STATZON

Electrifying the Future 2nd Edition

A Comprehensive Handbook on the EV Market

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Rika came to Statzon with a background in market research, both in qualitative and quantitative studies. She has a strong interest in data collection and analysis and how to communicate those data in a simple yet interesting fashion.

This book explores the electric mobility revolution and its anticipated effects on the cities in which we reside and plan for. The rise of e-mobility is very much related to the rising awareness of environmental problems. The transport sector accounted for 37% of the total global CO2 emissions. The International Energy Agency (IEA) recorded emissions as big as 7.7 Gt CO2 produced by the transport sector in 2021. Around 77% of that number came from the road transport category in which passenger cars produced more emissions compared to any other mode of road transport.

It is clear that e-mobility and sustainability are closely linked: the more e-mobility solutions we adopt, the larger the decrease in CO2 and other greenhouse gas emissions. Transition to e-mobility and renewable energy generation holds the key to a cleaner, healthier future.

Some important points that will be covered in this book are:

- Global EV charging market
- Megawatt charging market outlook
- Europe EV charging expansion
- Global wireless EV charging market
- Europe's EV market
- US EV market
- Global electric scooter market
- Global electric bus market
- Global electric boat market
- Global autonomous vehicle market

IEA Global EV Outlook 2023 Reveals Another Record-Breaking Sales

The IEA's Global EV Outlook 2023 report is a must-read for anyone interested in the e-mobility industry. The International Energy Agency (IEA) annually evaluates the electric car market and the state of EV charging infrastructure. This data is then published in their publication, the Global Electric Vehicle Outlook, which examines and highlights recent global advances in electric mobility.

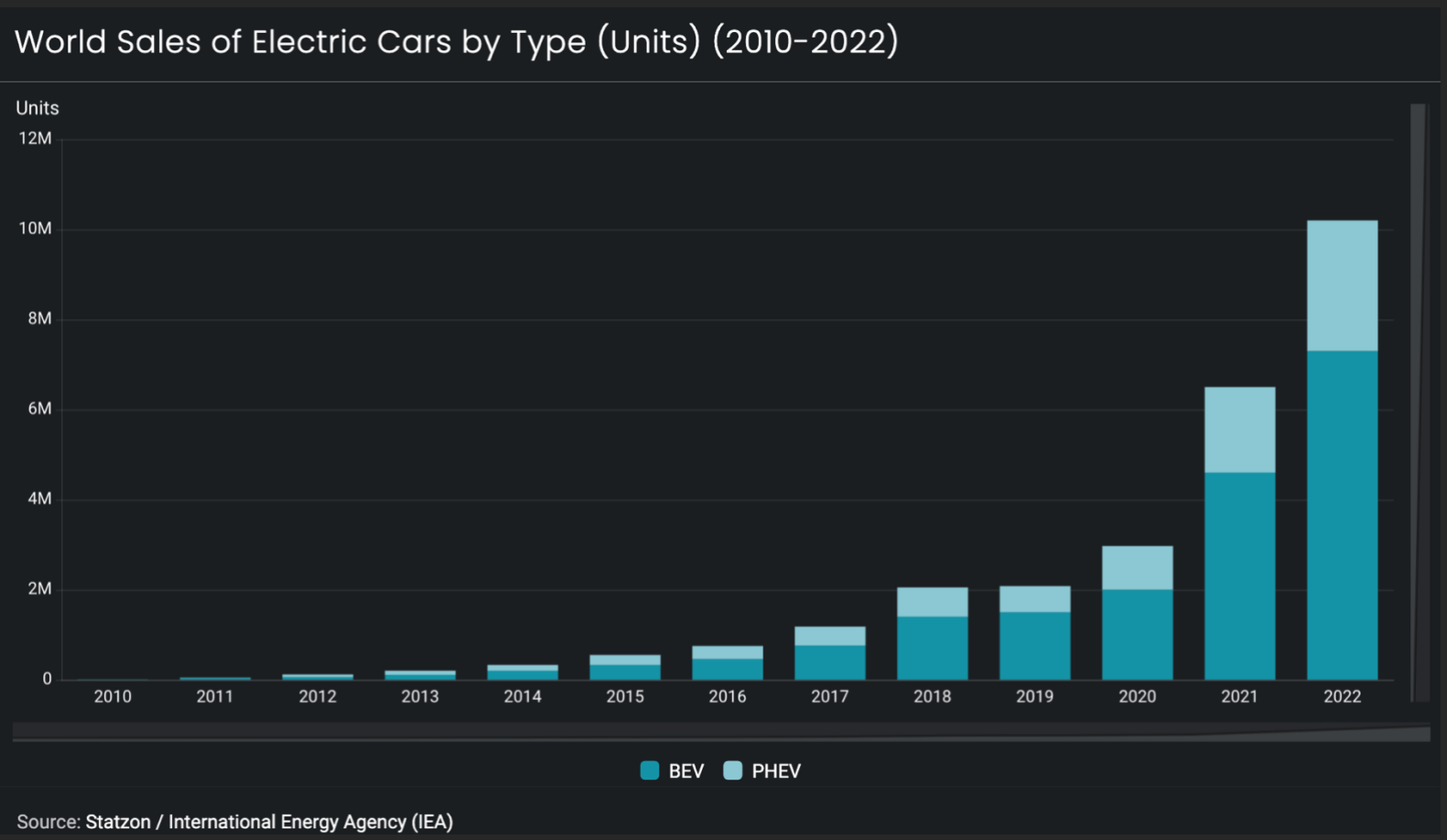
This year's report presents a more comprehensive analysis of the global electric vehicle market, including more countries and two different scenarios for projections.

Newcomers include Austria, Israel, and Turkey, providing a broader **worldwide overview** of the electric vehicle market. Additionally, the report has more data on India and Brazil and a separate dataset for EU-27.

Aside from historical data, the report also includes projections up to 2030 based on two scenarios: the more conventional Stated Policies Scenario (STEPS) and the comprehensive Announced Policies Scenario (APS). The STEPS scenario takes a more conservative approach by considering existing policies and measures to reach energy-related objectives. On the other hand, the APS scenario assesses progress towards achieving net-zero emissions by 2050 and assumes full implementation of national targets by 2030 and 2050, including country-level access to electricity and clean cooking targets.

Global Electric Car Market 2022

IEA’s Global EV Outlook 2023 shows that electric car sales have increased despite a declining global car market. The combined sales of battery electric and plug-in hybrid vehicles surpassed 10 million in 2022, indicating a 55% rise from 2021. The report also suggests sales for 2023 are expected to grow by another 35%, meaning nearly one in five cars sold globally this year will be electric.



The significant surge has resulted in an increase in the electric car market share from 4% in 2020 to 14% in 2022. the market share is expected to further rise to 18% by the end of this year.

When it comes to stock, in total we have more than 25 million electric cars on the roads worldwide in 2022, representing 3.1% of the total global car stock, up from 2.5% in the previous year.

PHEVs constitute a significant portion of the total EV sales, representing approximately 34% of all EVs sold in 2021 and 28% in 2022. However, the proportion of PHEVs is expected to decline in the coming years, with a predicted share of 22% in 2025 and 16% in 2030, based on the STEPS scenario, while the share of BEVs is expected to increase steadily. This is in line with the trend towards more sustainable transportation options and a shift away from fossil fuels.

Global Sales of Electric Buses and Trucks

As electric car sales have been consistently rising, the same cannot be said for electric buses and trucks. Electric bus sales peaked in 2015 with 68,000 sold globally but have since

decreased to 55,000 in 2021 and 63,000 in 2022. Electric truck sales peaked in 2017 with 67,000 sold, but have since fluctuated, with 34,000 sold in 2019, 40 000 in 2021, and 58,000 in 2022.

This non-linear pattern for the sales of electric buses and trucks can be attributed to various factors, such as the lack of charging infrastructure for heavy-duty vehicles, the higher cost of electric buses and trucks compared to their diesel counterparts, and the limited driving range of electric buses and trucks. Additionally, the long operational life of buses and trucks (compared to cars) means that the transition to electric buses and trucks may take longer. According to the STEPS scenario, electric passenger cars are projected to make up 36% of sales by 2030, while the APS scenario predicts 41%. For electric buses and trucks, the STEPS scenario predicts a sales share of 17% and 9% by 2030, while the APS scenario projects a sales share of 22% and 13%, respectively.

Nevertheless, the data indicate that there has been an overall increase in the sales of electric vehicles, including electric buses and trucks, over the years, which is a positive sign for the electric vehicle market.

China and Norway, Still the Prominent EV Market Leaders

The bulk of electric car sales have been predominantly concentrated in three major markets: China, Europe, and the United States. China dominated the electric car market, making up 60% of the global sales. Over half of the world's electric cars are in China, and the country has even exceeded its 2025 targets for new energy vehicles. China will most likely retain its leadership position in the coming years, despite the phasing out of EV policy incentives. China’s success probably lies in its success in producing smaller EV models with prices edging lower towards those of their combustion engine equivalents.

China sets a target of 50% of electric car sales share by 2030 across "key pollution control regions" and 40% across the country remains in place.

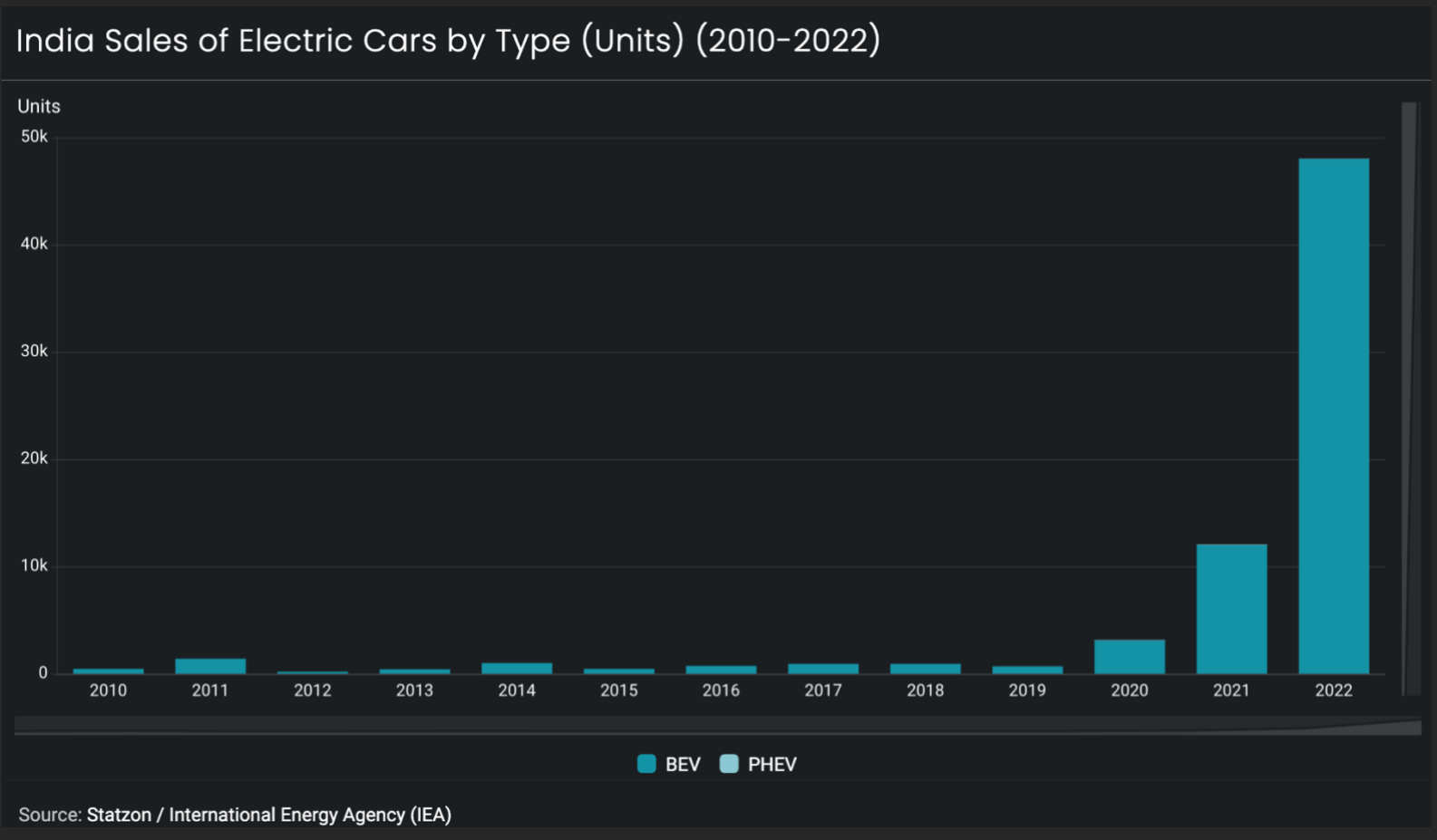
Norway, on the other hand, does not lead in number of sales but the country has maintained its position as the top country for electric car sales share, just like in the previous years. In 2022, the country achieved an electric car sales share of 88%, which is an improvement from the 86% recorded in 2021. However, Norway is gearing towards full electricity. In 2022, only 16,000 PHEVs were sold in Norway, a meager 10% of the total electric car sales for the year. It was a considerable decrease from the 38,000 sold in 2021.

Furthermore, Norway boasts the highest percentage of electric vehicles among all passenger cars sold in 2022, reaching an impressive 27%. This figure is considerably higher than the global average of 2.1%. Even China, a world leader in electric car production and sales number, only achieved an electric car stock share of 5% in 2022.

Electric Vehicle Sales in Emerging Markets

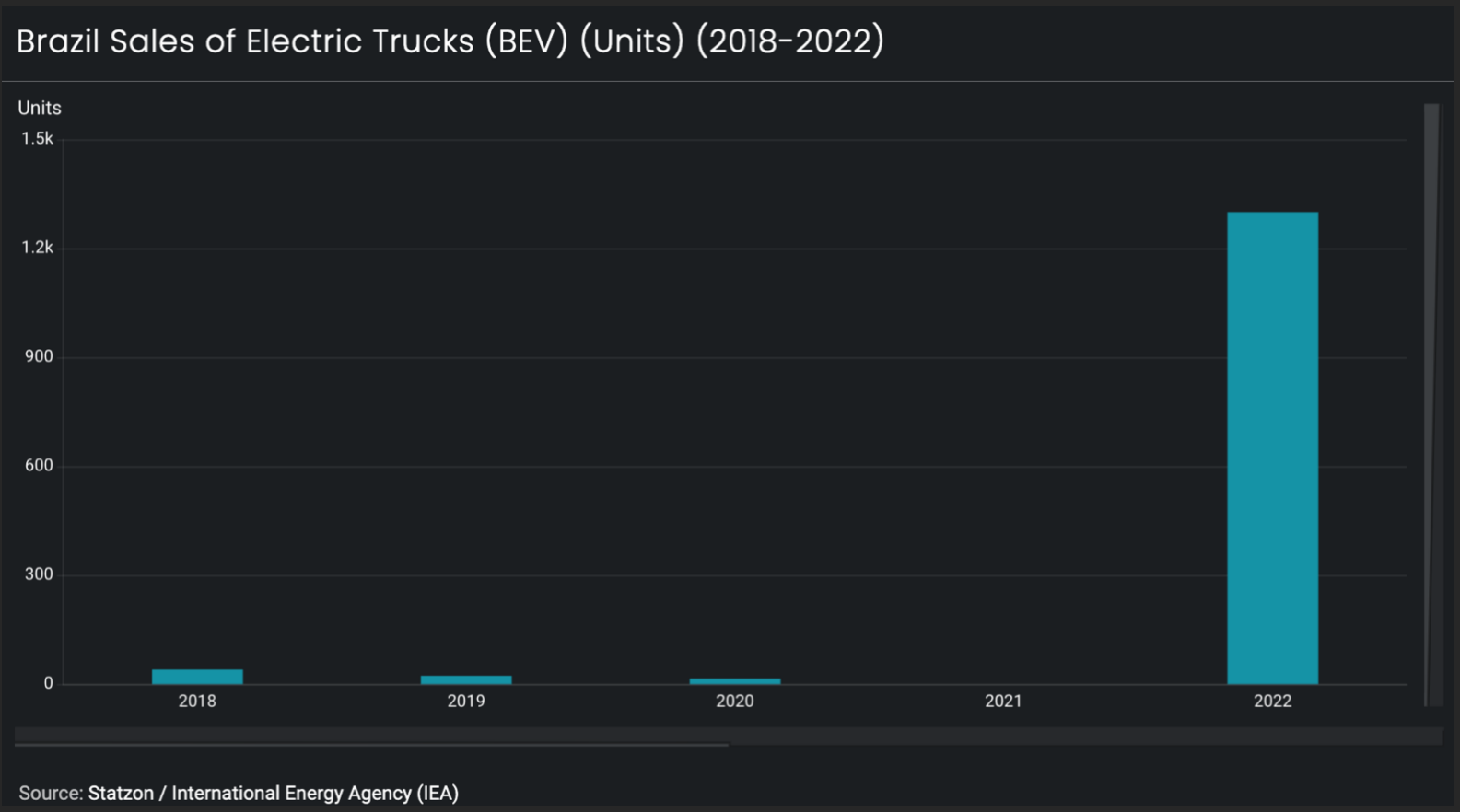
Emerging markets have been slower in adopting electrified four-wheeled transport due to the high cost of electric vehicles (EVs) which have yet to reach price parity with internal combustion engine (ICE) cars. With the exception of China as emerging market, Climatescope 2022 Electrified Transport Factbook recognizes Ukraine, India, and Brazil as the three biggest EV markets among developing nations, accounting for over half of emerging markets (ex-China) sales. Other emerging markets with top EV sales rates include Romania, Croatia, Taiwan, and Turkiye.

India aims to reach net zero emissions by 2070 and we can see some serious movement that they have been taking to reach that target. Focusing on BEV, India's sales of battery-electric passenger cars jumped from 12 000 vehicles in 2021 to 48 000 in 2022. A fourfold increase in just one year. India's sales share of 2022 stood at 2.5% and is expected to reach 7% by 2025 and 15% by 2025, based on the STEPS scenario.



India also put special emphasis on electrifying its bus fleet. The number of operating electric buses in the country is growing from 550 in 2019 to 1100 in 2020 and to 3100 in 2021. The Indian government has also set a very ambitious goal to put 50 000 electric buses on the roads by 2030 to make sure the country cuts its carbon emissions by 1 billion tonnes by 2030 and reaches zero emissions by 2070.

Brazil, on the other hand, shows a serious movement towards electrifying its truck fleet. Sales of electric trucks in Brazil have grown from only 15 in 2020 to 1,300 in 2022. Some of the big names in Brazil's mining industry are now betting on electric trucks as part of their efforts to reduce greenhouse emissions from their activities.



However, the most dynamic area of electric mobility in emerging and developing economies is two- and three-wheel vehicles, which far outnumber cars. More than half of India's three-wheeler registrations in 2022 were electric, demonstrating their growing popularity. In many developing economies, two- or three-wheel vehicles offer an affordable way to access mobility, making their electrification crucial to support sustainable development.

Expansion of EV Charging Infrastructure

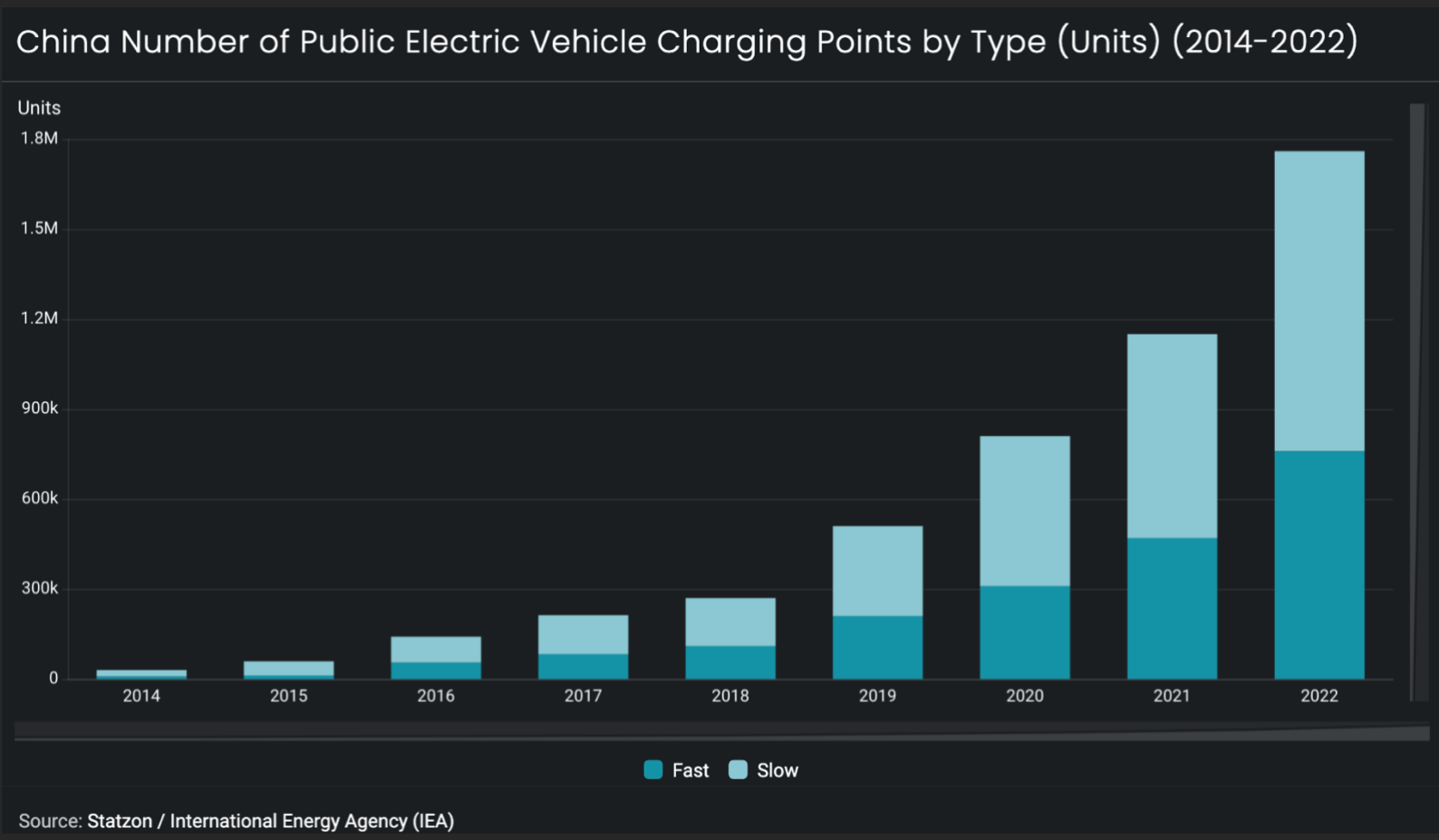
As of the end of 2022, the number of public charging points worldwide reached 2.7 million, with over 900,000 new installations, indicating a 55% increase in comparison to the previous year. This growth is comparable to the pre-pandemic growth rate, which was around 50% between 2015 and 2019. More than 600,000 public slow charging stations were established worldwide, and the number of fast chargers increased by 330,000.

