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EMERGING TECH RESEARCH

EV Charging Segmentation

Fine-tuning the view as EV charging expands

PitchBook is a Morningstar company providing the most comprehensive, most accurate, and hard-to-find data for professionals doing business in the private markets.

Key takeaways

- EV adoption remains constrained in many countries by a lack of adequate charging infrastructure.
- This note provides further segmentation of the EV charging category into public, nonpublic, residential, and mix.
- Drivers appear relatively insensitive to paying higher prices per KwH for public fast charging options—convenience and location seem to drive decision-making.
- Dynamic pricing represents a potential means to manage congestion at public charging stations.
- Residential charging is likely to remain the dominant mode of charging. Bidirectional charging could be set to take off in key geographies.
- Countries with higher rates of adoption provide suggestions for others seeking to bolster the market, but some got where they are from unique resource advantages.
- Range anxiety may be overblown as an impediment to broader adoption. Education and marketing should be able to assuage drivers' concerns.

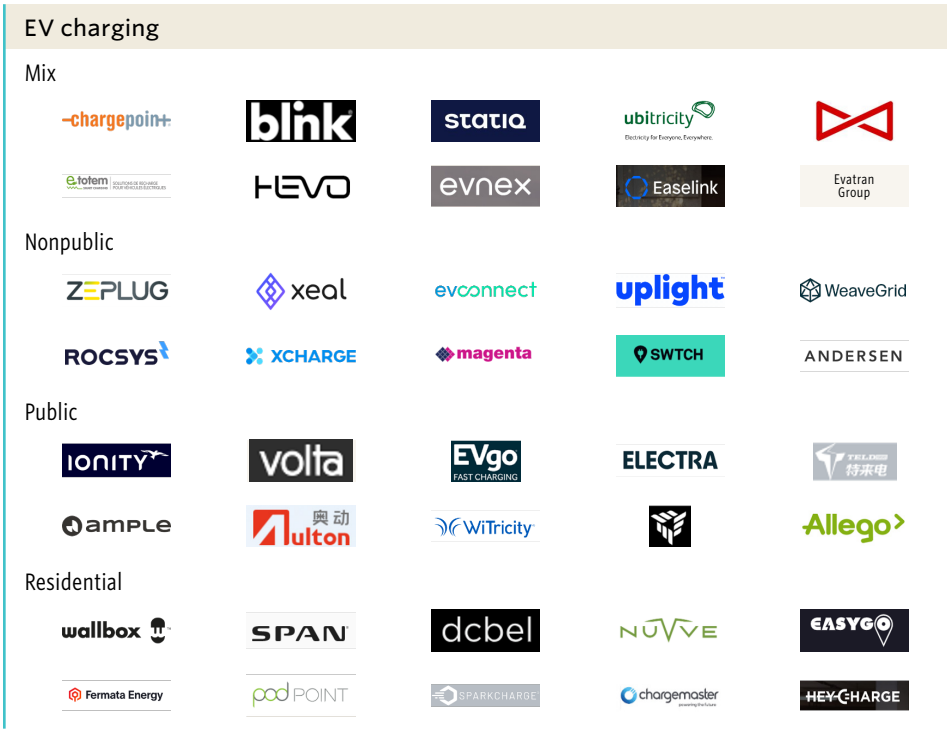
Introduction

Mainstream adoption of electric vehicles (EVs) faces something of a chicken-and-egg problem regarding EV charging. Most EV adopters will charge at home—approximately 80% of charging today—but, beset by range anxiety, most drivers want to know they can charge when out and about without getting stuck with a dead battery somewhere on the road. This remains a key sticking point for potential EV customers. However, widespread investment into EV charging remains constrained until the broader market for EVs expands; low levels of utilization mean limited, if any, returns on capital.

To date, PitchBook has segmented EV charging as a single category within the broader electric vehicle segment in market maps and coverage. But the EV charging landscape is not monolithic. This note provides a further segmentation of the EV charging landscape and a deeper dive into each of those categories. Additionally, a number of countries are further along the EV adoption curve, and it is useful to examine their real-world driver experiences with EV charging. Finally, this note looks at government regulation and policy that attempt to solve the chicken-and-egg problem of the EV charging rollout.

