begun to capture an increasing market share. Among leading DC CPOs, oil and gas companies stand out as the fastest-growing sector, while vehicle manufacturers hold the largest market share. Carmakers, however, have little representation among the top AC CPOs. Vehicle manufacturers and oil and gas companies have a competitive advantage due to their access to relevant data and valuable land, such as petrol stations along highways that are well suited for DC charging hubs. In Canada and the United States, pure players like ChargePoint operated more than 50% of the AC market as of January 2024, while the DC market was dominated by Tesla, followed by pure players.

The European MSP market is primarily led by vehicle manufacturers, which typically operate closed MSPs reserved exclusively for drivers of their respective brands. As of January 2024, six of the top 10 MSPs were owned by vehicle manufacturers, with only one of them being open to all drivers. Notably, vehicle manufacturers can integrate their MSP services directly into the vehicles they sell to enable functionalities such as Plug and Charge. As of January 2024, only one open MSP achieved coverage exceeding 80% of all public chargers installed in Europe, compared with five carmaker-owned MSPs that reached similar levels of coverage.

As of January 2024, 42% of European NUTS 3 regions had a leading CPO with a market share exceeding 40%, the threshold for market dominance according to the German Competition Authority. Among European markets analyzed, Poland ranked highest, with 52% of its regions having a top DC CPO that operates more than 40% of chargers installed. Among AC markets, the Netherlands stands out, with 50% of its regions having a top CPO with over 40% market share. In terms of geographic differences, while Eastern Europe generally exhibits slightly higher market concentration levels than the rest of Europe, there is no clear trend.

Despite the rise in EV adoption over recent years, market concentration has not consistently decreased across markets. While the overall share of NUTS 3 regions in Europe with a top CPO holding over 40% of the market decreased between 2022 and 2024, in Norway and the Netherlands—two leading countries in terms of EV sales share—the opposite occurred in the AC market. Ongoing monitoring could provide regulators with the necessary information to identify any potential competition concerns.

Billing per recharged energy (kWh) is dominant among European EV public charging rates. This trend reflects recent AFIR requirements, which also limit the number of pricing components in ad hoc DC charging rates and requires that charging rates are presented to users before the start of each charging session. In North America, recent regulations in California and funding requirements such as those of the NEVI program in the United States are also promoting a transition to energy-based charging rates. Still, with an expected increase in dynamic energy fees to encourage off-peak charging and charging at times of renewable energy production peaks, monitoring price transparency continues to be essential to ensure prices remain understandable and comparable.

Market dominance of a CPO has not had clear effect on ad hoc prices. Ad hoc charging prices are generally similar to MSP prices excluding subscription costs. Moreover, no clear correlation was observed between average ad hoc prices and regional market concentration, indicating that leading CPOs have not, so far, exhibited signs of abusing local market power. Taking subscription fee costs into account, average MSP prices tended to be highest among the pricing models analyzed. For frequent drivers, though, the per-kWh cost impact of the subscription fee decreases, making these plans more cost effective. So far, despite ad hoc prices being comparable to MSP rates on average, drivers have rarely opted for ad hoc payments. However, this may shift with provisions in the AFIR requiring that all chargers support ad hoc payments and accept widely used payment methods.

Appendix

This appendix provides supplementary information on the European MSP market and on regional competition in European CPO markets. Additionally, it includes a table outlining the approach to EV public charging rates applied in Quebec, Canada.

Table A1 and Figure A1 detail MSP charger coverage in Europe and select European markets as of January 2024.

Table A1. Number and share of chargers installed in a country per MSP network as of January 2024. Calculations include those MSPs which only have agreements with a single CPO.

Country	Number of chargers installed per MSP network		Share of chargers installed per MSP network	
	Mean	Median	Mean	Median
Netherlands	21,018	65	14%	0.6%
France	11,995	1,027	11%	0.9%
Germany	8,271	98	0.7%	0.08%
Norway	3,605	935	12%	3%
Poland	603	72	9%	1%
Europe	21,018	65	3%	0.008%

Figure A1. Distribution of MSPs by charger coverage and country as of January 2024. The total number of MSPs active in a country is included at the top of each bar. The figure includes those MSPs which only have agreements with a single CPO.