The majority of the growth came from China both for slow and fast charging. China added 320,000 slow charging points and 340,000 fast charging points in 2022, numbers that are way higher than any other country worldwide. In total China accounts for 760,000 fast chargers, but more than 70% of the total public fast charging pile stock is situated in just ten provinces.

In Europe the overall fast charger stock numbered over 70,000 by the end of 2022, an increase of around 55% compared to 2021. The countries with the largest fast charger stock are Germany (over 12,000), France (9,700), and Norway (9,000).

The United States installed 6,300 fast chargers in 2022, about three-quarters of which were Tesla Superchargers. The total stock of fast chargers reached 28,000 at the end of 2022.

Although slow chargers still dominate in numbers, fast chargers are being rolled out at a faster pace and some countries are putting an emphasis on them. For instance, in 2022, India installed nearly 11,000 charging points, with almost 40% of them being fast chargers. Similarly, in Thailand, fast chargers accounted for 54% of the total 3,700 charging points installed that year, while in China, the installation of fast chargers constituted 40% of the total installation of charging points.



According to the STEPS scenario, fast chargers are projected to have a 36% share of the total publicly available charging points in the world by 2025. This share is expected to slightly increase to 38% by 2030.

In markets with widespread availability of home charging, such as the US and Norway, the ratio of EVs per public charging point can be as high as 24 and 30, respectively. However, as EV market penetration increases, public charging becomes more important, even in countries with high home charging availability. The optimal ratio of EVs per charger will vary depending on local conditions and driver needs.

Sources: Statzon, CleanTechnica, Climatescope

Global EV Charging Station Market Will Reach USD 32.2 Billion by 2032

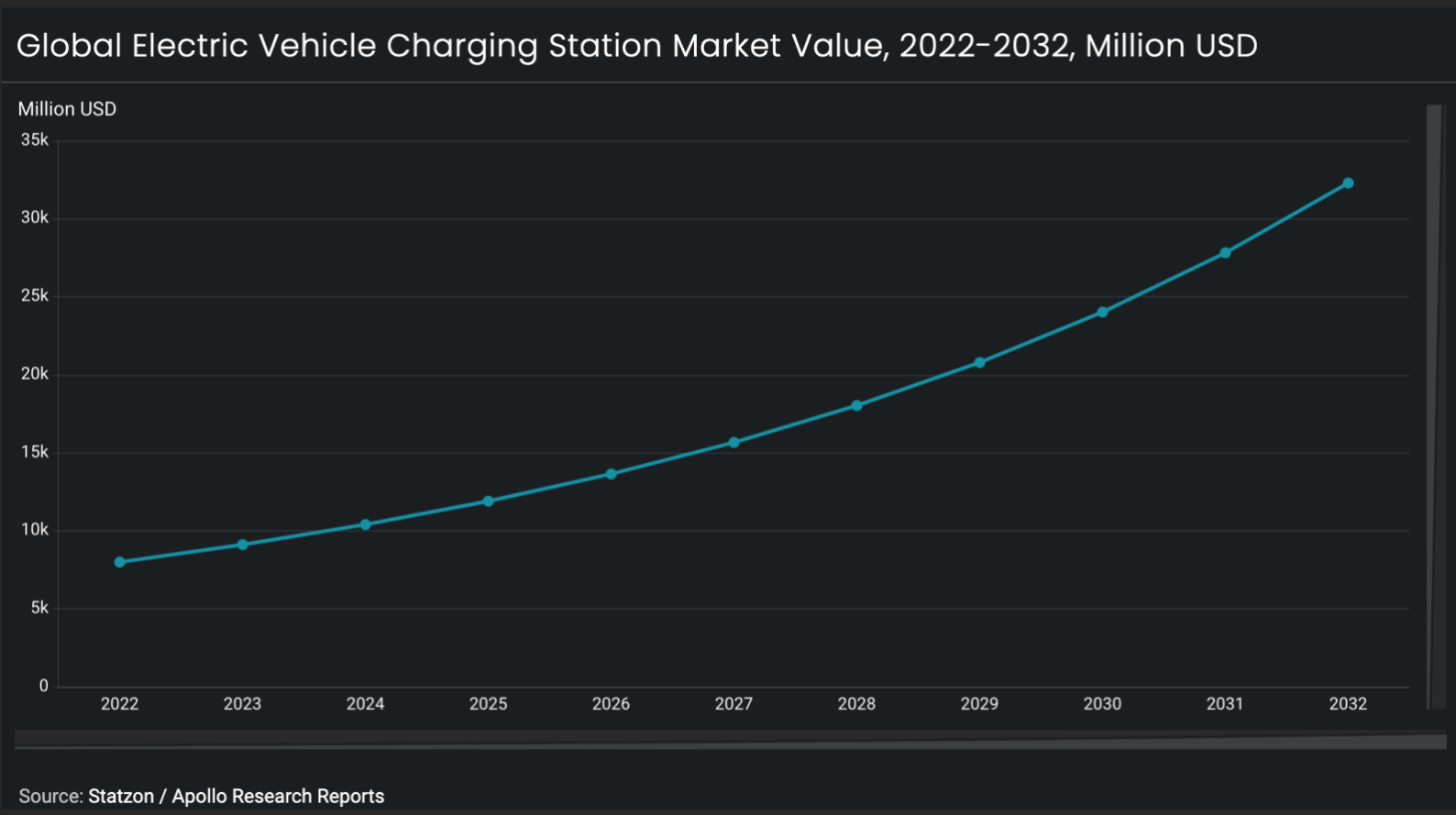
Like any other device or technology that can be charged, electric vehicles (EVs) need a charger to keep their batteries charged. EV charging infrastructure is a system of stations that connects EVs or plug-in hybrids to a source of energy, allowing them to be recharged. Different types of chargers offer varied current and voltage levels to suit vehicle-specific battery requirements.

EV Charging Station Market Size

The global charging infrastructure market is expected to grow well in the coming year. In 2022 alone, the market for EV charging stations was valued at USD 7.9 billion, based on market research conducted by Apollo Research Reports. This number is forecast to grow to USD 32.2 billion by 2032 with a steady 15.1% CAGR.

The growth of EV charging stations can be attributed to the rapidly accelerated production and sales of EVs in recent years. The global policy support for zero-emission vehicles also helps accelerate EV sales in the market.

Major corporations are investing significantly in R&D to create faster EV charger types for public charging stations. This will ultimately help push for the migration of more drivers toward EVs.



APAC Leading in Market Size

The bulk of EV charging infrastructure installations have been predominantly concentrated in three major markets: China, Europe, and the United States. With China being the biggest market in the world, Asia Pacific (APAC) is the leading region in the industry with USD 4.5 billion in market size or 57% share in the global market. The region is expected to keep its leadership position until the end of the forecast period with a market value of USD 17.4 billion, registering a 14.6% CAGR.

China has long been a leader in the field of electric vehicles. The country does not actually have big EV automakers, but it takes its transition to electrification very seriously. With strong governmental assistance for EV ownership and infrastructure, China currently has the most EV charging stations in the world, with an estimated 2.2 million charging stations across the country.

By the end of 2022, there were 2.7 million public charging points for electric vehicles worldwide, with China contributing over 60% of this total. China significantly contributed USD 3.3 billion to the global market value in 2022. According to Apollo Research Reports' forecast, the Chinese market is expected to grow at a CAGR of 12.3% and reach USD 10.3 billion by the year 2032.

Indian market, on the other hand, is predicted to be the next massive market by many. The country shows rapid growth at 18.3% CAGR according to a study by The Insight Partners. By 2030, the Indian government wants to electrify 70 percent of its commercial vehicles, 30 percent of private automobiles, 40 percent of buses, and 80 percent of two-wheeler and three-wheeler sales. This simultaneously will accelerate the growth of the charging infrastructure market in the country.

Back to the regional market, Europe is the second biggest market with over half a million charging points at the end of 2022, accounting for 20% of the total global stock. The annual "Making the Transition to Zero-Emission Mobility" survey published by ACEA in 2021 found that EV charging stations in Europe are not equally dispersed. 70% of Europe's charging points are located in three nations: The Netherlands, Germany, and France. On the contrary, these three countries account for only 23% of the overall surface area of the region, providing the need for a substantial installation of more charging stations. While the situation improved slightly in 2022, these three countries still account for more than half of Europe's total charging points.

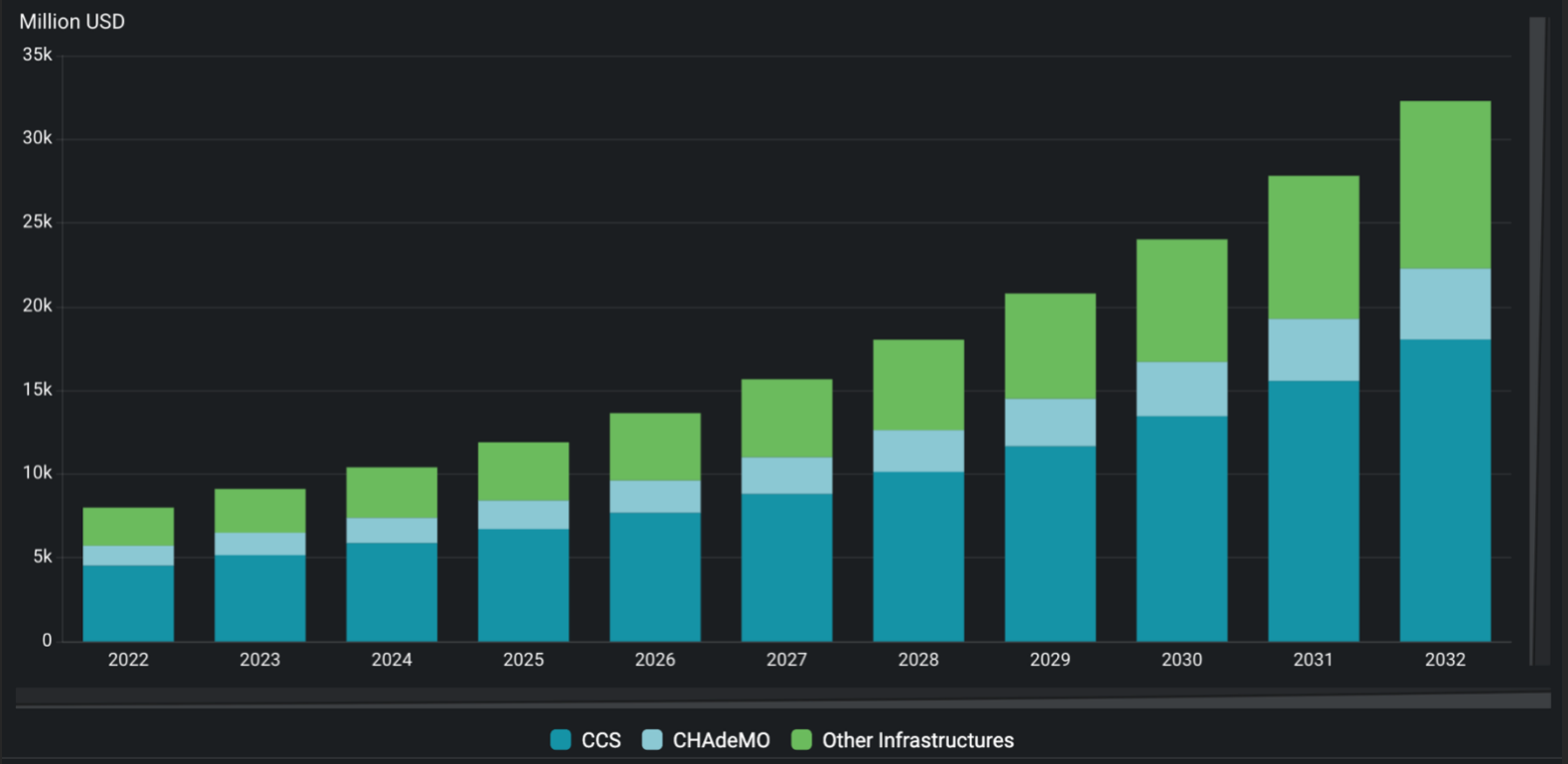
Charging Station Market Segmented by Type of Charger

CCS (Combined Charging System) segment dominated the market in 2022 with a substantial market share of approximately 57%. Its value amounted to USD 4.5 billion, making it the most significant player in the EV charging industry. The CAGR for CCS between 2023 and 2032 is projected to be 15%, suggesting a steady and substantial expansion of the CCS charging network over the forecast period.

The CHAdeMO segment held a significant share of the market, accounting for around 28% of the total market value. Its market value was approximately USD 2.2 billion. With a CAGR of 18.1%, CHAdeMO is anticipated to experience robust growth, making it a noteworthy contender in the fast-charging segment.

The remaining charging standards collectively constituted approximately 15% of the market share.

Global Electric Vehicle Charging Station Market Value, By Infrastructure Type, 2022-2032, Million USD



Source: **Statzon / Apollo Research Reports**

Based on IEA's latest data, the slow charging segment currently controls 67% of the total 2.7 million charging points available globally, leaving the rest 33% share to fast chargers.

There has been a noticeable increase in the installation of fast chargers, which are instrumental in shaping the future of electric mobility. Fast charging stations play a crucial role in providing rapid charging solutions, enhancing driving convenience, alleviating range anxiety, and promoting broader adoption of electric vehicles (EVs). Notably, China has been at the forefront of fast charger expansion, contributing nearly 90% of the global growth in this segment. In Europe, the deployment of fast chargers surged by approximately 55% compared to the previous year, effectively addressing the challenge of limited access to home chargers in densely populated urban areas.

In the coming years, the International Energy Agency (IEA) foresees substantial expansion in the EV charging infrastructure. By 2025, the global charging landscape is projected to comprise 4.3 million slow chargers and 2.4 million fast chargers, marking significant growth in both categories. The total number of charging points is set to triple compared to the availability in 2022, reflecting the remarkable advancement in the charging network to meet the escalating demand for electric vehicles.

Major Players in EV Charging Station Market

In the EV charging industry, different markets are dominated by different players. Top EV charging networks in Europe include Allego, Enel X, Ionity, Virta, EVBox, and Tesla. In the United States, ChargePoint leads with the most charging stations, followed by Tesla, Electrify America, EVgo, SemaConnect, and Blink.

Tesla has established a significant presence with its widely popular Supercharger network, offering the fastest and smoothest charging experience both in the US and Europe. While initially exclusive to Tesla drivers, Tesla has started to open some Supercharger stations for use by other electric vehicle drivers.

In China, notable names in the charging network sector include Teld, China Southern Power Grid (CSG), and State Grid Corporation of China (SGCC).

Sources: Statzon, IEA, TheHindu.com

A Megawatt Future for HDV Charging Networks

The focus on electrifying transportation has extended beyond personal cars to encompass commercial vehicles, particularly heavy-duty vehicles (HDVs). HDVs, including trucks and buses, play a crucial role in global logistics and public transportation but are also significant contributors to greenhouse gas emissions. In the European Union, HDVs account for 25% of emissions from road transport and more than 6% of total EU greenhouse gas emissions. Globally, the situation is even more concerning, as HDVs are projected to contribute more emissions than light-duty vehicles by 2025.

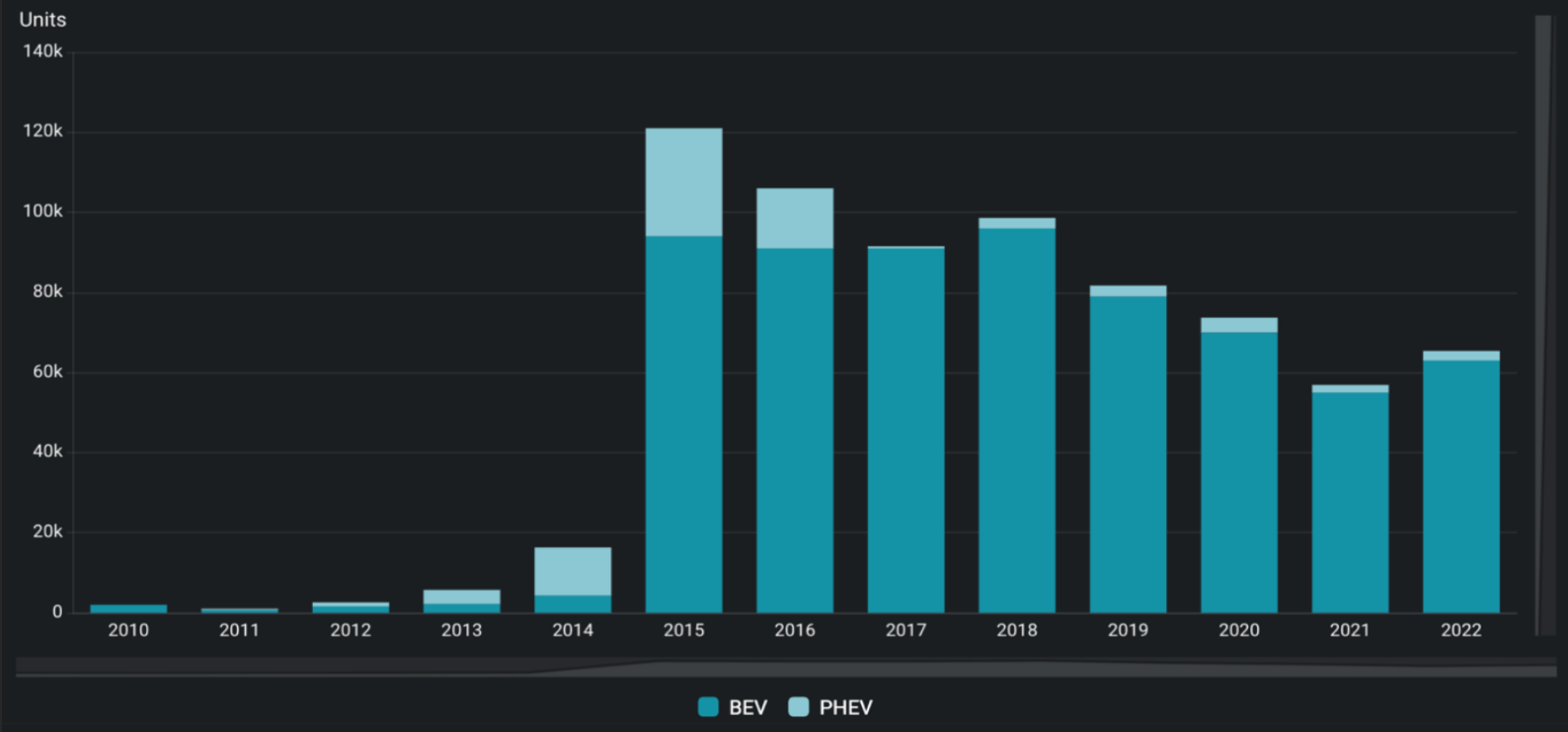
Fluctuated Sales of Electric Heavy-Duty Vehicles (HDVs)

Electric vehicle penetration in the global heavy-duty vehicle (HDV) market has experienced varying trends in recent years. As of 2022, electric HDVs accounted for 2.2% of global new sales, a slight increase from 1.9% in 2021. This follows a peak of 2.7% in 2016, with fluctuations around 2% in the intervening years, as reported by ICCT.

China, initially leading with an 18% electric share in 2016, saw a decline over four years, then a recovery to 12% in 2022. Conversely, Europe has witnessed consistent growth in EV adoption among HDVs, exceeding an average of 2% in 2022, up from 1.4% in the previous year. The UK notably reached a high of 3.3% in 2022, doubling its 2021 figure.

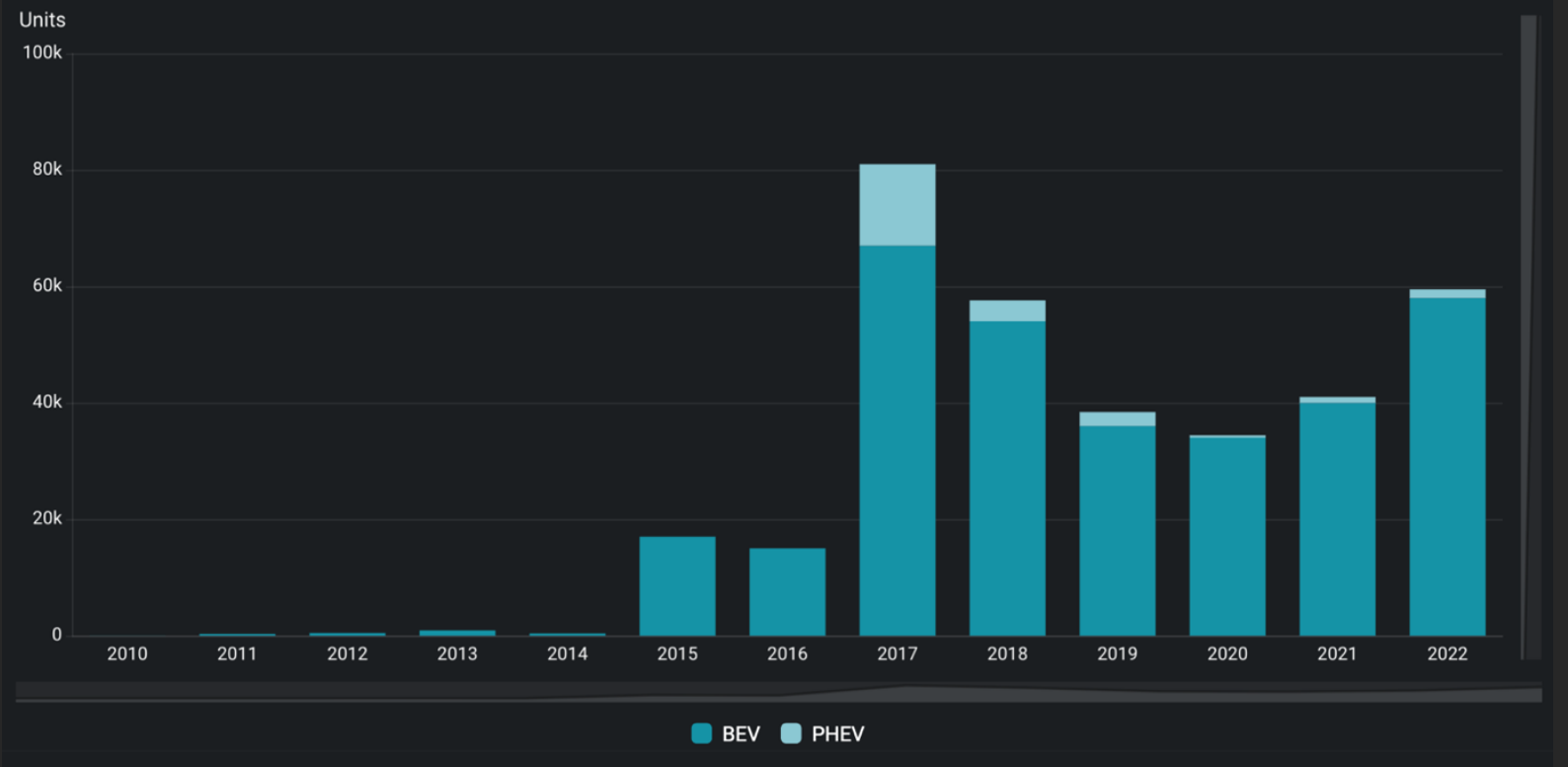
According to the IEA's Global EV Outlook, the 2022 sales figures included around 66,000 electric buses and 60,000 medium- and heavy-duty trucks sold globally, constituting roughly 4.5% of all bus sales and 1.2% of truck sales. China dominates this sector, accounting for 18% and 4% of its total bus and truck sales, respectively, and approximately 80% and 85% of these vehicles' global sales.