EV charging segmentation

EV charging market map



The EV charging segments include public, nonpublic, residential, and mix, as detailed below.

Public

The public charging segment refers to charging systems available to the general public—with some constraints, given that charger connection standards can vary by auto manufacturer. Here, a key constraint is time to charge. Drivers are accustomed to the gas station experience where they can fill up and be back on the road in a few minutes. Stretching out this interval is more than just jarring to drivers' typical habits; a fixed number of charging ports per station and longer charge times result in long lines and delays. Additionally, cold weather and drivers determined to fill to capacity—charging rates drop off significantly in the final 20% to protect batteries—can compound the time to charge further. DC fast charging is key to reducing charge times at charging stations and is the fastest growing category today. One report shows capital expenditure per kilowatt (kW) drops dramatically with Level 3 fast charging.[1] As charging rates increase, however, stations face constraints from utilities regarding available power and connections able to support that throughput. On-site storage batteries can help buffer and balance load times but add to overall capital costs of a station. Dynamic pricing—depending on time of day, vehicle state of charge, and possible other factors such as the weather—could help to shape driver behavior and more effectively manage charge times. So far, drivers appear willing to pay multiples of the kilowatt-hour (kWh) rates they pay at home for fast charging on the go. Station owners have not fully tested the upper limit of this elasticity or experienced the impact of price competition when charging infrastructure is fully built out. Drivers' sensitivity to price is evolving as the market grows. Charging apps reduce search costs and likely steer or spur price competition. Branding to distinguish quality, convenience, renewable power, and speed represents a potential for differentiation in the early days of this rollout, where driver experiences with broken or inoperable chargers have exceeded 25% in some geographies, and charging apps lead them to dangerous, undesirable, or poorly lit charging sites.[2] Providing prime locations, maintenance, and quality service, however, comes at a cost. So far, as detailed in the Q3 2023 EV Charging Analyst Note, Tesla is the clear leader on this front in the US.

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Nonpublic

Nonpublic systems include fleet charging for commercial operations, businesses offering charging connections for employees, as well as charging systems for apartment buildings and multifamily structures. Fleets of EVs for delivery and other commercial operations are typically going to be charged in the yard or parking area of the company running them. Similar to residential systems, vehicles can charge overnight or during nonoperating hours. Range and hours of operation are likely to be more finely tuned for commercial fleets, however, with telematics systems monitoring state of charge and routes to ensure compliance with delivery or operating schedules and other key business metrics. Time to charge is not as important as for public charging stations, but maintenance, uptime, and consistency

1: "Electric Vehicles and the Charging Infrastructure: A New Mindset?" PwC, n.d., accessed May 21, 2024.
2: "86% of EV Drivers Can Charge at Home, but Over Half Still Rely on Public Chargers, Chargelab Survey Finds," PR Newswire, ChargeLab, February 29, 2024.

are critical measures, as these vehicles typically support carefully measured business activities. The servicing opportunity for fleet charging management is likely considerable given many businesses would rather outsource than manage the complexity of this operation. Parking garages of office and apartment buildings can be wired to offer charging for tenants. Companies can offer perks to employees to keep their vehicles' batteries topped up during the day. Similar to fleets, rate of charge is a lesser consideration, given vehicles will likely be plugged in all day or night. Level 2 chargers are adequate for the task. Managing the number of ports in a building is a consideration as EV adoption grows, but ports can also easily be added ad hoc as the ratio of EVs increases. Pricing per kWh is likely to approximate typical utility rates, so value-add for nonpublic systems mostly derives from equipment sales, maintenance, and service.