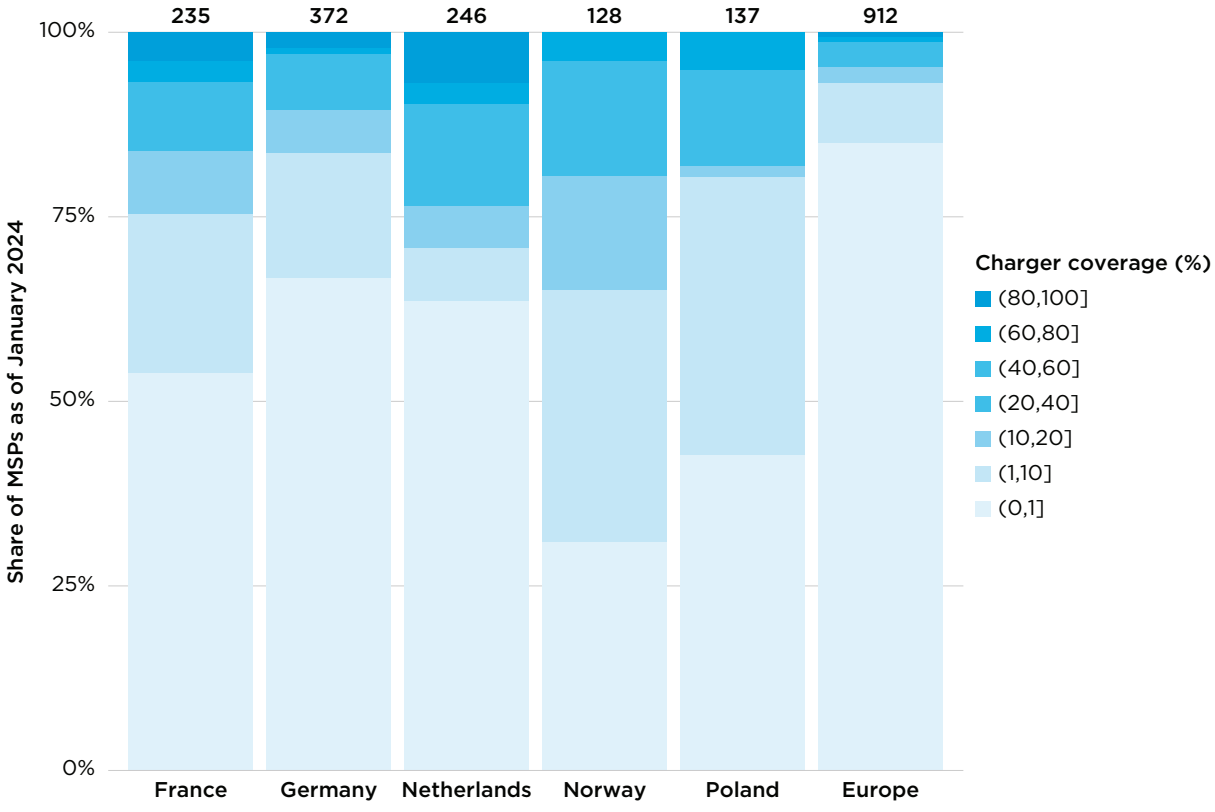


Figure A2 shows the average market share of the leading CPO across postal codes by European market from January 2022 to 2024.

Figure A2. Average market share of the leading CPO at the postal code level by country, power output type, and date