World Sales of Electric Buses by Type (Units) (2010-2022)



Source: **Statzon / International Energy Agency (IEA)**

World Sales of Electric Trucks by Type (Units) (2010-2022)



Source: **Statzon / International Energy Agency (IEA)**

Overall, electric truck sales remain low outside China, with cumulative sales in most countries numbering in the hundreds. In 2022, the European Union sold just under 2,000 electric trucks. Sales shares in medium- and heavy-duty segments generally stay below 1%, with some major shipping logistics companies conducting demonstrations of electric trucks for regional and long-haul operations.

The Need for Higher Power Charging System

The acceleration of electric HDVs is primarily hindered by the lack of mid-shift fast charging. According to the IEA STEPS projection, approximately 1.1 million zero-emission trucks and buses, including 130,000 tractor-trailers, are expected on the roads by 2030. These vehicles will rely on a mix of slow overnight charging, offering 50-150 kW, and ultra-fast charging exceeding 1 MW.

Currently, most HDVs use depot charging, with capacities ranging from AC 22 kW to DC 150 kW chargers. However, to match the operational efficiency of diesel trucks and minimize waiting times, faster charging solutions are necessary. Research shows that most DC fast charging stations offer 250-350 kW, but the demands of regional and long-haul trucking in the United States and Europe will require charging powers above 350 kW, potentially up to 1 MW. This need is driven by regulatory break requirements: the European Union mandates a 45-minute break every 4.5 hours, while the U.S. requires a 30-minute break after 8 hours. This context highlights the critical need for advanced charging infrastructure to support the widespread adoption of electric trucks.

ACEA, the European Automobile Manufacturers' Association, believes that some 40,000 to 50,000 high-capacity public charging points will be needed across Europe by 2030 to enable comprehensive electrification of road goods transport.

Development of Megawatt Charging System

Responding to the urgent need for efficient and high-powered charging solutions for electric heavy-duty vehicles, the Megawatt Charging System (MCS) emerges as a game-changer in the industry. Designed to cater to the needs of large battery electric vehicles, the MCS offers an impressive charging rate of 3.75 megawatts (3,000 amps at 1,250 volts DC). Initiated by CharIN in 2018, this innovative system extends its utility beyond just trucks and buses to include marine and aeronautical applications, demonstrating its versatility in a range of high-power charging scenarios.

In parallel to MCS, the ChaoJi charging project, initiated by the CHAdeMO Association and the China Electricity Council, has developed its own ultra-high-power standard, known as CHAdeMO 3.0. ChaoJi is designed to charge electric vehicles at up to 900 kilowatts, showcasing a significant presence and influence in the Chinese market. While MCS is focused on a broad range of heavy-duty applications with a higher power output, ChaoJi emphasizes compatibility with existing Chinese and global charging standards, indicating a more region-specific approach.

Megawatt charging

High-power standards in development

Standard name	Organizations in charge	Market	Max voltage and amperage
ChaoJi	China electricity council and CHAdeMO	First used in China and Japan	1,500V and 600A
MegaWatt charging system (MCS) CharIN	Industry task force set up by CharIN	Europe and North America	3.75MW

Source: ICCT (International Council on Clean Transportation)

MCS distinguishes itself by offering a charging potential significantly greater than the current Combined Charging System (CCS), making it particularly suitable for time-sensitive operations. It is designed to align with the operational constraints of long-haul trucks and other commercial vehicles, ensuring minimal downtime. This feature is especially relevant in the European context, where a 45-minute mandatory break for drivers can be efficiently utilized for charging. Beyond just speed, MCS is also focused on enhancing the reliability of charging through improved communication systems, aiming to minimize the frequency of unsuccessful charging events.

The realization of MCS, however, presents notable challenges, primarily in terms of the required investment for the establishment of 1 MW charging stations. These stations will demand substantial infrastructure upgrades and installations, as well as innovative solutions like on-site energy storage and solar integration to manage high energy demands. Planning for these high-power charging stations, particularly along busy highways, involves considerations for additional space to

accommodate the extended charging duration of larger vehicles. The commercial rollout of this ultra-power charging system is expected in 2024.

Megawatt Charging Stations Project

The EU’s Charging Infrastructure Masterplan highlights the growing need for such infrastructure. By 2030, it is estimated that trucks will require 279,000 charging points, with 84% of these in fleet hubs. The remaining will be fast-charging points along highways and public overnight charging points. For buses, about 56,000 charging points will be needed, with the majority again in fleet hubs. The MCS, with its high average charging speeds of 700 to 800 kW for trucks and buses, is anticipated to become the industry standard for fast public charging for commercial vehicles (CVs) by 2025. This shift could potentially reduce the number of public charging stations by around 70%, as MCS chargers would offer faster charging and higher utilization rates.

Recent developments in MCS infrastructure further highlight its potential. Scania successfully tested an MCS from ABB E-Mobility with a next-generation electric truck, marking a critical step towards the future deployment of high-power chargers. The trial aims to demonstrate the technical feasibility of MCS, with ABB E-Mobility planning to launch the next version of the MCS technology in late 2024 or early 2025. Scania, targeting that 50% of all vehicles it sells annually by 2030 will be electric, sees MCS as a critical piece of the puzzle for future infrastructure. Notably, MCS is designed for a charging voltage of up to 1,250 volts and a current of 3,000 amperes, equating to a charging power of up to 3.75 megawatts. The standardized position of the charging port on vehicles is intended to simplify the layout of megawatt charging parks.

Scania's recent successful test of ABB E-Mobility's MCS with a next-generation electric truck is a notable step in high-power charger deployment. Aiming for a late 2024 or early 2025 launch, this trial underscores the technical feasibility of MCS, aligning with Scania’s goal for 50% electric vehicle sales by 2030. Building on this momentum, companies like Kempower are also making significant strides in the MCS arena.

Kempower's development focuses on a system that combines two 600 kW units for a 1.2 MW output, with a European launch targeted for early 2024. This initiative showcases the broader industry movement towards standardizing high-power charging solutions. In a similar vein, Tesla is pushing the boundaries of charging technology in the consumer EV market.

Tesla's integration of 1 MW ultra-fast charging technology into its Cybertruck and Semi demonstrates the crossover potential of these innovations. Featuring new "immersion cooling technology," this advancement is set to enhance Tesla's Supercharger network, significantly expanding high-power charging capabilities for a wider range of electric vehicles.

Swiss company, Designwerk, is joining the bandwagon with one of the latest MCS projects to date. The new “mega charging station”, as Designwerk refers to it in the announcement, relies on the latest Megawatt Charging System (MCS) standard. Buffer batteries, integrated into a large container, shall avoid peak loads and guarantee continuous megawatt charging. The 25-ton container contains batteries worth 1,800 kWh, coming from new productions or second-life projects. The unit connects to the power grid via CEE 125. The MCS output can deliver up to 2,100 kW of charging power (up to

3,000 amps at 500 to 900 volts). The charging system is designed for a charging voltage of up to 1,250 volts and a current of 3,000 amperes, which theoretically corresponds to a charging capacity of up to 3.75 megawatts.

What Would Happen to Hydrogen Trucks?

While megawatt charging presents significant advancements for battery electric heavy-duty vehicles (BEVs), its impact on hydrogen fuel cell trucks (FCEVs) market is a growing debate. MCS's capacity to potentially reduce charging times for BEVs to as low as 12 to 15 minutes is revolutionizing the field, offering a viable alternative to the traditionally favored hydrogen trucks for their long-range capabilities and fast refueling times.

In terms of range and efficiency, while FCEVs can offer up to 1000 km with liquid hydrogen storage and a longer fuel cell lifespan of up to 30,000 hours, BEVs are rapidly closing this gap with technological advancements. The cost comparison between these two types of vehicles also plays a crucial role, with battery electric trucks priced between USD 188,000 to USD 250,000 and fuel-cell trucks ranging from USD 240,000 to USD 288,000. The MCS, exceeding the current maximum capacity of 500 kilowatts by the Combined Charging System (CCS), is particularly crucial for long-haul electric trucks that require a charging power of 550 to 1,000 kilowatts within a legally mandated 45-minute break.

Experts have suggested that the advancements in BEV technology might diminish the need for hydrogen trucks. FCEVs, despite their benefits, face challenges such as lower efficiency and higher operational costs per mile compared to BEVs. The choice between BEVs and FCEVs will likely hinge on the specific requirements of the trucking industry and the evolving capabilities of these technologies, especially as advancements in battery technology continue to progress.

Building Electric Truck Charging Networks

The development of charging infrastructure for HDVs is a complex and costly endeavor, projected to require an investment of around USD 450 billion by 2040. This investment is primarily driven by the need to support the growing fleet of BEV and FCEV trucks, with a significant portion likely allocated to China due to its large truck fleet. The roll-out of this infrastructure is crucial, as it directly impacts the operational efficiency and viability of HDVs.

Megawatt charging

2022 cost estimates for four different speeds of public chargers

Public charger power	Upfront costs	Maintenance costs
Public 50 kW DC	€44,700	€340/year
Public 150 kW DC	€91,700	€840/year
Public 350 kW DC	€231,700	€2,040/year
Public 1 MW DC	€615,800	€5,300/year

Source: ICCT (International Council on Clean Transportation)

In regions like the European Union, there is a concerted effort to build robust charging infrastructure, especially for trucks needing a minimum of 350 kW. Supported by initiatives like the Connecting Europe Facility (CEF), the EU aims to deploy charging stations along key freight transport corridors. The Trans-European Transport Network (TEN-T) regulation further mandates the installation of charging stations for cars, vans, and trucks every 60 km on core networks by 2025, expanding to comprehensive networks by 2030. This structured approach is designed to integrate electric HDVs seamlessly into the EU's transportation ecosystem.

The Fraunhofer Institute's study, conducted for ACEA, used GPS data from trucks operating across the EU to pinpoint critical truck stops for electric charging infrastructure. It revealed that just 10% of these stops see half of all truck visits, suggesting these locations as priorities for installing electric chargers. ACEA recommends these key stops be equipped with chargers by 2027. The study also categorized stops into short and long durations, affecting the type of charging solutions needed, such as the power output and charging time.

ACEA is also advocating for dedicated and ambitious targets for truck-specific infrastructure in each EU member state. The identified locations for the charging infrastructure rollout are evaluated based on criteria like available grid power and existing local initiatives. This study, one of the largest analyses of real-world data, examined around 30,000 aggregated truck stop locations based on the logistics activity of 400,000 trucks over a year.

Contrastingly, China's strategy for electrifying its HDV fleet is a bit different, focusing less on traditional charging infrastructure and more on battery swapping as a viable alternative. Despite having over 5 million public charging stations for electric cars, China does not have national plans for similar infrastructure for HDVs on highways. Instead, battery swapping is seen as a fast track to deployment due to its advantages like shorter charging times and guaranteed battery lifecycles. The process can be completed in as little as 2-5 minutes, with batteries maintained by professionals to optimize operation for health and safety. This approach not only extends battery lifespan but also reduces costs and increases efficiency.

However, the lack of standardization in battery swapping, primarily because OEMs prefer to operate these services independently, poses challenges for the deployment of public battery swapping stations. They tend to be expensive, non-interoperable, and tailor-made for specific sites or routes. This model is mostly feasible for specific industries, such as waste collection, mine shuttles, and industrial transport, where the operational cost advantages and environmental mandates drive the adoption of electric trucks.

Sources: Statzon, ICCT report Charging Solutions for Batter Electric Truck, world-energy, SAE (1), SAE (2), IEA Global EV Outlook 2023, Milence, chargedevs, Transport Topics, ACEA European EV Charging Infrastructure Masterplan, ACEA, electrive (1), electrice (2), electreck, intertraffic

Wireless EV Charging Market Charges Forward at 55.6% CAGR

Wireless charging is elevating electric mobility (e-mobility) to new heights, revolutionizing electric vehicle (EV) ownership by making recharging effortless and seamlessly integrated into daily life. Unlike conventional wired connections, wireless charging significantly amplifies the convenience, efficiency, and appeal of e-mobility for both individual drivers and vehicle fleets.

How does Wireless EV Charging Work?

At its core, wireless charging for electric vehicles eliminates the need for physical cables and plugs to recharge an electric vehicle. Instead, it operates on the principle of electromagnetic fields, enabling the transfer of energy between a ground-based charging pad (or one embedded in the ground) and a corresponding receiver positioned beneath the vehicle. To initiate charging, the vehicle simply needs to be parked over the charging pad, and the energy transfer occurs through the air. This innovative technology streamlines the charging process by eliminating the need for manual plugging and unplugging, creating a smoother and more user-friendly experience. However, it's important to note that current implementations often require the installation of fixed charging pads at designated locations.

The potential benefits of wireless charging are impressive. In theory, this technology could lead to reduced maintenance costs and a more efficient charging experience. Yet, its present cost remains higher compared to conventional cable-based solutions. However, industry players are betting on scaling up production to drive down costs in the near future. Additionally, the challenge of standardization has been a hurdle to its widespread adoption in the mass market.

Despite these challenges, automakers are firmly committed to exploring the potential of wireless charging. Tesla, for instance, has showcased its interest in this technology through its acquisition of the German inductive-charging company, Wiferion. In a similar vein, Hyundai's Genesis is conducting real-world tests with 23 wireless charging pads in South Korea. Meanwhile, Volkswagen is pushing the boundaries by aiming for 300-kilowatt wireless charging in trials at its innovation hub in Knoxville, Tennessee.

Empowering Dynamic Charging with Wireless EV Charging Roads

Charging stationary EVs without a plug is a step forward, yet dynamic induction charging takes it even further. This entails embedding charging coils into the road, making it a wireless EV charging road, enabling cars to charge while in motion Carmakers are enthusiastic about testing this advanced technology.

Current wireless charging roads are still quite short in distance and targeted for short-distance travel vehicles such as shuttle services around a facility or public transport uses such as the one in Gumi, South Korea. Similar test areas for electric roads are also limited in length, such as the 4 km route established in 2020 from Visby to the airport in Sweden's Gotland County.

However, Sweden is embarking on the creation of what they term a "permanent e-motorway." This road, set to be built by 2025 along the E20 route, marks the initial phase of a broader strategy aiming to electrify over 3,000 kilometers of Swedish roads.

Global Market Overview for Wireless EV Charging

The wireless EV charging market was valued at USD 13.1 million in 2022 and is expected to reach USD 567.7 million by 2030, with a CAGR of 55.6% from 2023 to 2030, based on a market report from Next Move Strategy Consulting.

The wireless electric vehicle charging market is hindered by slower charging rates and higher technology costs compared to traditional cable chargers. Furthermore, wireless charging devices are subject to distance constraints.

The Asia-Pacific (APAC) region is set to lead this growth trajectory, contributing significantly with a value of USD 6.8 billion in 2022. By the year 2030, it is expected to surge to an impressive USD 218.9 billion, reflecting a remarkable compound annual growth rate (CAGR) of 49.8% from 2023 to 2030.

China leads both the APAC and global markets, holding approximately 38% of the total market share. Chinese firms have outpaced their global counterparts in patent applications for EV charging and battery swapping, submitting 41,011 patents from 2010 to 2022. Despite limited individual rankings, the collective efforts of Chinese companies resulted in almost 50% more applications than Japanese firms, which came in second with 26,962.

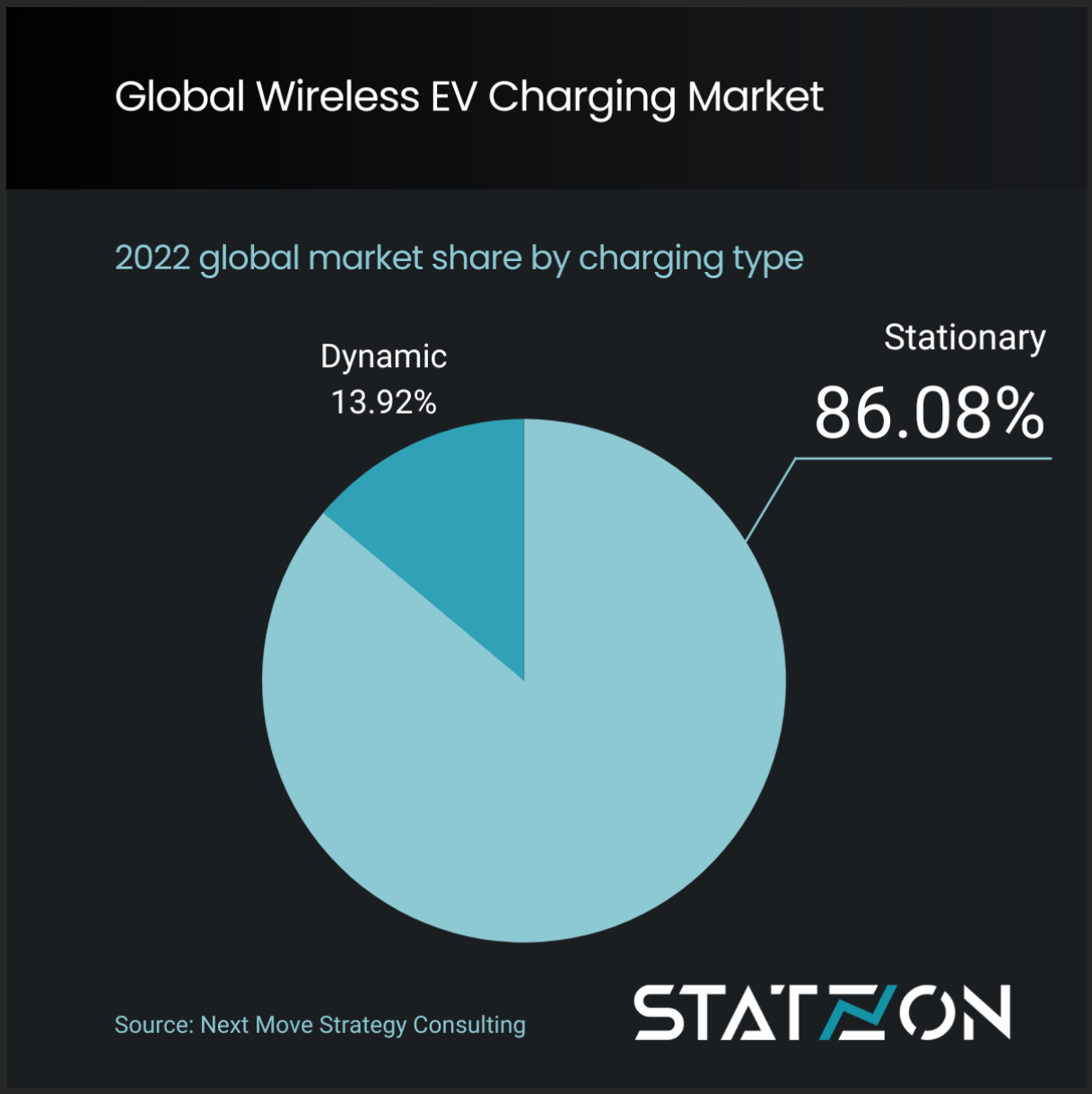
Shifting the focus back to the regional markets, Europe claims the second position, even though its market value in 2022 was notably smaller (at USD 3.9 billion) compared to APAC. However, the European market's growth outpaces that of APAC, with a robust CAGR of 59.4%. Meanwhile, the North American market is projected to experience even more accelerated growth, targeting a CAGR of 62.1%.

Wireless EV Charging Market Segmented by Charging Type

The stationary wireless charging segment is currently at the forefront of the market with a market value of USD 11.3 billion in 2022. Predictions indicate it will escalate to USD 457 billion by 2030, showcasing a noteworthy 54.3% CAGR between 2023 and 2030. Meanwhile, a significant number of advancements are underway in the development of dynamic wireless charging systems. This segment's growth outpaces that of the stationary category. In 2022, the dynamic charging segment reached a valuation of USD 1.8 billion and is on track to achieve USD 110 billion by 2030. This progress is characterized by the highest CAGR of 62.1%.

Israeli wireless charging startup Electreon has captured attention by achieving an impressive feat: driving a hybrid RAV4 with an 18 kWh battery non-stop for an astounding 1,942 km over 100 hours. Although conducted on Electreon's 200m test track, this accomplishment directly addresses crucial challenges in EV adoption, notably range anxiety and battery capacity limitations.

The wireless EV charging technology showcased a remarkable extension, surpassing the current real-world maximum EV range by at least 26 times. The 18 kWh battery was never fully depleted, as the electric road continuously charged the vehicle while it circled the track. This record-setting demonstration not only underlines the robust potential of wireless charging but also highlights its seamless adaptability. Even with just 25% of the track electrified, this technology offers an endless range for any EV. This shared charging platform accommodates multiple users simultaneously, spanning from small passenger vehicles to large e-trucks, while remaining adaptable to various battery technologies.