Residential

Residential refers to home charging systems typically provided by EV automakers or utilities. This is likely to remain the dominant means of EV charging. Today, between 70% and 80% of charging occurs at home. Depending on the size of the battery in the EV and daily driving habits, homeowners can opt for a Level 1 charger that can easily plug in to a 120 volt outlet, or a faster Level 2 charger, which can require more extensive (and costly) wiring and a potential electric panel upgrade to accommodate higher wattage.[3] There are a number of federal, state, and utility incentives and subsidies to offset the cost of installing charging equipment at home.[4] The widespread impact of residential EV charging on the grid can be significant. In September 2022, California asked EV owners not to charge during peak hours during a heat wave because of stress to the electrical grid.[5] In the Seattle area, Puget Sound Energy is offering customers who own EVs and enroll in its Flex program $100 upfront and $0.50 for every kWh of electricity saved. The program automatically limits charging through onboard telematics or Level 2 chargers during peak power episodes. Bidirectional charging is also increasingly an option for residential EV owners, providing electricity during power outages, storage for renewable energy systems, and even bolstering overall grid resilience.[6] In California, legislation requiring bidirectional charging for all EVs sold in the state is working its way through the state capitol.[7] Residential charging is expected to remain the dominant mode for EV charging. The US Department of Energy estimates that by 2030 there will be 33 million EVs on the road in the US and 28 million charging ports, of which 26.8 million will be private charging ports.[8]

The widespread impact of residential EV charging on the grid can be significant.

3: "A Big EV Purchase Decision That's Not About the Car Model You Buy," CNBC, Cheryl Winokur Munk, September 29, 2023.
4: "Charging Electric Vehicles at Home," US Department of Energy, n.d., accessed May 21, 2024.
5: "Amid Heat Wave, California Asks Electric Vehicle Owners to Limit Charging, The New York Times, Livia Albeck-Ripka, September 1, 2022.
6: "Bidirectional Charging and Electric Vehicles for Mobile Storage," US Department of Energy, Office of Federal Energy Management Program, n.d., accessed May 21, 2024.
7: "Bidirectional Charging and EVs: How Does It Work and Which Cars Have It?" CNET, Dan Avery, September 4, 2023.
8: "Electric Vehicle Charging Infrastructure Trends From the Alternative Fueling Station Locator: Third Quarter 2023," National Renewable Energy Laboratory, Abby Brown, et al., February 2024.

Mix

This category reflects charging services or equipment vendors with offerings that meaningfully straddle or encompass multiple subsegments across the EV charging landscape. Over time, companies focused on one segment of the market may choose to expand to other segments or blend hardware and service aspects of their offerings.

Real-world examples—looking down the road

As the US and other countries grapple with the challenges of building out EV charging infrastructure, it is useful to look at a couple of economies where EV adoption is much higher for clues to how drivers have adapted.

In March 2024, sales of plug-in EVs achieved 91.5% market share, up from an average of 83% in 2023.

Evidence from Norway, where EV adoption is among the highest in the world, suggests drivers are willing to pay a significant premium for public charging resources. In March 2024, sales of plug-in EVs achieved 91.5% market share, up from an average of 83% in 2023.[9] By comparison, in the US, EVs accounted for 7.6% of new car sales in 2023, and in China, the figure was 24%.[10] The cost for on-the-go charging in Norway is 3x to 4x that of charging at home.[11] McKinsey sees public EV charging remaining profitable, driven by the limited availability of attractive charging locations in Norway and around the world. In Norway, McKinsey expects on-the-go charging to account for 21% of power demand but capture 45% of EV charging EBITDA.

There are a lot of options for public charging in Norway, but one common concern is that customers do not like maintaining multiple mobile apps. Glitches remain, even in Norway. A 2022 annual survey from the Norwegian EV Association revealed fully half of respondents stated fast chargers do not work all of the time. Norway is a relatively small passenger car market, with just under 127,000 cars sold in 2023.[12] The country is also unique—and ready for electrification—with nearly 100% of electricity coming from abundant hydropower. In 2023, the country had 23,800 charging stations to support the 817,500 EVs and plug-in hybrid cars registered.[13]

The Netherlands has also seen some of the highest EV adoption rates in Europe. The Dutch Association of EV Drivers conducts an annual driving survey, and it offers some useful insights.[14] The association surveyed nearly 3,000 EV drivers in the Netherlands in 2023. On average, Dutch EV drivers logged 18,845 kilometers (km) per year (about 12,000 miles). It may be the result of a sampling issue, but EV drivers logged nearly double the average of a typical private car (10,000 km). Real-world examples suggest range anxiety may be overblown. The survey shows that despite the greater-than-average levels of driving, an EV battery is usually sufficient