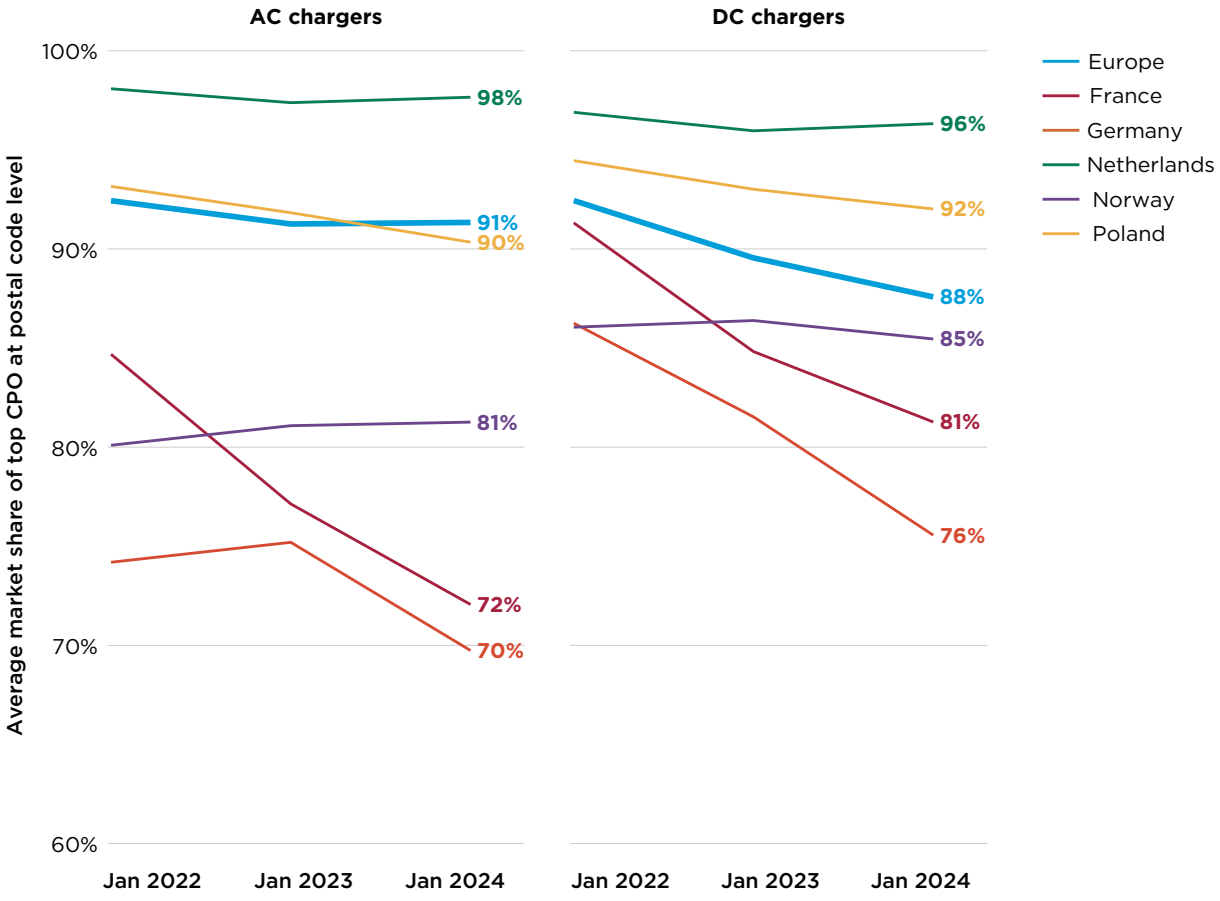


Table A2 outlines the approach to EV public charging rates applied in Quebec, Canada, from March 2024.

Table A2. Fast-charging rates by charger rated power output, power used, and battery state of charge in Quebec, Canada

Charger rated DC power output	Power used	Battery state of charge	Cost per kWh (in Canadian $)	Cost per hour (in Canadian $)
24 kW	< 10 kW	≤ 90%		$6.75
		> 90%		$6.75
	≥ 10 kW		$0.31	
50 kW	< 20 kW	≤ 90%		$11.43
		> 90%		$22.87
	≥ 20 kW		$0.31	
100 kW	< 20 kW	≤ 90%		$14.09
		> 90%		$28.18
	20 kW – < 50 kW		$0.41	
	≥ 50 kW		$0.36	
> 100 kW	< 20 kW	≤ 90%		$15.93
		> 90%		$31.87
	20 kW – < 50 kW		$0.46	
	50 kW – < 90 kW		$0.36	
	90 kW – < 180 kW		$0.46	
	≥ 180 kW		$0.52	

Note: Blank cells reflect that the cost (per hour or kWh) is independent of the state of charge.

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