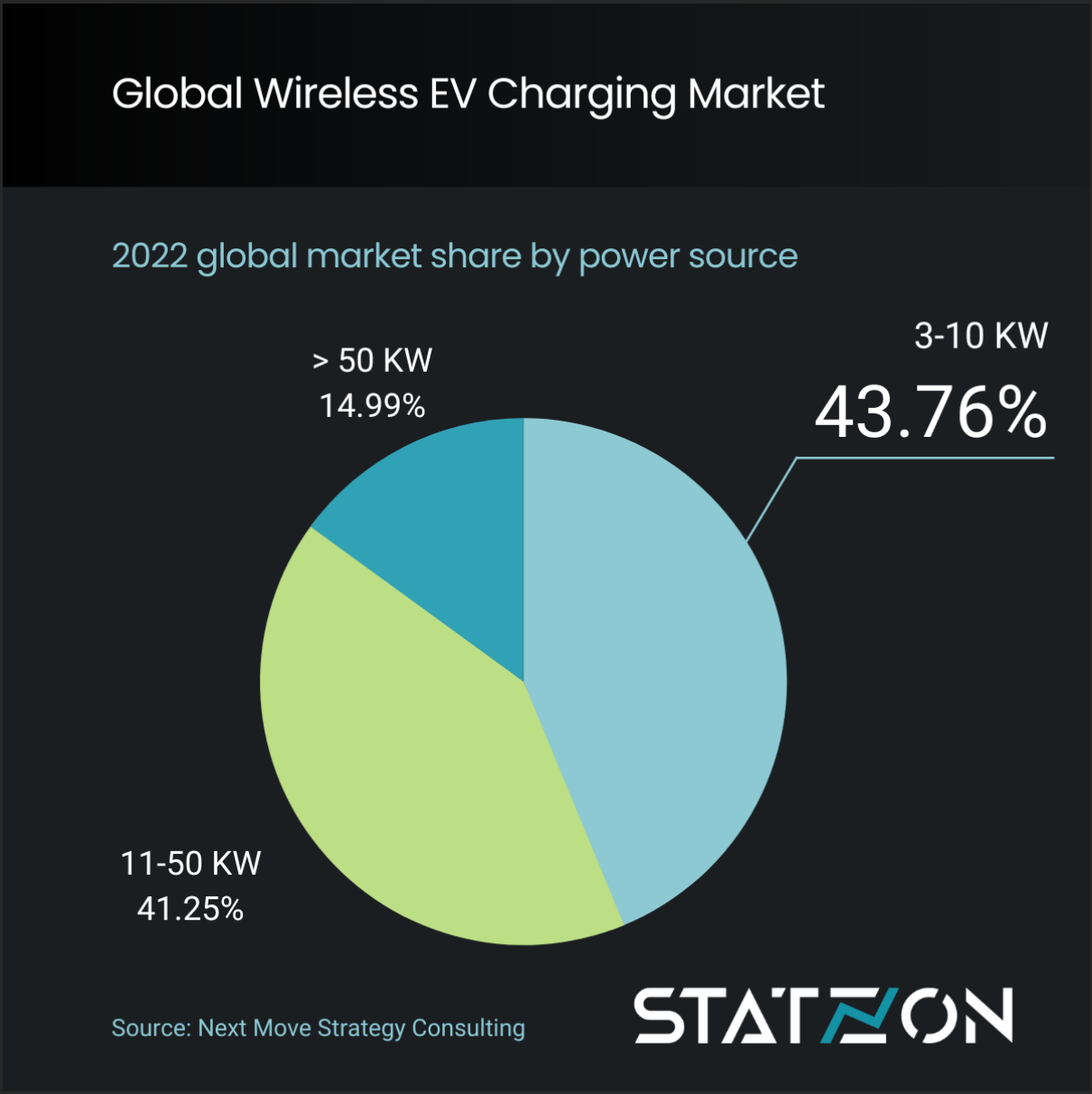
Wireless EV Charging Market Segmented by Power Supply

Based on power supply, the market is segmented into 3–10 KW, 11–50 KW, and more than 50 KW.

The 3–10 KW segment held a major market share in 2022 with a market value of USD 5.7 billion, growing at a CAGR of 57.4% to reach USD 21.9 billion by 2030.

The 11–50 KW power supply segment came close in second position, contributing USD 5.4 billion to the total market. This growth of this segment is predicted to take over the 3-10 KW leadership position as it will reach USD 24.6 billion by 2030.

Over 50 KW is the smallest segment among all, contributing to the market a market value worth USD 1.9 billion in 2022.



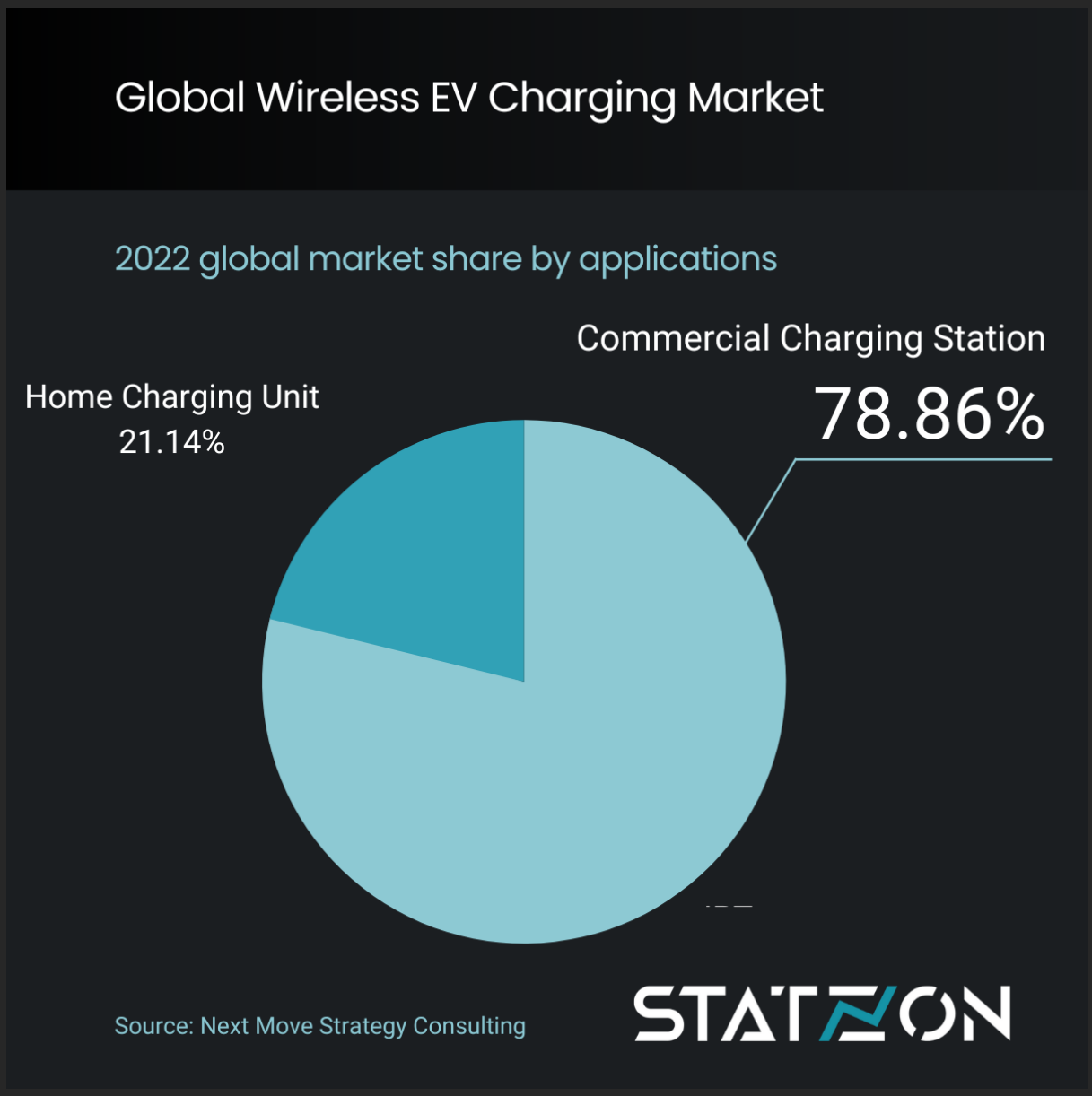
Wireless EV Charging Market Segmented by Application

Based on application, the wireless charging for electric vehicle market is segmented into commercial charging stations and home charging units.

The commercial charging station sector is poised to experience an impressive CAGR of over 57.4%. This growth is driven by the increasing necessity to establish EV charging infrastructure in public spaces, the surging demand for commercial wireless charging systems in China, and the widespread

adoption of such systems in Europe. The rapid expansion of this segment is heavily influenced by the prevalence of large commercial garage parking facilities and densely populated urban regions.

Commercial charging units gained USD 10.7 billion while the home charging segment gained USD 2.8 billion in 2022 with a slightly lower CAGR of 55%



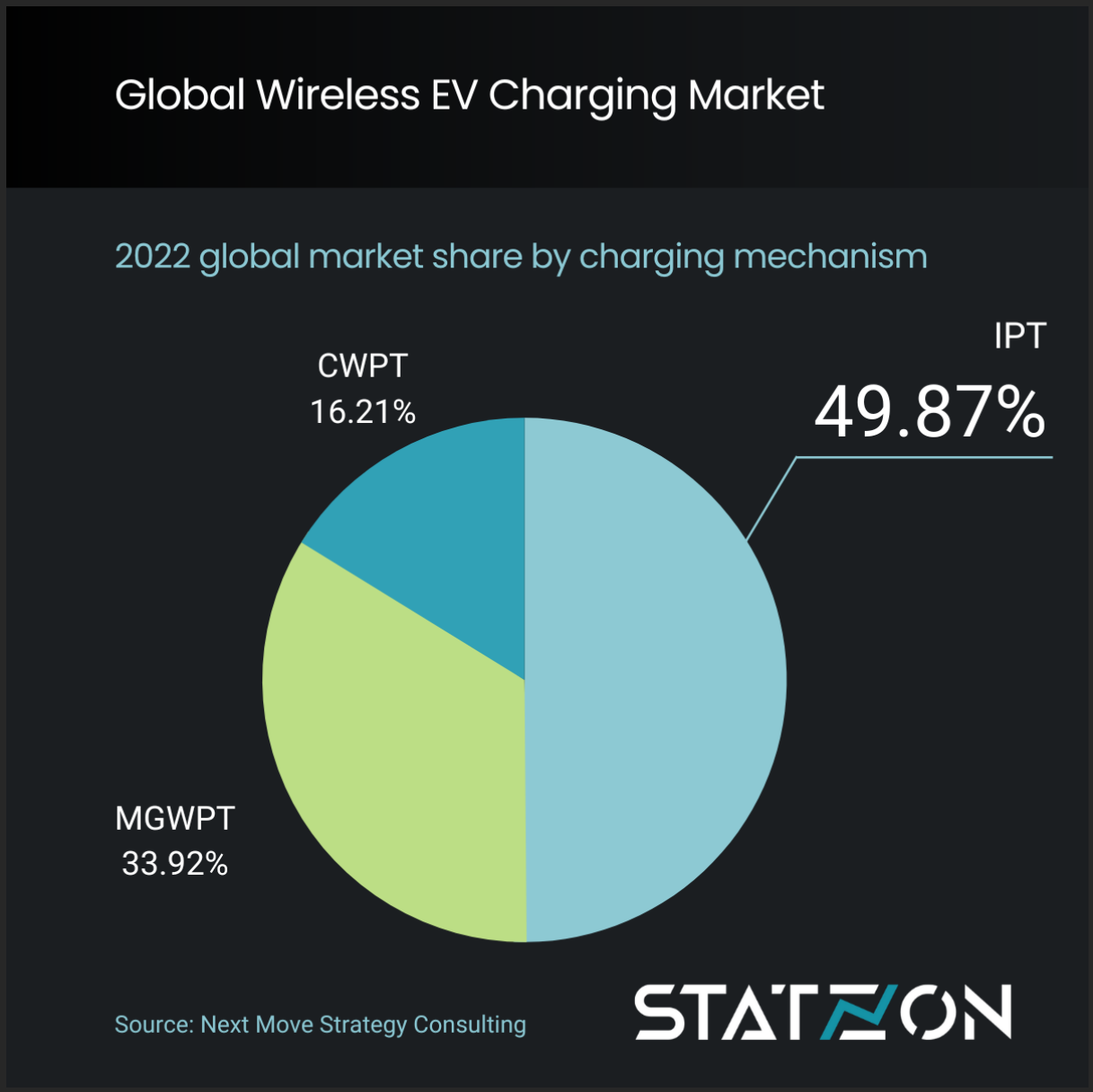
Wireless EV Charging Market Segmented by Charging Mechanism

Based on the charging mechanism, the market is classified into Inductive Power Transfer (IPT), Magnetic Gear Wireless Power Transfer (MGWPT), and Capacitive Wireless Power Transfer (CWPT).

IPT segment is the highest contributor to this market with a market value of USD 6.5 billion in 2022, and is anticipated to reach USD 247 billion by 2030, registering a CAGR of 52.91%. Similarly, the Magnetic Gear Wireless Power Transfer segment, currently at USD 4.4 billion, is projected to reach USD 206.2 billion by 2030. The CWPT segment, which stood at USD 2.1 billion in 2022, is anticipated to reach USD 114 billion by 2030 with the highest CAGR of 59.9%.

The IPT segment takes the lead in this market, starting at USD 6.5 billion in 2022 and is expected to hit USD 247 billion by 2030, showcasing a 52.91% CAGR. Similarly, the MGWPT segment, valued at USD 4.4 billion for the same year, is projected to reach USD 206.2 billion by 2030. The CWPT segment is the smallest in the market, stood at USD 2.1 billion in 2022 and is set to reach USD 114 billion by 2030, boasting the highest CAGR of 59.9%.

IPT and MGWPT segments collectively accounted for about 83.9% share of the global wireless EV charging market in 2022, with the former constituting around 49.9% share.



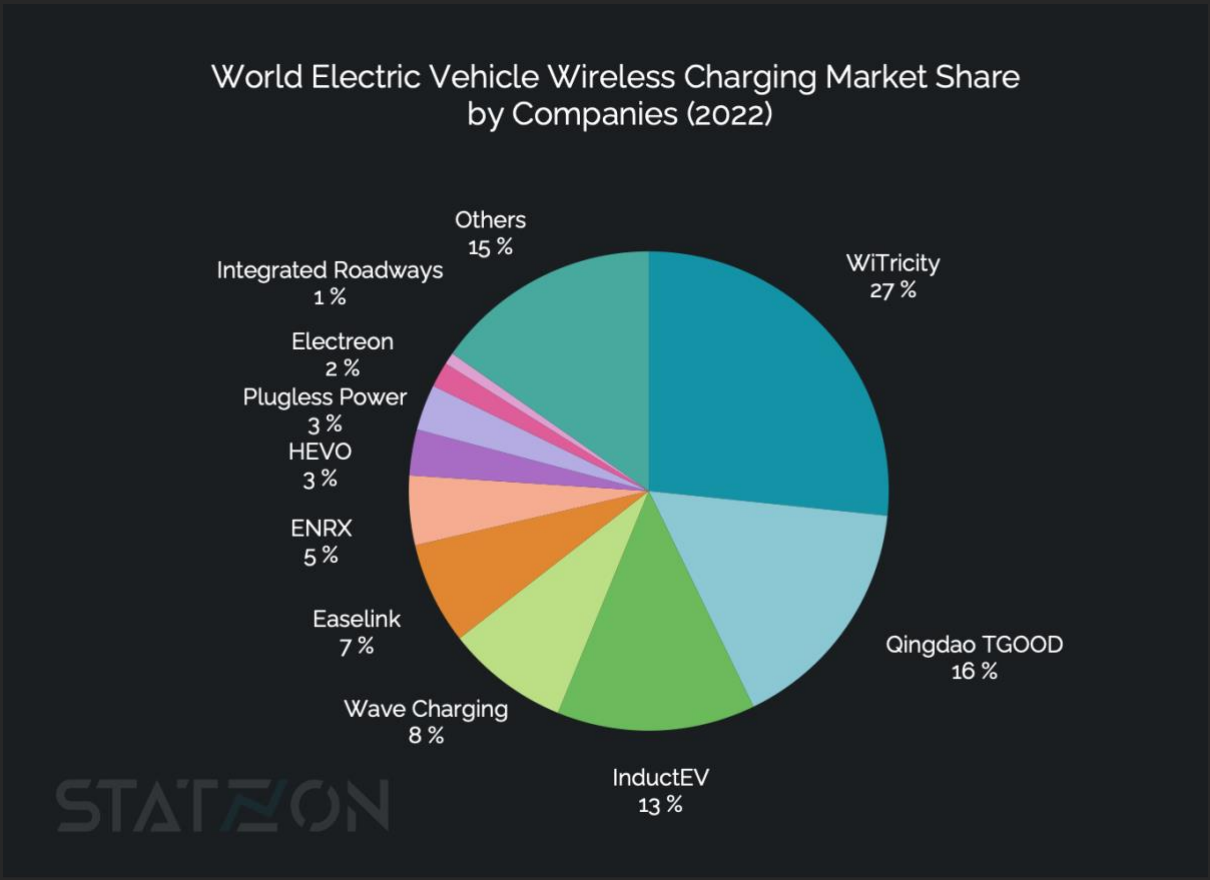
Top Wireless EV Charging Companies

The market for wireless EV charging is dominated by start-ups and more established companies.

Established in 2007, WiTricity has spent over a decade refining its magnetic resonance wireless technology, emerging as a vital player in the EV stationary wireless charging sector. As a spin-off from MIT, they've leveraged licensed MIT intellectual property to advance their innovations.

Similarly, Plugless Power played a pioneering role in promoting wireless concept throughout the 2010s. Another notable contender is InductEV, recognized for its wireless EV charging solutions tailored to accommodate trucks, buses, and other electric commercial vehicles.

Based on Next Move Strategy Consulting calculations, WiTricity has the biggest slice of the market pie, with a 26% share of the total market. The Chinese company, QingDao TGOOD is in the second position with a 17% share while InductEV is in the third position with 13%.



Source: Next Move Strategy Consulting

Sources: Statzon, Next Move Strategy Consulting market report on Wireless EV Charging, Bloomberg, Business Insider, Korea Herald, Euronews, Nikkei Asia

E-Mobility Europe: An Overview of Europe's Latest Electric Vehicles Data

Global EV Market 2023

In 2023, the global market for electric vehicles (EVs) saw an expansion, reaching 14.2 million new deliveries of Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs), a 35% increase from the previous year but slower than the 55% rise in 2022.

Out of these, 10 million were BEVs, while 4.2 million included PHEVs and Range Extender EVs (EREVs).

China remained the largest EV market worldwide, with sales topping two million in Q4 of 2023 alone. However, China's BEV growth decelerated to 24%, a sharp drop from 172% in 2021 and 85% in 2022, mainly due to an economic slowdown.

The US and Canada saw significant BEV growth, with a 46% year-on-year increase. Notably, the US crossed the threshold of 1 million BEVs sold by the end of 2023.

Yet, not every region saw positive trends. Germany, at the forefront of Europe's EV market, witnessed a fall in sales and market share, attributed to major cuts in EV incentives, contrasting with the steady increases in other areas throughout the year.

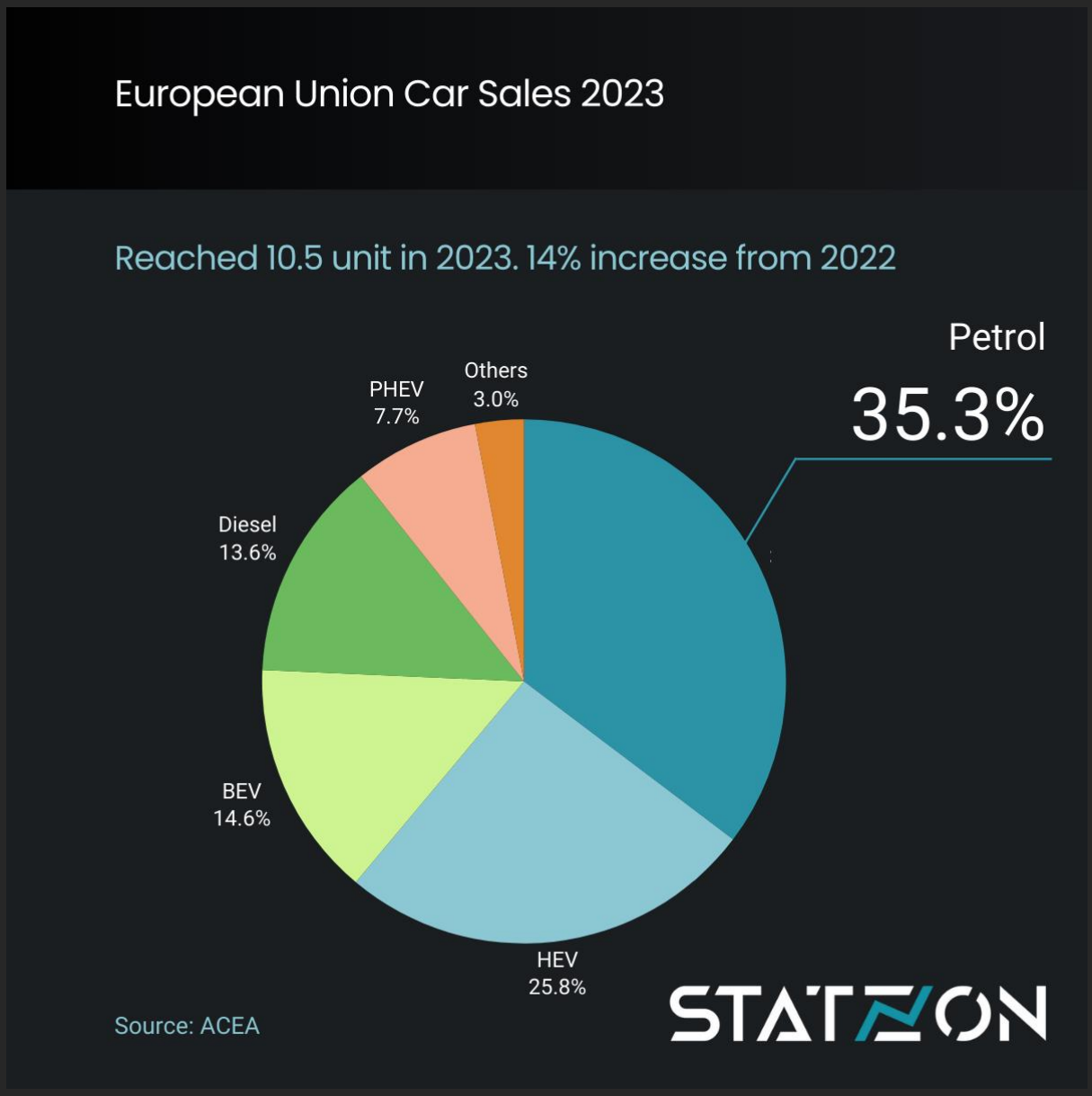
Beyond these major markets, EV sales in other regions jumped by 81%, starting from a smaller base.

Europe EV Sales 2023

2023 was a good year for the car industry in Europe, with the European Automobile Manufacturers Association (ACEA) reporting that car sales in the European Union increased by almost 14%, reaching over 10.5 million new registrations. This was the highest number of new car registrations in Europe since before the pandemic.

In 2023, battery-electric (BEV) models became the third most popular type of car for buyers, overtaking diesel cars for the first time. BEV sales increased by 37%, taking up a 14.6% market share (up from 12.1% in 2022) with over 1.5 million units sold during the year. By 2025, BEV sales are expected to surpass those of ICE vehicles in Europe.

Meanwhile, Plug-in Hybrid Electric Vehicles (PHEVs) had a 7.7% market share (down from 9.4% in 2022).



The ratio of BEV to PHEV sales shows how the electric vehicle market is changing. BEVs made up 67% of all EV (BEV + PHEV) sales, while PHEVs made up 33%, showing a decrease in the popularity of plug-in hybrids. This change is more noticeable compared to the previous years; PHEVs accounted for 46% of the plugin market in 2021, which fell to 39% in 2022 and then to 33% in 2023.

The cumulative stock of electric vehicles in the EU reflects this growth, with BEVs reaching a total of 4.7 million units and PHEVs at 3.4 million units.

Despite the overall positive trajectory, December 2023 presented significant challenges, particularly in Germany, Europe's largest car market. A dramatic decrease in EV sales occurred, led by a sharp reduction in new electric vehicle registrations, marking the first downturn in new EV sales in the EU since early 2020. The sudden cut in EV subsidies in Germany, just two weeks before the year's end, led to a near standstill in sales as consumers and dealers navigated the new landscape.

As a consequence, December saw a historic decline in Europe's passenger plugin electric car market, recording only 294,200 registrations compared to 413,500 in the same month

the previous year. This 29% year-on-year drop represents the most severe decline witnessed in over a decade, affecting sales of both plugin hybrid and battery electric vehicles.