9: "Norwegian EV Market Surges to 91.5% Market Share, Setting a Sustainable Example," European Commission, April 7, 2024.
10: "What the U.S. Can Learn From Norway When It Comes to EV Adoption," CNBC, Jeniece Pettitt, February 17, 2024.
11: "What Norway's Experience Reveals About the EV Charging Market," McKinsey & Company, Márton Békés, et al., May 8, 2023.
12: "Number of Passenger Cars Sold in Norway From 2010 to 2023," Statista, Mathilde Carlier, March 21, 2024.
13: "Number of Public Charging Stations for Electric Vehicles in Norway From 2011 to 2022, by Type," Statista, Mathilde Carlier, September 12, 2023.
14: "Nationaal Laadonderzoek 2023," Rijksdienst voor Ondernemend Nederland, Britt Wolterman, et al., September 7, 2023.

64% supported using bidirectional charging and EVs to balance the grid so long as they are compensated.

for daily distances, and 40% of respondents never need to recharge while on the road. 85% of drivers do not need to recharge on the road more than two times a month. When they do use public chargers, EV drivers have on average two or three charging apps and cards. 94% of drivers pay with a charging card when using public chargers, and only 4% use an app for payments.

Satisfaction with the charging experience is generally high. Private charging at home was rated highest at 9.1 out of 10. Public charging near home fell to 7.2, while public charging abroad was rated just 6.7. The fast charging experience is improving, with 32% having bottlenecks in 2023, down from 62% in 2021, and the biggest issue being broken or defective charging stations. For those charging at home, 34% had their utility service or wiring expanded to install the home charging station, and 55% had smart charging that could vary over time. Bidirectional charging is popular, with 62% of users wanting to use it and fully 50% of EV drivers supporting making it mandatory.

Interestingly, 77% of survey respondents have solar panels on their homes—solar installations have surged in the Netherlands in recent years as the Russia-Ukraine war increased the volatility of electricity prices—and support for bidirectional charging stems largely from a desire to use the EV to store and manage power from the solar panels for both the vehicle and the home. 64% supported using bidirectional charging and EVs to balance the grid so long as they are compensated. Given the increased occurrence of negative energy prices in the wake of the surge of solar installations across Europe recently, the need for bidirectional charging and EV storage to balance electricity grids and prices appears to be looming larger.[15]

Price sensitivity among survey respondents is fairly low. Despite higher electricity costs overall recently, 72% said they did not use their EV any differently, while only 19% said they now seek out lowest charging costs. Moreover, when asked about factors in choosing a charging card, 65% emphasized the widest coverage of charging stations, while only 19% looked for the cheapest rates. 68% responded to knowing the price of public charging "only sometimes" to "never."

Although a number of countries may have higher EV adoption rates, in absolute numbers, China is dominant. Confronting the chicken-and-egg problem outlined above, China simply said "yes" and has barreled ahead with aggressive EV charger deployment. For 2023, the country was expected to deploy twice as many chargers as the rest of the world combined.[16] At the end of 2022, the country's two largest public charging operators were running at utilization of 5% to 8%, levels generally believed to require subsidies to remain viable. A report from early 2023 speculated that the average charging post is used about once per day.[17] A separate report shows average charging utilization across 32 Chinese cities at 11% in 2023, ranging from a high of 17.4% in Xiamen to a low of 4.1% in Shenzhen.[18] The urban cores of several

15: "European Electricity Prices Tumble Into Negative Territory Amid Glut of Green Energy," Business Insider, Filip De Mott, July 18, 2023.
16: "There's No Such Thing as Too Many Electric-Car Chargers in China," Bloomberg, Ryan Fisher, June 20, 2023.
17: "OIES China Programme: An Update on China's EV Revolution," The Oxford Institute for Energy Studies, Anders Hove, February 20, 2023.
18: "Charging Up China's Transition to Electric Vehicles," The International Council on Clean Transportation, Hongyang Cui, et al., January 2024.