Nevertheless, 2023 ended with higher sales than the previous year. To overcome the drop in December, many car makers cut prices and offered other incentives, which helped sales start to increase again by January.

Europe Best-Selling Electric Cars 2023

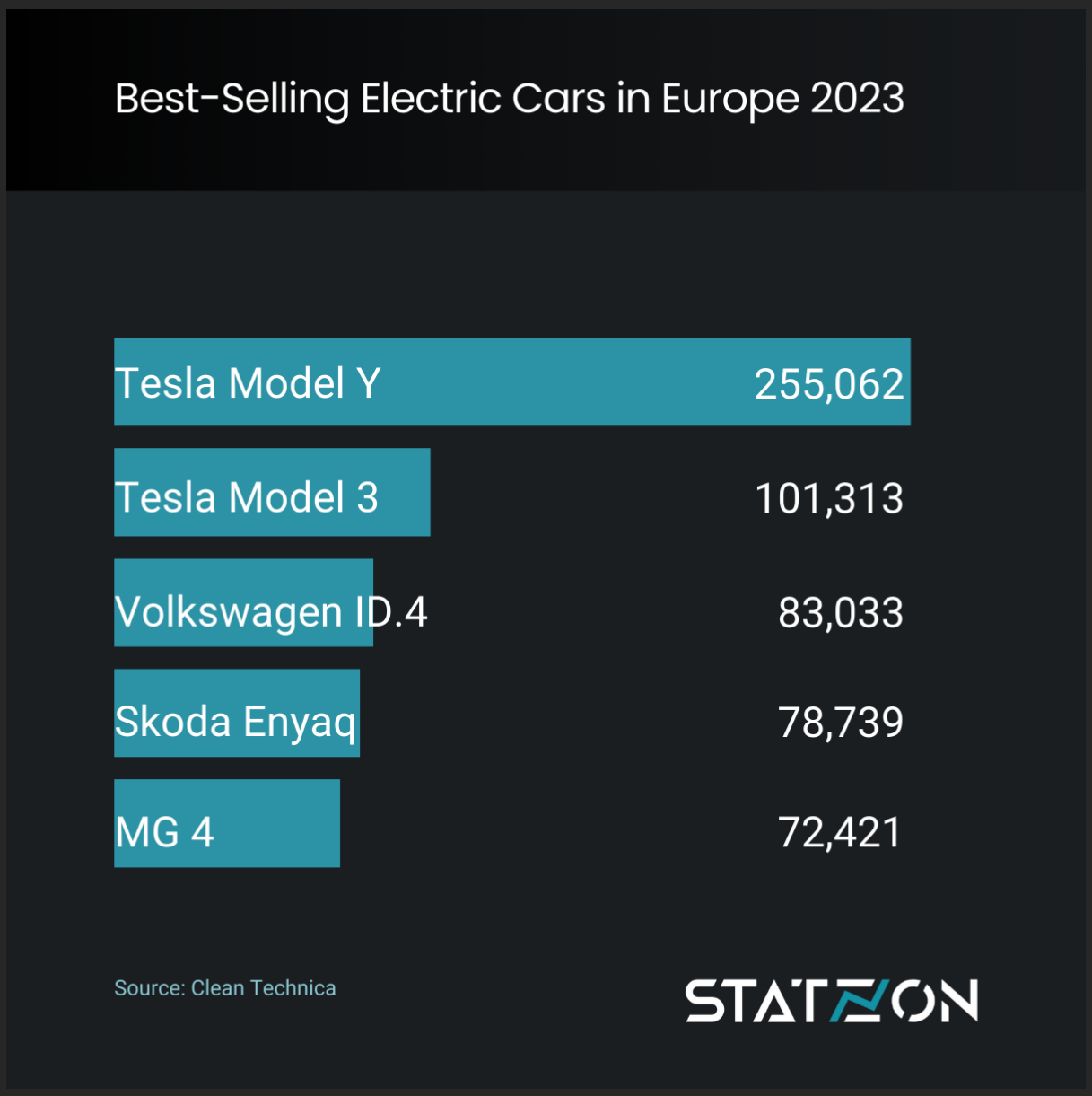
Tesla has made a significant impression on Europe's electric vehicle market in 2023, with the Model Y leading as the best-selling car. It not only topped electric vehicle sales but also overtook all car categories to become the best-selling car overall in Europe, with registrations exceeding 250,000 units. This signifies the first time an electric model, especially one from a non-European make, has led the European car sales.

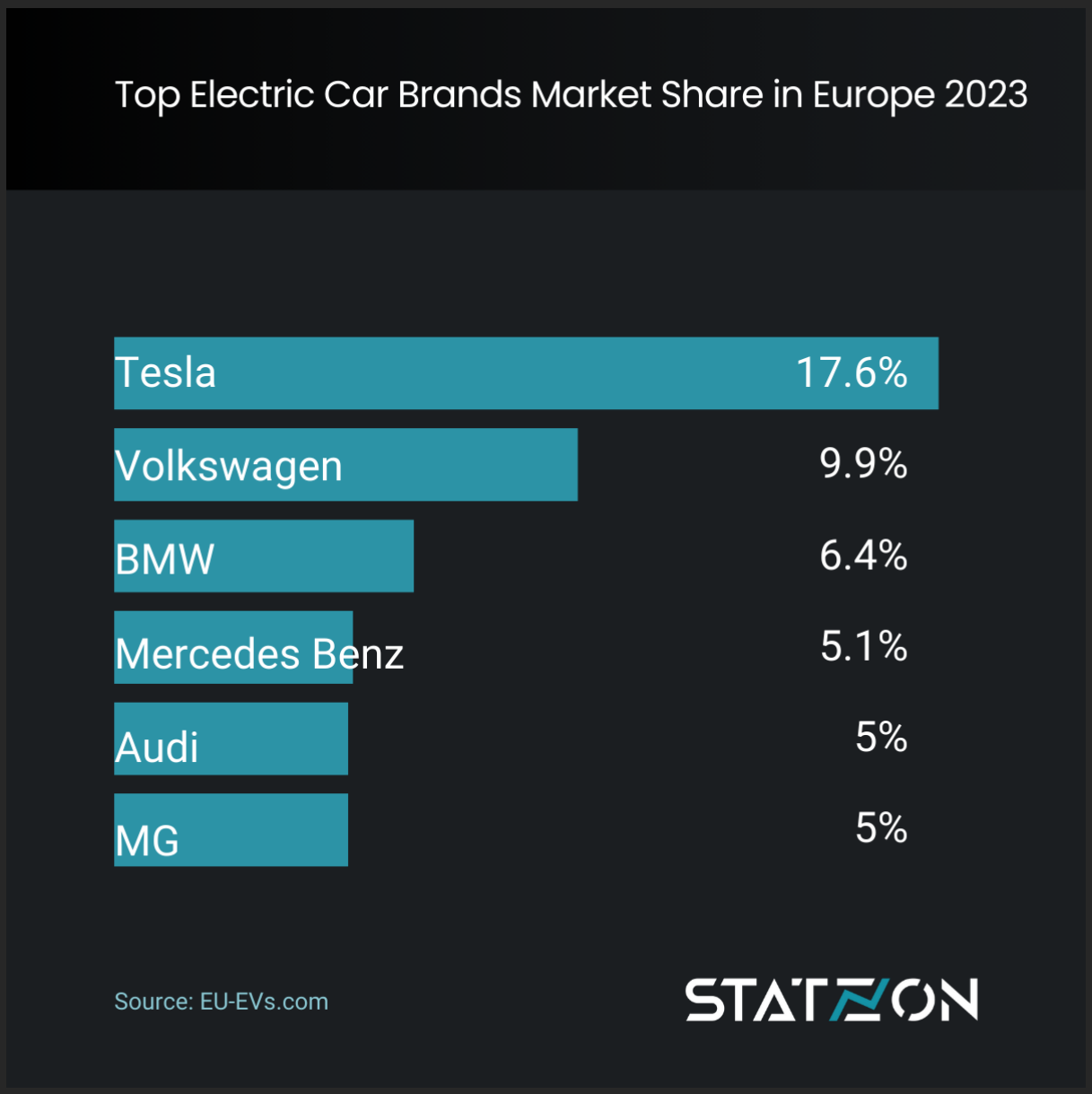
Tesla Model 3 came in as the second most popular electric vehicle in Europe, with sales reaching approximately 101,000 units. Tesla dominated various European markets in 2023 as the company is evidently the main driver behind a continuous increase in electric vehicle market share on the continent. The significant price cuts introduced by Tesla at the beginning of 2023 played a crucial role in boosting the sales of both models, maintaining their momentum into the current year.

Volkswagen's ID.4 trailed as the third best-selling electric model, with over 83,000 units sold, while Skoda’s Enyaq and the Volvo XC40 (which combines BEV and PHEV sales) were also among the top choices, with 78,739 and 73,650 units sold respectively. Coming in next, the MG 4 saw over 72,000 units sold and the Audi Q4 was close behind with sales nearing 70,000 units.

Meanwhile, the Ford Kuga emerged as the top-selling PHEV in Europe last year, achieving sales of over 52,000 units, with the Volvo XC40 PHEV coming in second, having sold more than 28,000 units.

In terms of brands’ market share, Tesla's dominance is further emphasized. The automaker claimed 17.6% of the market, overshadowing Volkswagen's 9.9% share. BMW came in third with 6.4% followed by Mercedez-Benz, Audi, and MG, each with a 5% market share.


Best-Selling Electric Cars in Europe 2023
Tesla Model Y
255,062
Tesla Model 3
101,313
Volkswagen ID.4
83,033
Skoda Enyaq
78,739
MG 4
72,421
Source: Clean Technica
STATZON



Which Countries in Europe Have the Most Electric Cars?

Germany, France, and the United Kingdom consistently rank as the top three EV markets in Europe.

Germany leads the pack, despite the government ending its electric car subsidy program in December 2023. This cessation led to a loss of up to 3,000 euros in government incentives per vehicle and a significant 47.6% drop in EV sales from the previous December. Nevertheless, BEV adoption in Germany continued to grow, with a 12% increase from 2022 and BEVs capturing an 18.3% market share—though PHEV saw a decrease from 13.6% to

6.2% market share. In 2023, Germany registered over 520,000 BEVs and 173,000 PHEVs, bringing the total to 1.4 million BEVs and 1 million PHEVs on German roads.

In France, BEV sales jumped by 46% and PHEV sales by 28% in 2023, with the total electric vehicle market growing by 39%. Registration data for 2023 indicates nearly 700,000 new BEVs and 170,000 new PHEVs. Overall, France has the second-largest fleet of electric vehicles in Europe, with 1 million BEVs and 570,000 PHEVs.

The UK holds the third spot, nearing 1 million BEVs and approximately 560,000 PHEVs. The UK has implemented the new Zero-Emission Vehicle (ZEV) Mandate starting in 2024, which requires car manufacturers to sell a certain percentage of zero-emission vehicles, starting at 22% of new registrations in 2024 and increasing annually to 80% by 2030 and 100% by 2035. In 2023, the UK saw a 17.8% year-on-year increase in BEV registrations, totaling over 314,000 units, while PHEVs expanded their market share from 6.3% in 2022 to 7.4% in 2023, with more than 142,000 new registrations.

And then, of course, there's Norway, a country renowned for its successful penetration of electric cars.

In 2023, the country saw a 27.2% reduction in its overall passenger car market from the year prior. Of the 126,953 new passenger cars registered, 103,946 were BEVs and 10,169 were plug-in hybrids (PHEVs), making BEVs 82% of all car registrations in Norway—the highest rate globally. Despite the downturn, the BEV segment witnessed a slightly smaller decrease of 24.4%, and PHEV sales dropped by 25%, reflecting a significant downturn in Norway's automotive market.

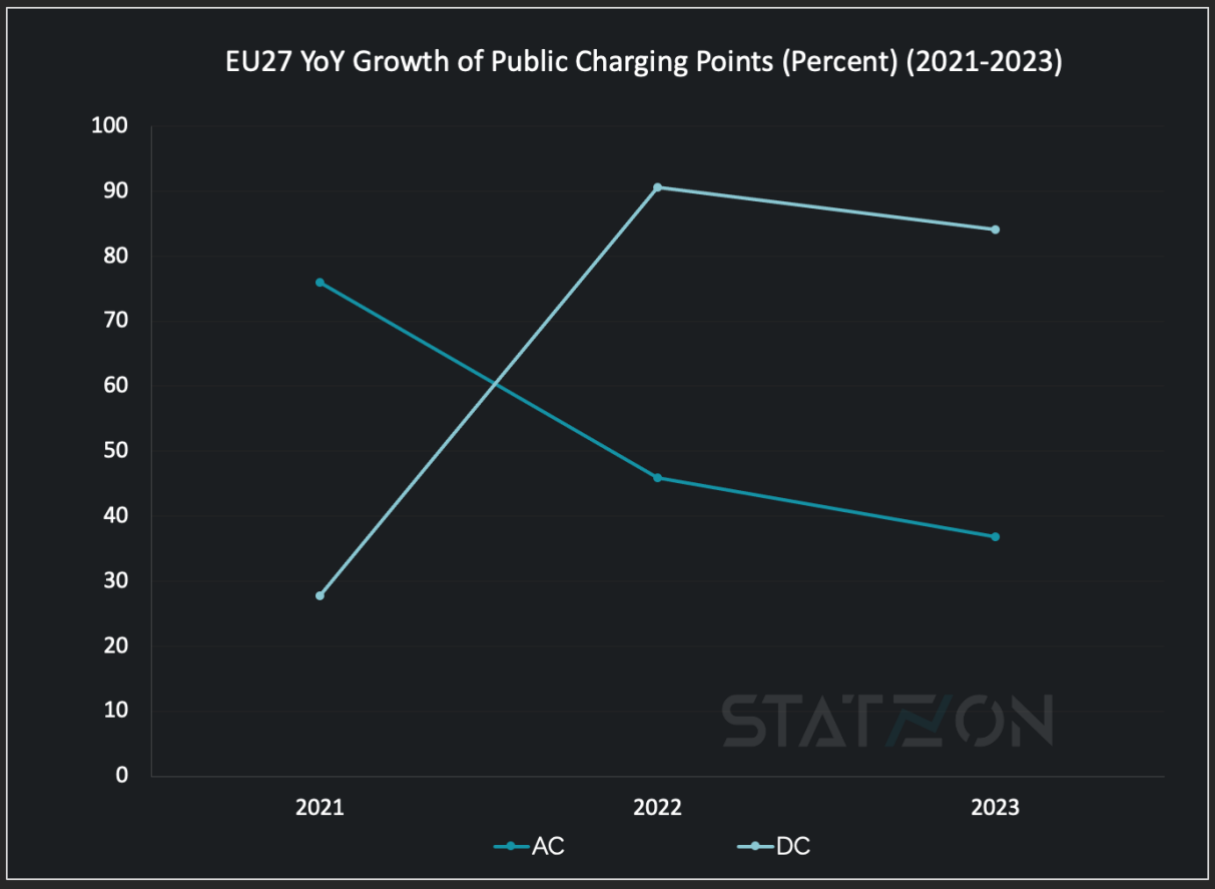
Norway ranks fourth as countries with the most electric cars in Europe with 103,000 registrations for BEV and 10,000 for PHEV in 2023. The accumulative stock of BEV in Norway is 710,000 and 190,000 for PHEVs.

Top 6 countries with the highest market share for pure electric car registrations in 2023 in Europe are Norway (81.8%), Iceland (57.9), Sweden (38.3%), Denmark (36.2%), Finland (33.9%), and the Netherlands (30.52%), followed by Austria (19.9), Belgium (19.6%), Germany (18.2), and UK (16.5%).

Public Charging Station Availability

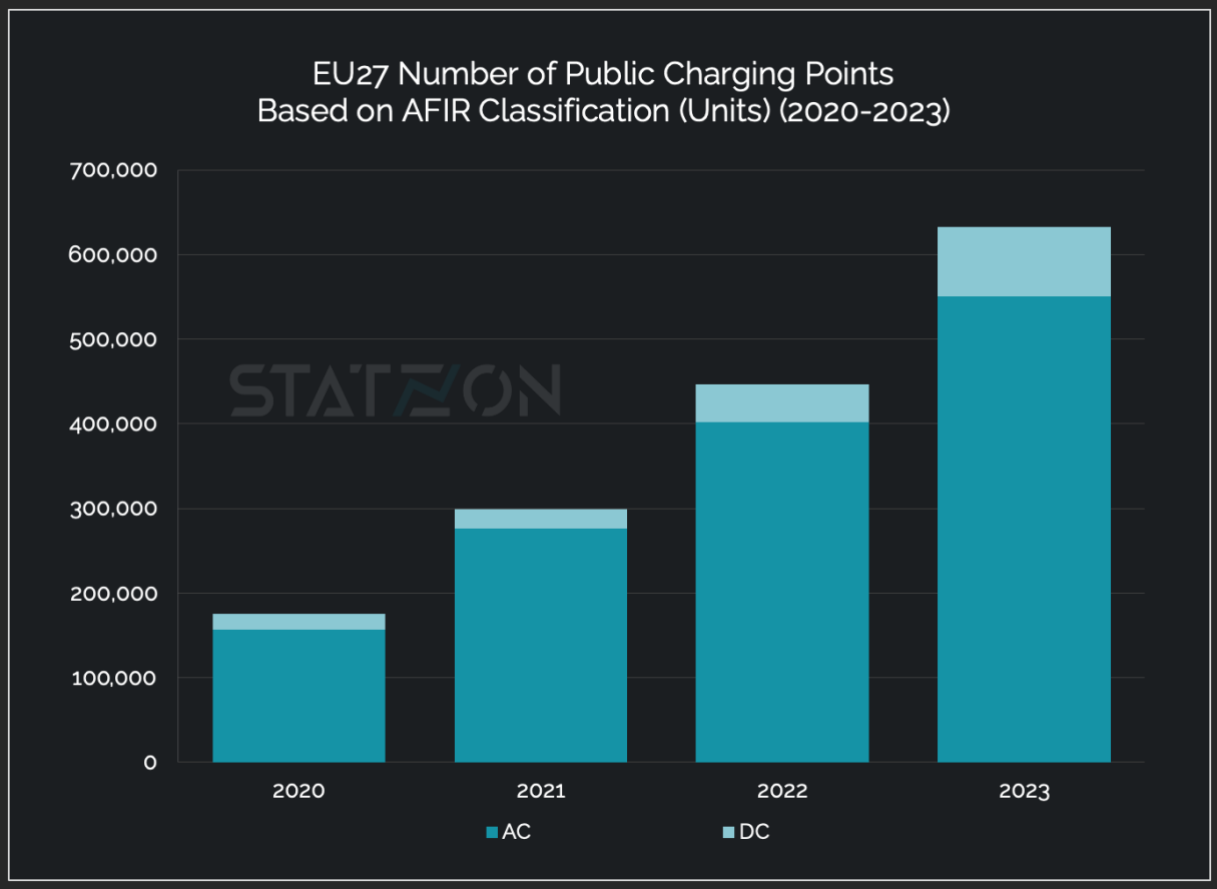
In Europe, the majority of EV charging happens at homes or workplaces, which represent 70% of charging activities. These locations generally offer lower power outputs and require more time to charge, making them the most cost-effective options for EV owners. This presents a challenge in accommodating the 46% of EU residents living in apartments, hence the need for accessible public charging infrastructure.

Growth in Europe's public EV charging sector, while faster than many regions, has experienced a deceleration. The installation of AC chargers in Europe increased by 46% in 2022, down from 76% the previous year, and slowed further to 37% growth in 2023. DC chargers also saw high growth rates, at 90% in 2022 and 84% in 2023.



Source: European Alternative Fuels Observatory (EAFO)

By the end of 2023, the European Union boasted over 630,000 public charging points according to the European Alternative Fuel Observatory (EAFO), with DC chargers making up 13% and AC chargers 87%. This is a considerable increase from the 7% share of DC chargers at the end of 2021.



Source: European Alternative Fuels Observatory (EAFO)

The High-Power Charging (HPC) network is essential for facilitating EV adoption across Europe. Under the Alternative Fuels Infrastructure Regulation (AFIR), ultra-fast charging stations are categorized by their output levels: Level 1 offers 150 kW to less than 350 kW, while Level 2 provides 350 kW or more, enabling the quickest charging times.

HPC stations account for 7% of all public charging points within the EU27. This percentage rises to 8% when including the wider European region. Norway leads in the HPC ratio with 25%, followed by Finland and Estonia at 16%, Germany at 13%, and Austria at 11%. Latvia, Croatia, Iceland, Sweden, and Bulgaria also have a substantial share, with 10% of their public charging points being ultra-fast chargers.

In the first quarter of 2023, the Alternative Fuels Infrastructure Regulation (AFIR) underwent revision, establishing guidelines for the extent of electric vehicle (EV) charging availability throughout Europe. This regulatory update demonstrates a clear commitment to advancing public charging infrastructure development across the continent.

As an illustration, by 2025, the European Union's Member States are required to ensure the presence of a fast-charging station within a maximum distance of 60 kilometers in each direction along the main European routes. This directive emphasizes the importance of enhancing the accessibility of fast-charging facilities for EVs across key travel routes.

Which Countries in Europe Have the Biggest EV Charging Network?

The Netherlands, Germany, and France are the top three countries with the highest penetration of public chargers (both slow and fast chargers combined) with the Netherlands at 144,453 charger points, Germany at 120,625, and France at 119,255 as of the end of 2003. In fact, the three countries account for more than 60% of all public charging points available in the EU. United Kingdom is in fourth place with 72,923 units, followed by Belgium with 44,363 public charging points for the same year.

The rate of installations in the EU experienced a slight deceleration in 2023 compared to the previous year, with growth figures declining from 49% in 2022 to 41% in 2023. Despite this general slowdown, several countries have made significant investments in expanding their electric vehicle (EV) charging infrastructure. Belgium, for instance, saw an impressive increase of 175% in their direct current (DC) charging points. Finland's charging network expanded by 103%, with alternating current (AC) charging points growing by 88% and DC charging points by 171%. Denmark reported a 112% overall growth in their charging network, with AC and DC charging points increasing by 110% and 136%, respectively. Similarly, Sweden observed a 52% growth in its charging infrastructure, with a 48% increase in AC charging points and a 93% rise in DC charging points.