Chinese cities, however, enjoyed utilization rates as high as those in Amsterdam, at about 35%.

Chinese cities, however, enjoyed utilization rates as high as those in Amsterdam, at about 35%. The disparity in utilization rates is likely a result of the rapid build-out of infrastructure and should moderate over time. Chinese highways remain a weak link in the nationwide infrastructure. In 2022, public charger density was 105 per thousand km on highways in contrast to 654 for Norway and 135 in California. Urban cores appear to be well covered, and deployment along highways and in suburban and rural areas is likely to accelerate over the near term. Chinese oil companies facing expected peak gasoline demand in China in 2025 are starting to build out charging networks.[19] Western oil majors including Shell and Total are building out charging stations in China as well. Varied and changing utilization rates in China make siting and scaling EV charging networks a challenge.

Government stepping in

Where markets face economic challenges building out EV charging infrastructure—such as the chicken-and-egg problem mentioned above—governments have stepped in to stimulate and steer the effort with subsidies and incentives. The 2023 EV Charging analyst note details US government efforts and incentives, so this note will emphasize another country's efforts. Norway has had considerable success with EV adoption, but it also started early and provided significant incentives. As early as 1990, Norway slashed registration fees for EVs to 0%; in 1996, the country offered free tolls to EV drivers; and in 1999, it offered free parking. The most significant incentive came in 2001 when the country cut value-added tax rates to zero for EV purchases. A value-added tax rate of 25% is applied to all other unsubsidized purchases in the country. In 2003, the country allowed bus lane access for EVs. Still, adoption rates remained relatively low, largely because battery technology could not provide sufficient range. In the past 10 years, however, since Tesla started mass production, adoption in Norway has climbed. Tesla leads the market with approximately 20% share today. Success has not come cheap. Norway has spent approximately $20 billion on the effort and currently spends $3.8 billion per year.[20] Ironically, Norway is the largest oil & gas exporter in Western Europe, accounting for 24% of the country's GDP. The country has chosen to invest its tax revenue to help its citizens purchase EVs and convert the nation's fleet of vehicles, after which they enjoy transportation energy and operating costs typically one-third that of internal combustion engine vehicles. Abundant hydropower also eases the transition on the nation's power grid.

19: "China's Oil Majors Face Uphill Climb to Adapt to EV Future," Reuters, Andrew Hayley, April 11, 2024.
20: "How Norway Built an EV Utopia While the U.S. Is Struggling to Go Electric," CNBC, Jeniece Pettitt, Erin Black, and Magdalena Petrova, February 17, 2024.

The US remains conflicted, with substantial incentives in place but relatively low EV adoption overall and political polarization over the issue threatening to extinguish the effort altogether.

The build-out of charging infrastructure to support broader EV adoption remains a challenge for many countries. For some, the approach is to barrel ahead regardless of market signals and lack of profits, accepting near-term volatility and variability of utilization as necessary costs to the greater transition. Others have leveraged unique resource advantages to spur the transition with generous and targeted incentives. The unintended consequence of volatile energy prices resulting from the Russia-Ukraine war could be that European EVs provide a critical balancing factor to match demand with variable renewable supply across power grids. The US remains conflicted, with substantial incentives in place but relatively low EV adoption overall and political polarization over the issue threatening to extinguish the effort altogether. Learning from surveys suggests that issues such as driver range anxiety, seen as a key impediment, may be overblown. AAA has launched services in numerous states to support EV drivers and recorded 160,000 EV-specific incidents in 2023. It reports that only 4% of service calls are for vehicles that have run out of power, and in many of those cases, the car still does have juice.[21] The Dutch survey shows concerns about range lessen the longer drivers are behind the wheel and have experience with the vehicle. Perhaps time, money, and effort is better spent fixing broken chargers and ensuring a positive experience for drivers while they charge.

21: "The Main Reason EV Drivers Call AAA for Help Is Not Dead Batteries," Time, Jeffrey Kluger, January 18, 2024.