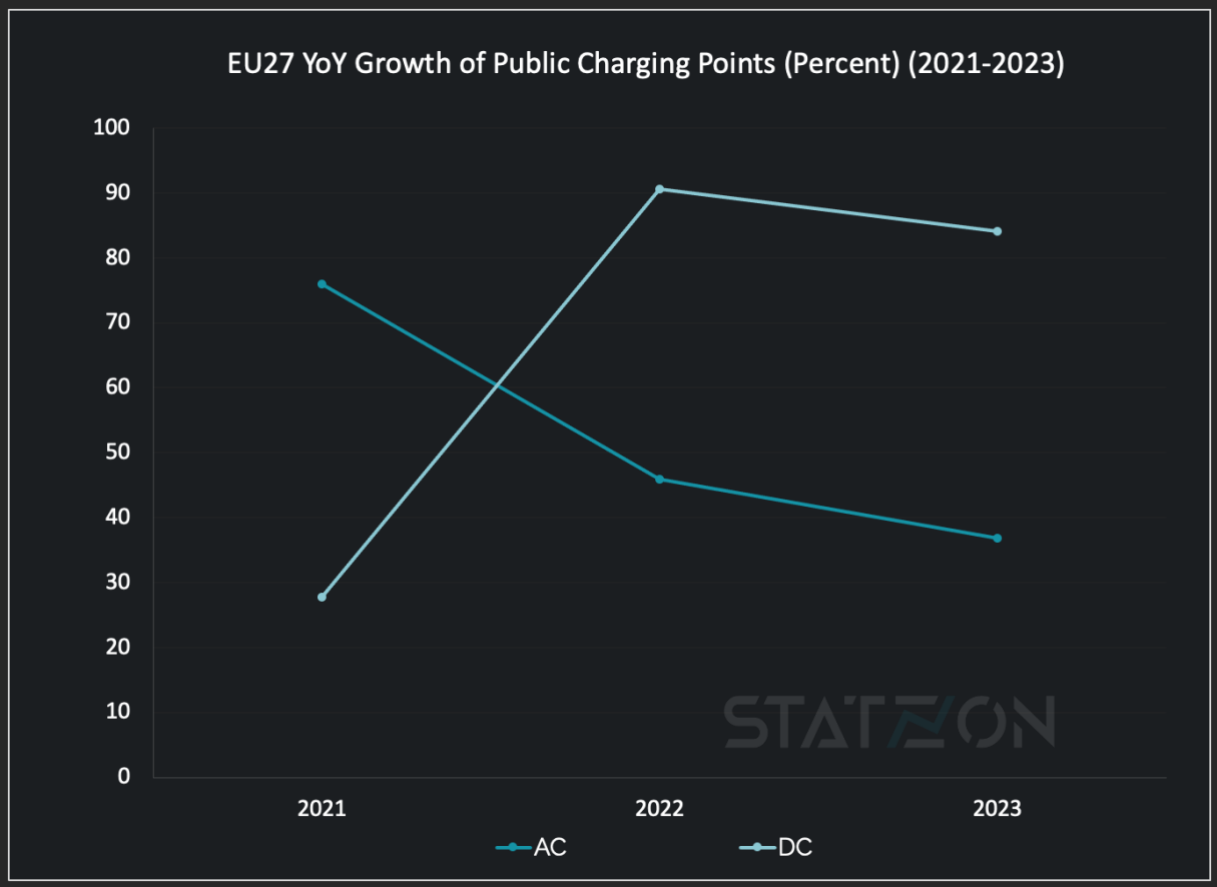
Sources: Statzon, ACEA, PwC, EAFO, arenaev.com, Reuters, eu-evs.com, CleanTechnica, electromaps.com

Navigating Europe's EV Charging Expansion

Europe EV Charging Station Market

Europe is currently ranked second to China in terms of e-mobility. However, China's statistics far exceed those of Europe and any other region in the world. In 2022, China had already installed more than 1.7 million EV charger points, whereas Europe couldn't even reach half of that number. The market for EV charging stations reached USD 9.8 billion in China, in 2022. In Europe electric vehicle charging station market was valued at USD 4.1 billion for the same year.

Despite trailing behind, Europe's EV charging sector is growing at a faster pace, albeit with a slowdown in recent years. AC charger installations saw a 46% growth in 2022, a decrease from the previous year's 76%, and further slowed to 37% in 2023. For DC chargers, there was a 90% growth in 2022, slightly reduced to 84% in 2023.



Source: European Alternative Fuels Observatory

There are things that China did a lot earlier than others to make EVs and EV charging infrastructure ubiquitous in the country. The Chinese government began subsidizing electric car sales in 2010 and

also enforced a standard plug for EV charging, which led to the high adoption of EVs. Europe has recently drafted some ambitious targets for EVs to align with its “Fit 55 Package”, the EU’s initiative to reduce emissions by at least 55% by 2030 (compared to 1990 levels). Emissions from the transport sector have been rising since the 1990s, accounting for nearly 20% of total EU GHG emissions.

The European Parliament aimed high in October 2022 by voting for a regulation on the alternative fuels infrastructure (AFIR) to ensure a smooth transition to renewable zero-carbon fuel. The regulation highlights the need to increase the power level of public charging, stimulate fast charging deployment, and enable swift deployment of electric charging infrastructure for heavy-duty vehicles.

Where do People Charge Their Electric Cars?

Residential Charging

In Europe, 70% of EV charging occurs at home or at work, where charging outlets have lower power output and longer charging durations, resulting in lower costs. This makes charging at home and at work the most economical option for EV customers. However, providing charging solutions for residents living in apartment buildings, which represent 46% of EU inhabitants, can be challenging, as reported in ChargeUp Europe's State of the Industry 2022 publication. The main obstacle is the shared parking garages, which receive electricity from the common area meter, making it difficult to install personal EV chargers. In addition, local regulations often prohibit direct connections between charging stations in parking garages and corresponding flats. The ongoing revision of the Energy Performance of Buildings Directive (EPBD) presents an opportunity to address this issue.

Almost 80% of residential EV chargers in Europe (90% if we include Benelux) were sold in DACH (Germany, Austria, Switzerland) and France corresponding with the existing distribution of EVs in these countries.

Residential EV chargers are AC chargers with charging power between 7.4 and 22 kW. Each charging point receives more than four charging sessions per week, totaling an average of 100 kWh/week. More than 95% of home charging sessions take place between 12 PM and 8 AM.

Workplace Charging

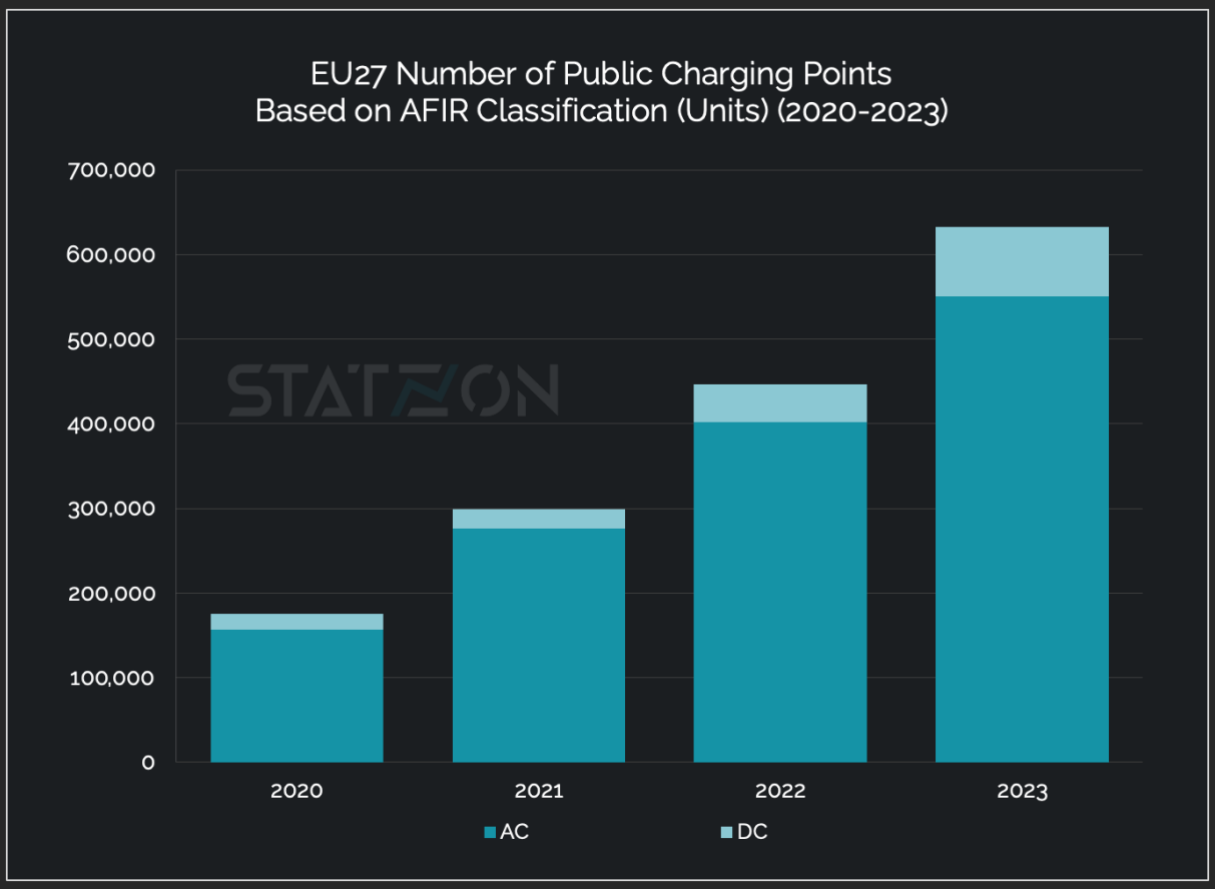
It's critical to offer workplace charging, especially for individuals without access to a home charger. Nordic countries and France have the highest share of workplace charging at 60% combined, followed by Benelux and DACH. Workplace chargers usually offer AC charging with a capacity of 22 kW. Despite its significance, workplace charging constitutes less than half of the total residential charging units.

Each workplace charging point receives more than eight charging sessions on average for each week, totaling 400 kWh/ week. Around 75% of workplace charging sessions happen between 8 am and 4 pm, with the remaining 25% happening between 4 pm and 12 am.

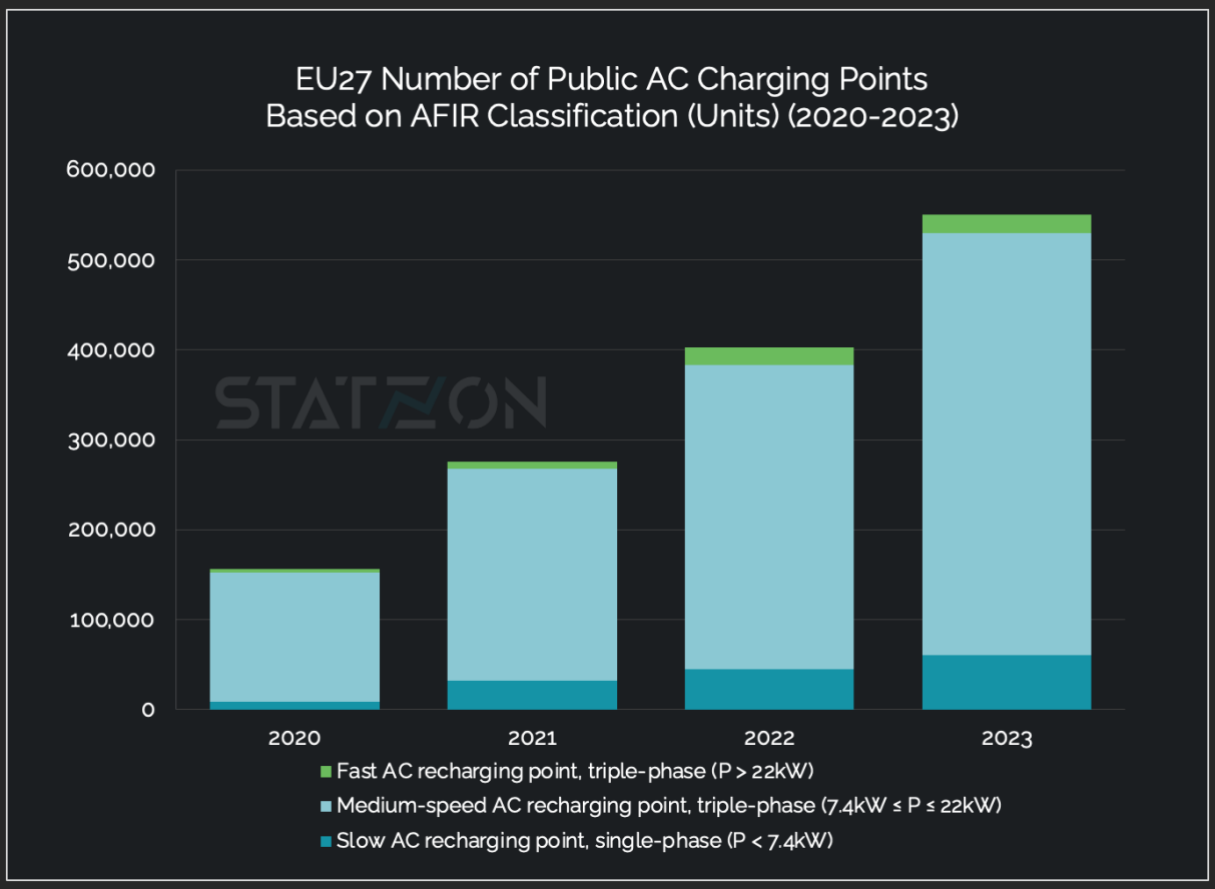
Public charging

Public charging options include AC and DC charging points. The majority of publicly available charging infrastructure are AC charging stations with a maximum of 22 kW power. Countries with a high density of charging points tend to offer more AC chargers than DCs.

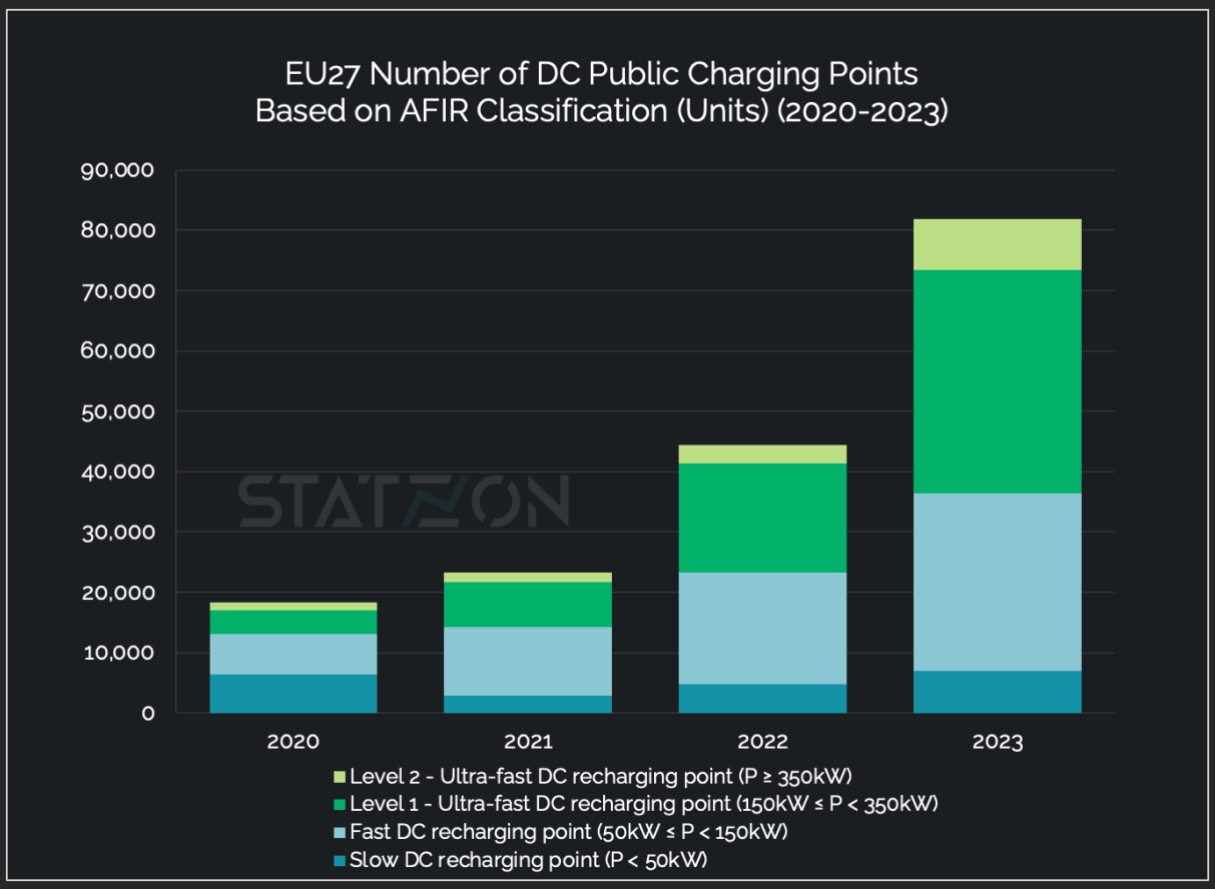
The latest data from the European Alternative Fuel Observatory (EAFO) shows that by the end of 2023, the European Union had over 630,000 public charging points, with 13% being DC chargers and 87% AC chargers. This marks a significant increase in the proportion of DC chargers, which grew from 7% at the end of 2021 to 13% by 2023.



Source: European Alternative Fuels Observatory



Source: European Alternative Fuels Observatory



Source: European Alternative Fuels Observatory

Public charging points are divided into two types: "fully" public and "semi-public." Fully public charging points, making up 63% of the total, are accessible anytime and located in public areas like streets or highways. On the other hand, semi-public charging points, constituting 37%, are situated on private properties with restricted access, such as in car parks, underground garages, supermarkets, and hotels, and may have limited hours or require using the property's facilities.

A study by GridX recorded a total of 137,258 charging stations across 28 countries (25 EU countries plus Norway, UK, and Switzerland). Most of these stations (46%) have two charging points. This is followed by charging stations with four charging points (19%), then one and three charging points as the third most common (10%). Only 14% of stations have five or more chargers, and only 1% can simultaneously serve 20 or more vehicles.

A few stations have 100 charging points or more. But these stations are exceptions, certainly not the norm, as only 0.03% of charging stations fall into this category. 0.15% of stations provide 50 or more charging points.

Ultra-Fast High-Power Charging (HPC)

The High-Power Charging (HPC) network is vital for the rapid expansion of electric vehicle usage across Europe. Under the Alternative Fuels Infrastructure Regulation (AFIR), HPC stations are classified into two distinct levels: Level 1 ultra-fast DC recharging points provide an output of 150 kW up to less than 350 kW, while Level 2 ultra-fast DC recharging points deliver a power of 350 kW or greater, facilitating the fastest charging times available.

Within the EU27, HPC stations make up 7% of the total public charging points. Expanding the scope to include a wider European region—adding Norway, the UK, Iceland, Switzerland, Liechtenstein, and Turkey—HPC stations constitute 8% of the total charging facilities. Leading the pack with the highest ratios of HPC points are Norway at 25%, followed by Finland and Estonia, each with 16%, Germany at 13%, and Austria at 11%.

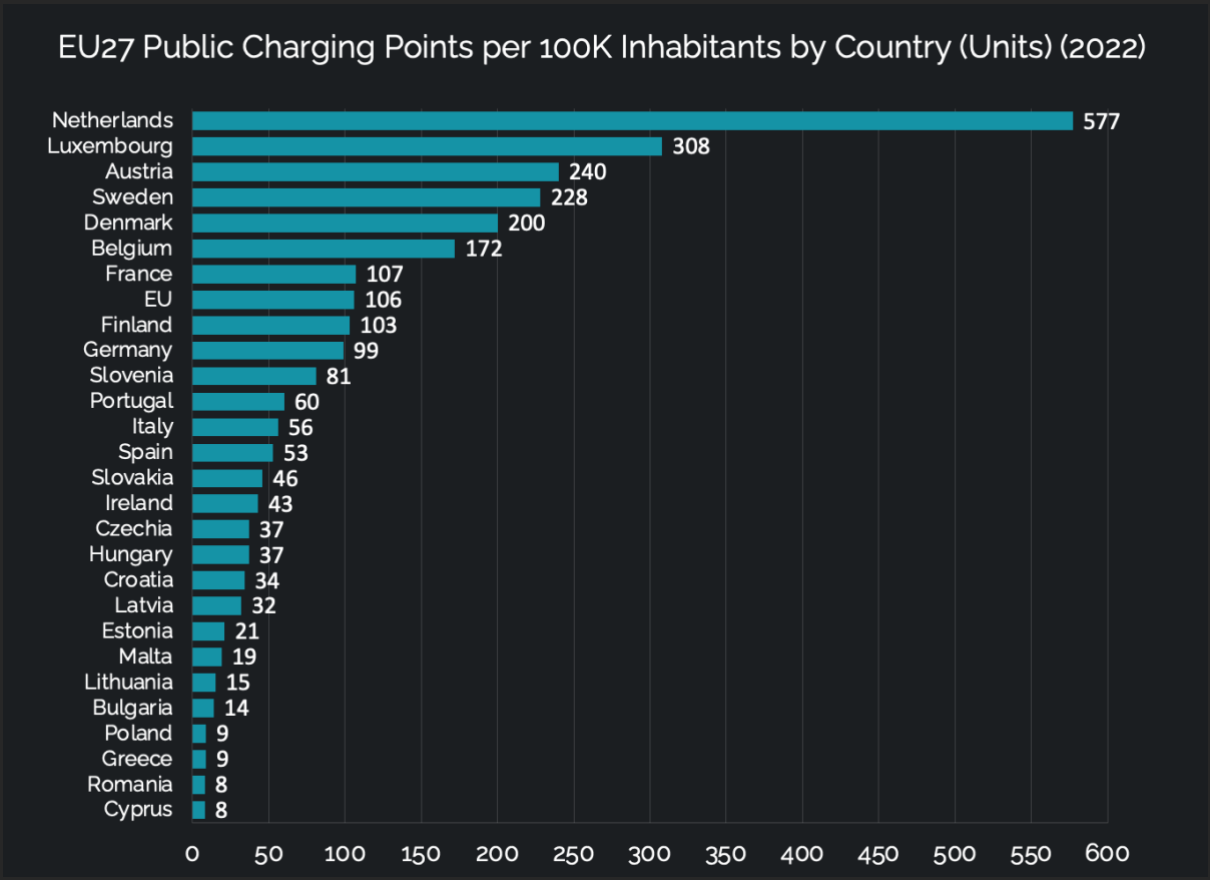
Additionally, Latvia, Croatia, Iceland, Sweden, and Bulgaria also feature a significant proportion of HPCs, each with 10% of their public charging points classified as ultra-fast chargers.

Uneven Distribution of Charging Infrastructures

In 2023, over half (52%) of Europe's total charging infrastructure was concentrated in just three countries: the Netherlands, Germany, and France. Remarkably, these countries together account for only 10% of the EU's total land area. This means that the vast majority of the EU's territory, making up 90% of its land mass, is left with just 48% of the charging stations.

The 2023 ChargeUp Europe report highlights a contrast in charging infrastructure across the continent. Western (and Northern Europe) significantly outpace their Eastern (and Southern) counterparts in terms of available charging options. On average, there were 106 public charging points for every 100,000 inhabitants in the EU in 2022. Seven countries—namely the Netherlands, Luxembourg, Austria, Sweden, Denmark, and Belgium—all located in Western Europe, surpass this average.

Most countries in Eastern Europe are lagging behind with way below-average numbers with Poland, Greece, Romania, and Cyprus at the bottom of the list having less than 10 public charging points per 100,000 inhabitants.



Source: Statzon/ ChargeUp EUROPE

Interestingly, assessing the ratio of EVs to public charging points shows Eastern European countries in a more favorable position than might be expected. The EU's recommendation is 10 EVs for every charging point. Within Western Europe, only Austria and the Netherlands achieved the recommendation with around 5 EVs per charging point in 2022. Belgium, Luxembourg, and France exceed it slightly.

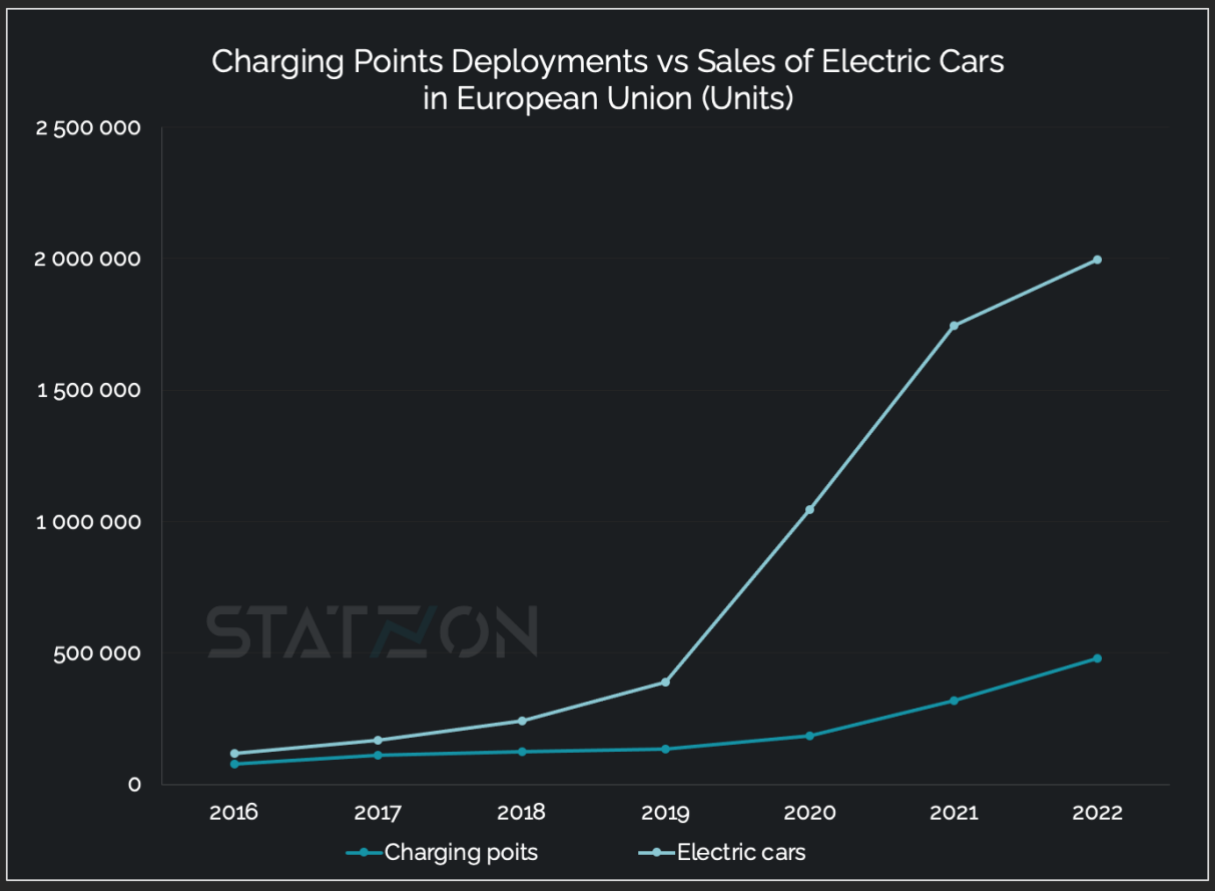
Nine countries in Eastern (and Southern) Europe—Slovakia, Latvia, Croatia, Bulgaria, Slovenia, the Czech Republic, Italy, Hungary, and Cyprus—have already met or done better than the recommended ratio, with Spain and Estonia having just marginally higher ratios.

Western Europe's shift toward electric vehicles has been swift and early, leading to a surge in EV adoption that is outpacing the expansion of charging infrastructure. In contrast,

Eastern Europe's move towards electric vehicles commenced more recently and is proceeding at a steadier rate. This gradual adoption ensures a better match between the number of electric vehicles and the charging stations available. It is also interesting to mention that the charging networks in Northern and Western Europe are predominantly composed of AC chargers, while Eastern European countries, despite having a sparser network, are characterized by a higher proportion of fast-charging DC stations.

Are There Enough EV Charging Points in Europe?

EV sales have been growing a lot more ambitious than the deployment of charging infrastructure. At the end of 2022, Europe sold close to 2 million BEVs, a 17-fold increase since 2016, paired with a 6-fold increase in charging point quantity since 2016. It's evident that the deployment rate of infrastructure is falling far behind the exploding demand for EVs.



Source: ACEA

An analysis from McKinsey suggests that the European Union will need at least 3.4 million operational public charging points by 2030 to enable a complete switch from ICEs to EVs. This figure includes 2.9 million public chargers for passenger cars, 0.4 million for light commercial vehicles, and

0.1 million for trucks and buses. It does not include the estimated 29 million residential and workplace chargers.

An average of 6,000 public charging stations per week would need to be deployed throughout the EU from 2021-2023 to achieve this target and with only 1,600 installations per week in 2021, according to McKinsey, the EU is currently way behind the target rate. We have around 407 weeks left until the end of 2030, with 2.9 million charging points to be installed. The two countries with the fastest public charging installation pace in the EU are France (400/ week in 2021) and Germany (200/ week in 2021), still, they would need to speed up their pace in the future.

Nevertheless, the predominant mode of charging in the future is anticipated to remain within private domains. By 2030, residential charging is forecasted to comprise the lion's share, making up 79% of all charging, followed by workplace charging at 15%.

Sources: Statzon, ACEA (1), ACEA (2), ACEA (3), EAFO (1), EAFO (2), McKinsey, Jato, ChargeUp EUROPE State of The Industry 2023 report, gridX

US EV Market Passed the 1 Million Sales Mark in 2023

EV Sales Share in the United States

In early 2023, Cox Automotive anticipated that EV sales in the US would surpass the 1 million marks, a prediction that materialized by the year's end. Indeed, in 2023, a remarkable nearly 1.2 million US vehicle buyers opted for electric vehicles, marking a record-breaking surge, according to the latest data from Kelley Blue Book, a Cox Automotive company. EVs emerged as the fastest-growing segment in car sales, capturing a 7.6% share of the total US vehicle market in 2023, up from 5.9% in the previous year.

Q4 of 2023 witnessed an unprecedented milestone in EV sales, with both volume and market share reaching record highs. Sales during this period surged by 52% compared to the fourth quarter of 2022, with Americans purchasing 317,168 EVs between October and December 2023, accounting for 8.1% of all new car sales.

The year 2023 saw electric vehicles commanding 7.6% of total US sales, a significant increase from 5.9% in 2022 and 3.2% in 2021. Forecasts by Cox Automotive research suggest that this figure is expected to surpass the 10% mark for the first time in the coming year.

EV sales shares have grown at a faster rate than sales shares of conventional hybrids that don't have a plug: It took about 25 years for hybrids to reach a 10% market share, compared to about 12 years for EVs.

Average EV Price in the United States

EV prices have shown signs of stabilization, maintaining their status as a premium segment in most cases. However, in 2023, Tesla's aggressive price reductions triggered a ripple effect throughout the automotive industry, leading to a significant decrease in the average transaction prices for electric vehicles. Consequently, by December of that year, the average price for a Tesla vehicle had dropped to USD 50,051, nearly aligning with the average price of internal combustion engine (ICE) vehicles, which stood at USD 48,759. This trend extended beyond Tesla, with the broader auto industry witnessing a decline in the average EV price to USD 50,798, marking the closest proximity to ICE prices in history.

Tesla's strategic maneuvers sparked a price war in the auto sector, prompting competitors to follow suit and reduce their EV prices. This concerted effort resulted in a narrowing gap

between the average prices of EVs and traditional ICE vehicles, indicating a significant shift in market dynamics.

By January 2024, the average price paid for a new electric vehicle saw a slight increase, reaching USD 55,353, despite still representing a notable year-over-year decline of 10.8%. For comparison, the average price of a new car, regardless of powertrain, in the same month was USD 47,401, meaning that the average price paid for a new EV was 17% higher than the overall new car market average. EV price is closer to the average price paid for a luxury brand vehicle in January which was at USD 60,978.

On a positive note, EV incentives experienced a substantial increase, with many models seeing incentives more than triple over the past year. This uptick in incentives further enhances the affordability and attractiveness of electric vehicles in the market.

These price adjustments and increased incentives have made EVs more accessible to consumers, contributing to a surge in EV adoption. In January 2023, the Hyundai Ioniq5's incentives were less than 3% of average transaction prices (ATP), but by January 2024, they had surpassed 18%. The Tesla Model Y, a key player in the EV market, saw its prices plummet by more than 21% over the past year, dropping from nearly USD 63,000 in January 2023 to less than USD 50,000 by the end of 2023.

US Best-Selling Electric Cars 2023

Tesla maintains its stronghold in the US EV market, accounting for 55% of electric vehicle purchases in 2023. Despite a slight decline from its 2022 market share of 65%, Tesla's aggressive price cuts throughout the year helped it maintain its leading position. Notably, the Model Y SUV and Model 3 sedan, now more affordable due to these price reductions, comprised one-third of all EVs sold in 2023. The Model Y, with over 394,000 units sold, emerged as the top-selling EV, representing one in every three EVs sold last year. Meanwhile, the Model 3 secured the second position with 220,910 units sold.

While Tesla remains at the forefront, other automakers, including German luxury brands, are making significant strides in the EV sector. In 2023, BMW saw 12.5% of its total sales come from EVs, while Mercedes-Benz and Audi accounted for 11.4% and 11.0% of their brand sales, respectively. Volkswagen leads among non-luxury brands, with EVs representing 11.5% of its sales for the year.

Chevy Bolt EV experienced its best sales year yet, with 62,045 units sold, while Ford's Mustang Mach-E and F-150 Lightning also saw record-breaking sales figures, with 40,771 electric crossovers and an undisclosed number of electric pickups sold, respectively.

Rivian, a notable EV startup, gained significant traction, selling 24,783 R1S electric SUVs in 2023. With over 50,000 EVs delivered in total, Rivian achieved an impressive growth rate exceeding 100%, solidifying its position as one of the fastest-growing players in the EV market.

The entry of new competitors into the EV market continues to expand consumer choices, with over 70 EV options expected to be available within the next two years, according to Kelley Blue Book analysis.

ELECTRIC VEHICLE SALES IN THE UNITED STATES				
Brand	Sales 2023	Sales 2022	YOY	Share 2023
Audi	25,039	16,177	54.8 %	2.1 %
BMW	45,417	35,589	27.6 %	3.8 %
Brightdrop	497	146	240.4 %	0.0 %
Cadillac	9,154	122	-	0.8 %
Chevrolet	62,988	38,120	65.2 %	5.3 %
Ford	72,608	61,575	17.9 %	6.1 %
Genesis	6,403	1,671	283.2 %	0.5 %
GMC	3,244	854	279.9 %	0.3 %
Fisker	2,669	-	-	0.2 %
Hyundai	57,561	30,339	89.7 %	4.8 %
Jaguar	297	298	-0.3 %	0.0 %
Kia	30,036	27,959	7.4 %	2.5 %
Lexus	5,386	-	-	0.5 %
Lucid	5,940	2,669	122.6 %	0.5 %
Mazda	100	324	-69.1 %	0.0 %
Mercedes	40,458	32,483	24.5 %	3.4 %
Mini	2,770	3,584	-22.7 %	0.2 %
Nissan	20,216	12,025	71.4 %	1.7 %
Polestar	12,215	9,322	31.0 %	1.0 %
Porsche	7,570	7,271	4.1 %	0.6 %
Rivian	50,189	20,632	143.3 %	4.2 %
Subaru	8,872	-	-	0.7 %
Tesla	654,888	522,388	25.4 %	55.1 %
Toyota	9,329	1,217	666.6 %	0.8 %
Vinfast	3,129	-	-	0.3 %
Volvo	13,887	7,605	82.6 %	1.2 %
VW	37,789	20,511	84.2 %	3.2 %
Total	1,189,051	812,821	46.3 %	

Source: Kelly Blue Book

EV Market Outlook in The United States

The outlook for electric vehicle (EV) sales in the United States reflects a mixed landscape of challenges and opportunities. Amidst the headwinds of negative press and a slowdown in the growth rate, the trajectory remains upward. Major automakers such as Ford and General Motors have scaled back production targets in response to a softening demand, a trend that mirrors the global market situation. In Germany, for example, EV sales have seen a decline, while Chinese manufacturers are becoming increasingly competitive internationally.

Globally, the EV market is experiencing a similar recalibration. In Europe, a significant downturn has been observed, with German EV sales, including plug-in hybrids, falling 16% in the previous year, and a further 9% decrease forecasted for 2024. This is indicative of a broader European market softening, as consumer demand wanes and competition from Chinese manufacturers intensifies.

China itself, after a period of booming EV sales, is confronting a domestic market slowdown. This has prompted Chinese EV companies to expand internationally, increasing competition in a global market that is already facing a transitional challenge. Moreover, Korea's LG Energy Solution anticipates slower global market growth, reflecting a widespread industry trend.

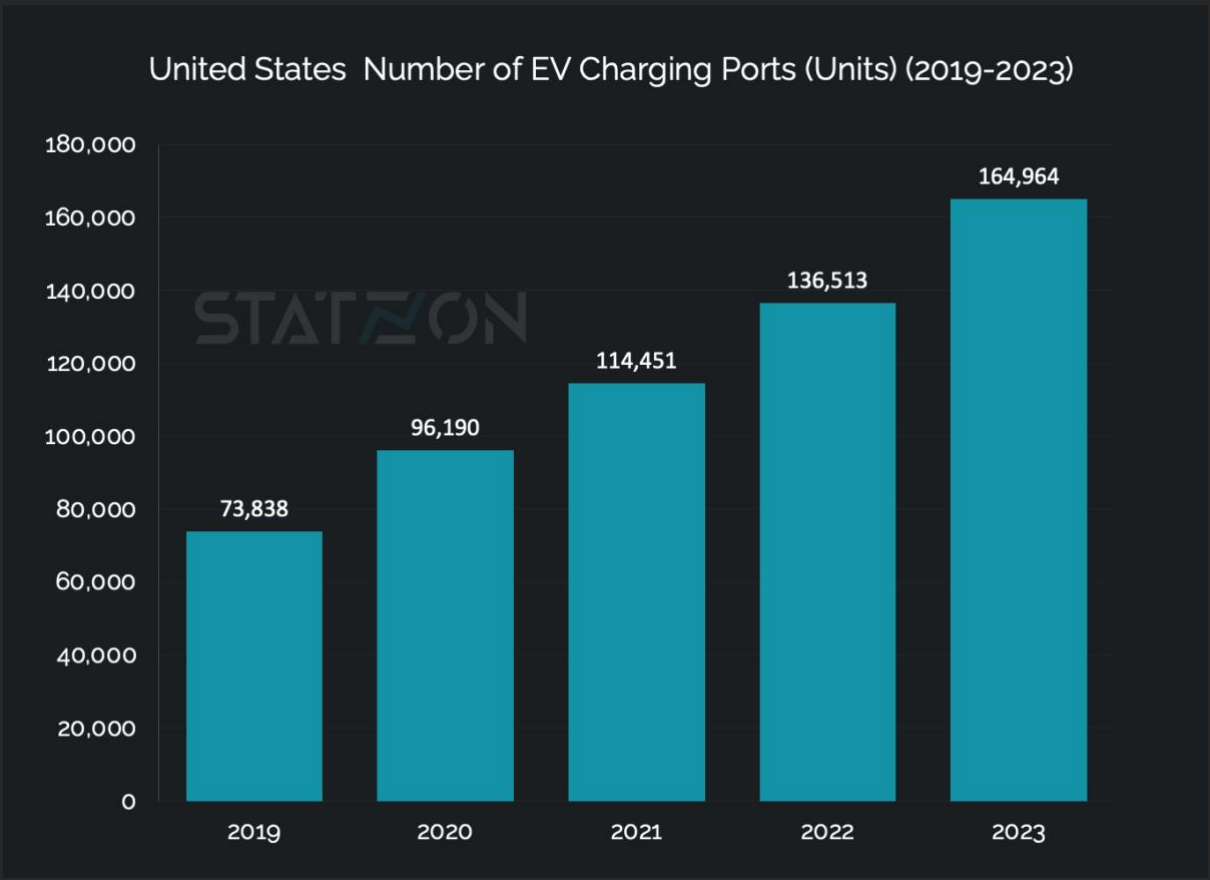
Despite these challenges, BNEF reports suggest that the perceived global EV slowdown may be overstated. Firms like Hyundai, Kia, and Volvo have reported robust U.S. demand, with no signs of a downturn in orders. The commitment to an electric future remains strong across the industry, with automakers planning to sell more EVs than ever.

The U.S. market, in particular, proves challenging to forecast. While some automakers indicate a softening demand, Tesla's ongoing success and Hyundai and Kia's sustained demand paint a diverse and unpredictable market landscape. Expected to reach nearly 1.9 million in sales, accounting for 13% of new vehicle purchases, the U.S. market could still face setbacks, particularly as political divides intensify.

Despite these uncertainties, consumer sentiment towards EVs seems optimistic. Surveys by McKinsey, J.D. Power, and Consumer Reports signal a growing readiness among Americans to embrace EVs, with 30% of drivers saying they would not consider gasoline vehicles from their future options. While concerns about affordability and charging infrastructure linger, they are being actively addressed. The Inflation Reduction Act of 2022 introduces new tax credits of up to $7,500 for new EV purchases and a surge in investments, totaling more than $21 billion towards charging infrastructure, is set to expand the network of public chargers from around 160,000 in 2023 to nearly 1 million by 2030. Although the U.S. represents just about 11% of the global EV market, its evolution is poised to significantly influence the overarching narrative in 2024.

How Many EV Chargers are there in the United States?

Approximately 80% of electric vehicle charging takes place at home, but access to reliable and convenient workplace and public charging stations is crucial in supporting EV customers. As of the close of 2022, the United States boasted around 136,000 EV charging ports. By year's end 2023, this figure had risen by 21%, reaching an estimated total of 165,000 charging ports distributed across more than 61,000 stations nationwide.



Source: AFDC, US Department of Energy

Most of the charging ports available are Level 2 chargers, which account for 76% of all public charging ports in the US. DC fast chargers make up around 24%, with the majority (62%) of these fast chargers on the Tesla Supercharger network and therefore only accessible to Tesla drivers except in some select stations. There are currently more than 24,000 Tesla Superchargers in the US that can add about 200 miles of range to a Tesla vehicle in 15 minutes.

Level 1 chargers can still be found in some public charging facilities. However, they are not very common and make up less than 1% of all charging points.

Nearly one-third of the nation's public charging infrastructures are in California. The state has the most significant number of EV charger points by volume (44,000), far outpacing the rest of the country. New York, ranked second, has around 10,000 charger points, less than

one-fourth the number of EV chargers as California. Texas is in third position with nearly 9,000 charging points.

Charging infrastructures outside urban areas are not getting enough attention currently. Although EV adoption is slow in these areas, it's still important to have enough charging stations there. Around 85% of Level 3 (fast) chargers and 89% of Level 2 (regular) chargers are located within US Metropolitan Statistical Areas (MSAs), areas with a high density of population. The same can be said about the Tesla charging network. 82% of its Superchargers (fast) and 83% of its destination chargers (regular) are located within MSAs.

Does the United States Have Enough EV Chargers?

US EV market share for new vehicles is likely to reach 30% or more by 2030, at which point the total number of EVs in operation could reach 26.4 million. The Edison Institute generated these numbers by aggregating many other forecasts from different organizations (e.g.: Deloitte, Boston Consulting Group, Guidehouse, Wood Mackenzie).

Approximately 12.9 million charging ports will be needed to support the 26 million EVs projected to be on US roads in 2030. This would be a mix between home charging, workplace charging, and public facilities with a composition of 74% (9.5 million ports) home and multifamily Level 2 charging, 9% (1.2 million ports) workplace level 2 charging, 16% (2 million ports) public level 2 charging, and 1% (140 000 ports) public DC fast charging as reported by S&P Global Mobility.

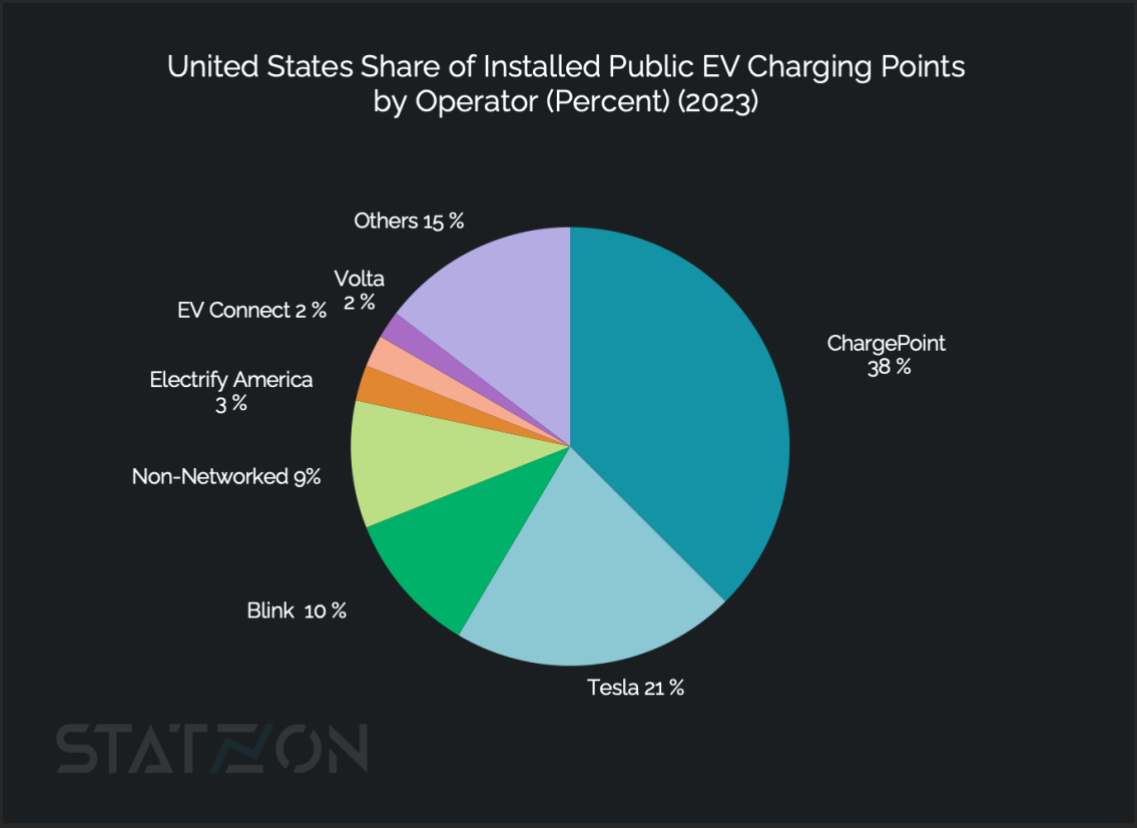
While DC fast charging ports make up only 1% of the EV charging infrastructure needed in 2030, these charging stations are vital and should become a top priority for policymakers, third-party charging providers, and electric companies. However, they are also much more costly than lower-powered Level 2 stations, often costing hundreds of thousands of dollars per station.

Top EV Charging Companies in the United States

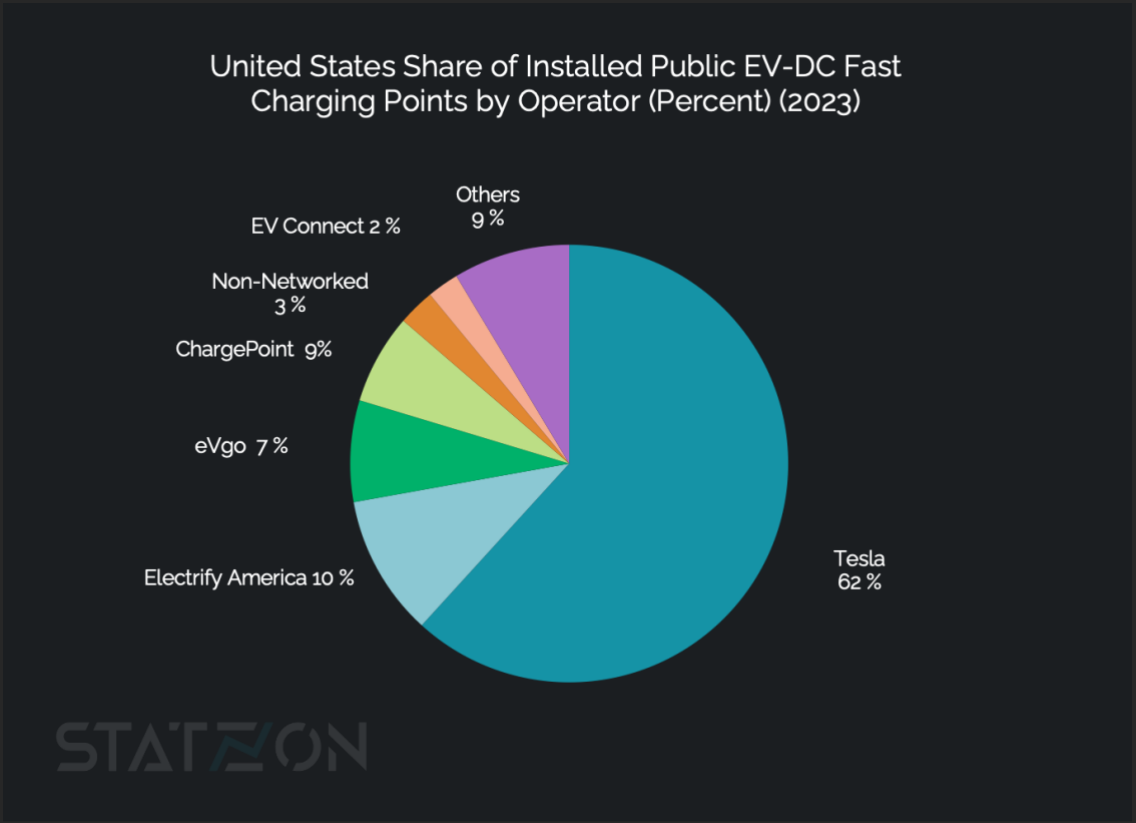
Combining the number of charger ports and locations across all levels of EV chargers, ChargePoint ranks well above all other networks and is easily the largest EV charging network in the US, accounting for 37% of all US public charging ports. Currently, ChargePoint is managing over 61,000 charging ports spread across 34,000 locations in the US.

Tesla is in the number two spot for the overall charging network, but it dominates the DC fast charging market. Tesla Supercharger is currently available to Tesla drivers only, yet Tesla has the highest number of EV sales compared to other automakers, therefore, the network caters to a big proportion of EVs on the road.

Tesla Supercharger network is known for having the fastest and smoothest charging experience. With 24,000 superchargers spread over 2100 locations, Supercharger accounts for 62% of total DC fast charger ports in the US.



Source: AFDC



Source: AFDC

Considering both Destination charging and the Supercharger network, the Tesla charging infrastructure represents 21% of all U.S. charging points, comprising 34,000 charging ports across 6,400 locations.

Next in line after Tesla is Blink, which expanded its network by acquiring SemaConnect in June 2022, holding a 10% market share. This is followed by Electrify America with 2.6% and EV Connect with 2.4%. Around 15,000 (9%) of public charger ports do not belong to any network and the rest is managed by various smaller operators

Within the fast-charging domain, Electrify America holds the second position after Tesla with a 10% market share, followed by EVgo in third with 7.5%, ChargePoint in fourth with 6.7%, and EVConnect ranking fifth with a 2.3% share. Approximately 1,100 ports, accounting for a 2.7% share, are classified under the "Non-networked" category.

Source: Statzon, Kelley Blue Book , WSJ, Alliance for Automotive Innovation, Copilot, SP Global Mobility, EVAdoption, EEI, electreck.co, CleanTechnica, COX Automotive, COX Automotive (2), CarEdge, Nasdaq.com, ev-columes.com, ICCT, Bloomberg NEF, caranddriver.com, Reuters, energy.gov, AFDC,

Global Electric Bus Market Growing Rapidly at 20.2% CAGR

Cities around the world are increasingly adopting electric buses as a key component of transport electrification, with some setting deadlines to phase out fossil fuel buses. Nearly 25% of registered buses in 2021 were zero-emission, a significant marker of the zero-emission bus adoption trend, according to new data from Transport & Environment. Countries like Denmark, New Zealand, and the Netherlands are aiming for 100% zero-emission bus procurements by 2025, and Costa Rica targets 100% bus fleet electrification by 2050.

Electric Bus Market Size

The global electric bus market is projected to reach USD 19.2 billion in 2022, as estimated by Apollo Research Reports. With an annual growth rate of 13.3%, the market size is expected to hit USD 66.5 billion by 2032. An alternate market evaluation from The Insight Partners forecasts even more growth, expecting the market value to grow at a 20.2% CAGR from USD 29 billion in 2021 to USD 105 billion by 2028.

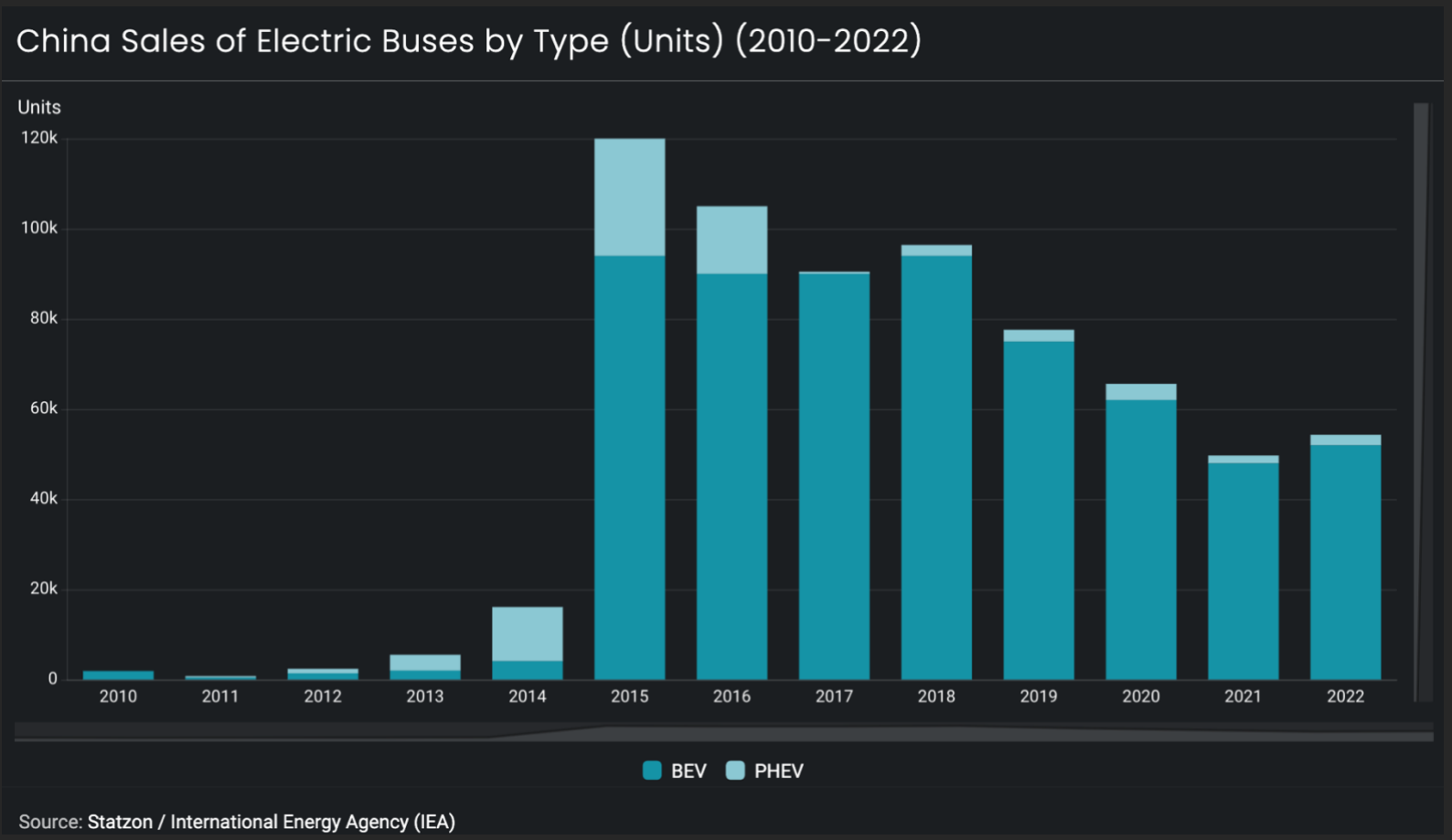
Other than government initiatives to decarbonize public transportation, the falling price of batteries has accelerated the adoption rate of electric buses by cities and countries. Batteries, which make up 40% of the cost of electric buses, are expected to decrease in cost, thereby reducing the high initial cost of developing an electrified transport fleet and encouraging growth in the electric bus market.

China Dominates the Global Electric Bus Market

APAC is touted as the leading region in the global electric bus market by both Apollo Research Reports and The Insight Partners. Based on data provided by The Insight Partners, APAC gained USD 26 billion in market value during the year 2021, and this number will grow to USD 96 billion by 2028, registering an 18.9% CAGR.

China alone contributed USD 24 million to the region's overall market value in 2021. In terms of market share, China is dominating the market both regionally and globally, controlling over 80% of the global market share, which will be maintained by the country throughout the forecast period.

This dominance is reflected in the sales figures: in 2022, around 66,000 electric buses were sold worldwide, about 4.5% of all bus sales. Of these global sales, 54,000 new electric buses were sold in China alone. This accounts for approximately 80% of electric bus sales and 85% of electric truck sales worldwide. China's substantial contribution to the electric vehicle market underscores its pivotal role in shaping the global shift towards electrification in public transportation.



The success story of electric buses in China is largely due to the proactive approach of its electric bus manufacturers and the Chinese government's early recognition of the need for a cleaner alternative to diesel-powered vehicles, which were major contributors to air pollution. Addressing this issue head-on, China prioritized electric buses as a means to reduce its reliance on imported oil and fuel consumption.

Since 2010, China has been aggressively expanding its electric bus network, supported by substantial government backing. By the end of 2022, the Chinese Ministry of Transport reported that 77% (or 542,600) of all urban buses were classified as "new energy vehicles," encompassing pure electric, plug-in hybrids, and fuel cell vehicles. Moreover, a remarkable 84% of these new energy buses were fully electric. The pace of this transformation is noteworthy; in 2015, diesel or gas-powered buses made up 78% of China's urban bus fleet. This rapid and widespread adoption has cemented China's position as the world's largest

market for electric buses and a model for other nations pursuing sustainable urban transportation solutions.

Electric Bus Market in Europe

Although Europe leads in research and development for electric buses, focusing extensively on advancing vehicle technology, the adoption rate of e-buses in the region still trails behind the Asia-Pacific (APAC) area. APAC also boasts some of the largest producers of buses and batteries.

Nevertheless, Europe's electric bus market is expanding rapidly, with a compound annual growth rate (CAGR) of 21.6%—the highest among all regions. According to The Insight Partners, the European market value is projected to grow from USD 1.5 billion in 2021 to USD 5.8 billion by 2028.

Sales data from the International Energy Agency (IEA) reflects a 21% increase in electric bus sales volume from 2022 to 2023, with sales climbing to 4,770 units from 3,940 units. Another 2,567 battery-electric buses were already registered in the first half of 2023. Although these figures are way behind China's numbers, a significant milestone was reached in Q1 2023 when, for the first time in over a century, the sale of diesel-only vehicles in Europe fell below the majority. This shift allowed battery-electric buses to emerge as the dominant technology in the European road transport sector, marking a historic moment in the transition away from the internal combustion engine.

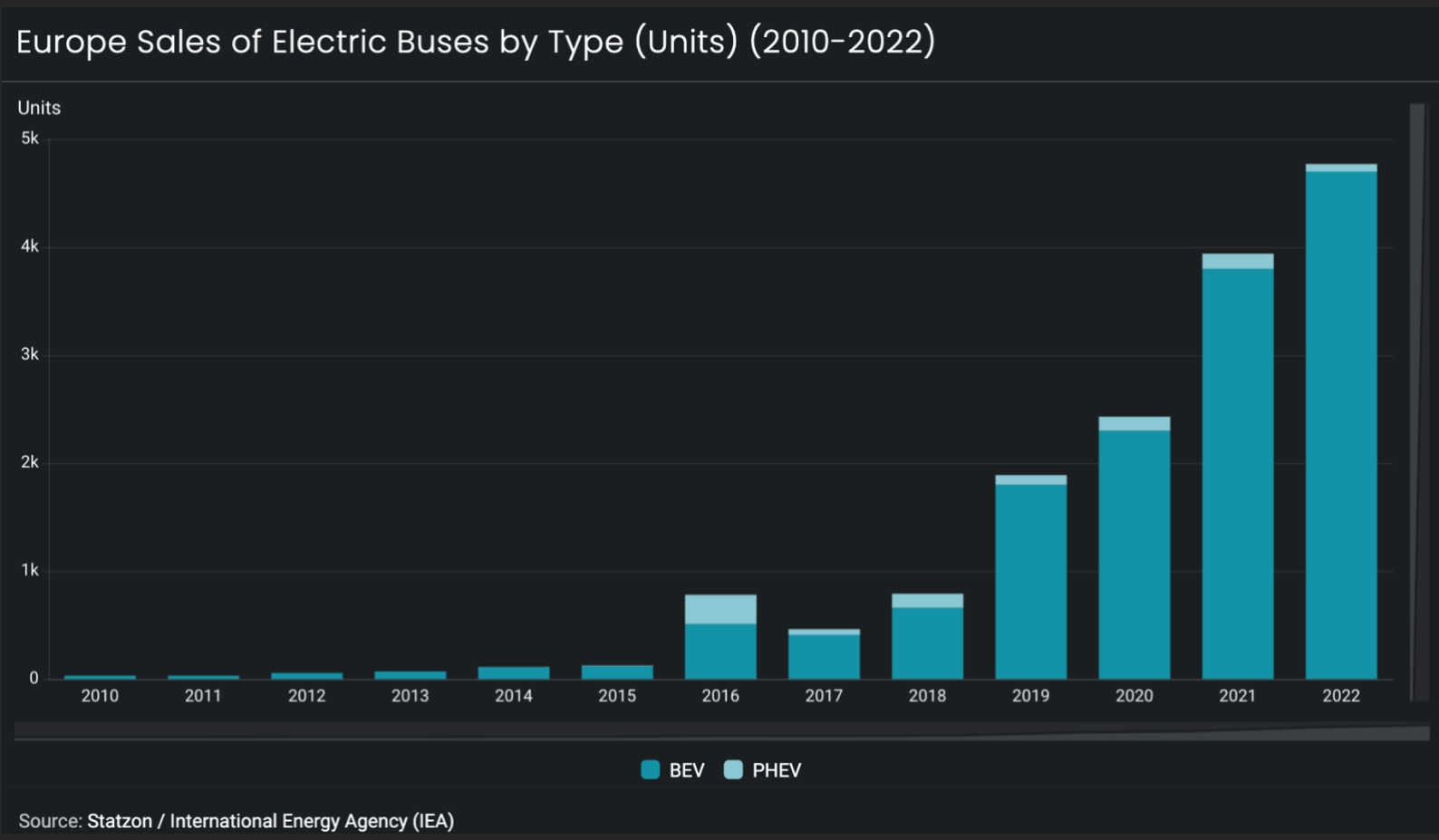
The EU Clean Vehicle Directive plays a critical role in this transition, mandating minimum quotas for the procurement of new zero-emission public buses by member states. The quotas vary by country, but generally, in Western European countries, at least 22.5% of the total bus fleet is expected to be zero-emission by 2025, increasing to 32.5% by 2030. This initiative is part of a broader movement towards sustainable transportation, as detailed in ING's 2021 report “All Aboard Europe’s Electric Bus Revolution”.

In 2022, Finland led Europe in electric bus sales, with two-thirds of all bus sales being electric. Norway and the Netherlands followed closely, with nearly half of their bus sales being electric, and Denmark with nearly one-third. Hybrid vehicles also play a significant role in the transition, particularly in Europe's larger countries. However, there is still considerable investment in natural gas engines in France, Spain, and Italy, indicating that while the shift towards electrification is well underway, it is not yet uniform across the continent.

While the European market is one of the leading regions for electric bus research and development (R&D) – including vehicle technology – the Asia-Pacific region is home to some of the biggest producers of both buses and batteries. However, in Europe, the market is accelerating slightly faster. Growing at a 21.6% CAGR, the highest among other regions, Europe's market value is expected to increase from USD 1.5 billion in 2021 to USD 5.8 billion by 2028, according to The Insight Partners.

IEA data shows there is a 21% increase in sales volume between 2021-2022 for electric buses. Sales up to 4,770 units from 3,940 units. Another 2,567 battery-electric buses were already registered in the first half of 2023. Though the number is still far behind China's, a

new record was achieved in Q1 2023 when the share of diesel-only vehicles sold dipped below its majority stake, giving way to battery electric to take a leading role. This marks the first time that zero-emission technology has become dominant in the road transport sector in Europe after over one hundred years, the internal combustion engine has reigned supreme.



The EU Clean Vehicle Directive sets minimum quotas for purchasing new zero-emission public buses for its members, although the quotas are different from country to country. The Directive mandates that Member States acquire 24% to 45% of their buses as alternatively fueled vehicles (excluding diesel-only buses) at the end of 2025. At least half of these targets must be met with zero-emission powertrains. Starting in 2026, these targets will rise to 33%–65%.

Finland led Europe in electric bus sales, with two-thirds of all bus sales being electric in 2022. Following Finland, Norway and the Netherlands each saw electric buses comprising nearly half of their total bus sales, while Denmark reported electric buses accounting for almost one-third of its sales. Hybrid vehicles have also become increasingly prominent in some of Europe's larger countries. However, there are still concerns over substantial investments in natural gas powertrain, particularly in countries like France, Spain, and Italy.

North America Electric School Bus Expansion Plan

North America is lagging behind APAC and Europe in the transition to electric buses. The region contributed USD 756 million to the global market in revenue, seizing around 2.6% of the total market share. The US, in particular, remains a long way from a complete transition to an electric fleet. The long lifespan of diesel buses is part of the problem. Most diesel buses last approximately 12 years, meaning it will take some time before they are up for replacement. Federal regulation also caps the number of buses that a transit agency may have, making it more difficult for them to add electric buses to their current fleets.

The region is catching up, focusing first on the country's iconic school buses. President Biden launched a plan to convert all 500,000 US school buses to zero-emission vehicles during his presidential campaign in 2020. Currently, school buses are run on diesel, but the limited daily mileage does not lead to significant savings, making a shift to electrification sensible.

As of June 2022, US school districts have committed to 12,275 electric school buses in 38 states, according to a report from the Washington DC-based nonprofit, World Resources Institute (WRI), consisting of more than 11,000 buses in awarded phase (funding or a contract for the bus has been approved or granted), 300 in ordered phase, 313 in delivered phase, 285 in operating phase. The number is almost a 10-fold increase from August 2021 data when WRI began tracking school electric buses nationwide.

By June 2023, the cumulative figure for electric school buses that have been ordered, delivered, or are operational stands at 2,277—an uptick of more than 1100 buses on the same phases since June 2022. Every state has now committed to transitioning their school bus fleets to electric models, and approximately one-third of U.S. school districts are under state or local mandates to initiate this switch. Nonetheless, there remains a substantial count of buses stalled in the 'awarded' phase, yet to proceed to ordering. In addition to that, the increment in buses that are operational is relatively modest when contrasted with the number of those delivered, suggesting a potential lag in the final stages of deployment.

Electric School Bus (ESB) Adoption in the US

Total number	June 2023	December 2022	September 2022	June 2022	March 2022
of commited ESBs	5,982	5,612	13,053	12,720	12,275
• of ESBs in "awarded" phase	3,705	4,214	11,838	11,616	11,375
• of ESBs in "ordered" phase	992	427	369	337	300
• of ESBs in "delivered" phase	844	633	535	465	313
• of ESBs in "operating" phase	441	338	311	302	285
of districts with committed ESBs	914	895	483	455	415
of states or territories with committed ESBs	54	55	39	38	38

Source: World Resources Institute (WRI)

STATZON

Electric Bus Market Segmentation

The electric bus market is segmented based on vehicle type: battery electric buses, hybrid electric buses, and plug-in hybrid electric buses. The battery electric bus segment is the market leader, with over 90% share in 2021. A higher acquisition cost of electric buses is justified because the overall cost is less expensive over the course of its lifetime. A fully electric bus also produces zero pipeline emissions compared to hybrids which sometimes run on fossil fuels. The hybrid electric bus and plug-in hybrid electric bus each gained a market share of 4% and 2% in 2021.

Segmentation by end-user is divided between the public and private sectors. The public segment held the largest revenue with 88% market share in 2021, while the private segment

is anticipated to expand rapidly at a CAGR of 22.4% during the forecast period. Many private bus operators experienced setbacks during the Covid-19 pandemic. Now, as lockdowns are being lifted, the surge of migration and tourism activities will positively impact the private transportation industry.

The electric bus market is segmented based on length into less than 9m, 9–14 m, and above 14m. Throughout the forecast period, the 9–14 m segment will dominate the market with around 50% market share. This segment makes up most of the electric bus fleet of China as it is ideal for city transit in terms of size, passenger capacity, and battery consumption.

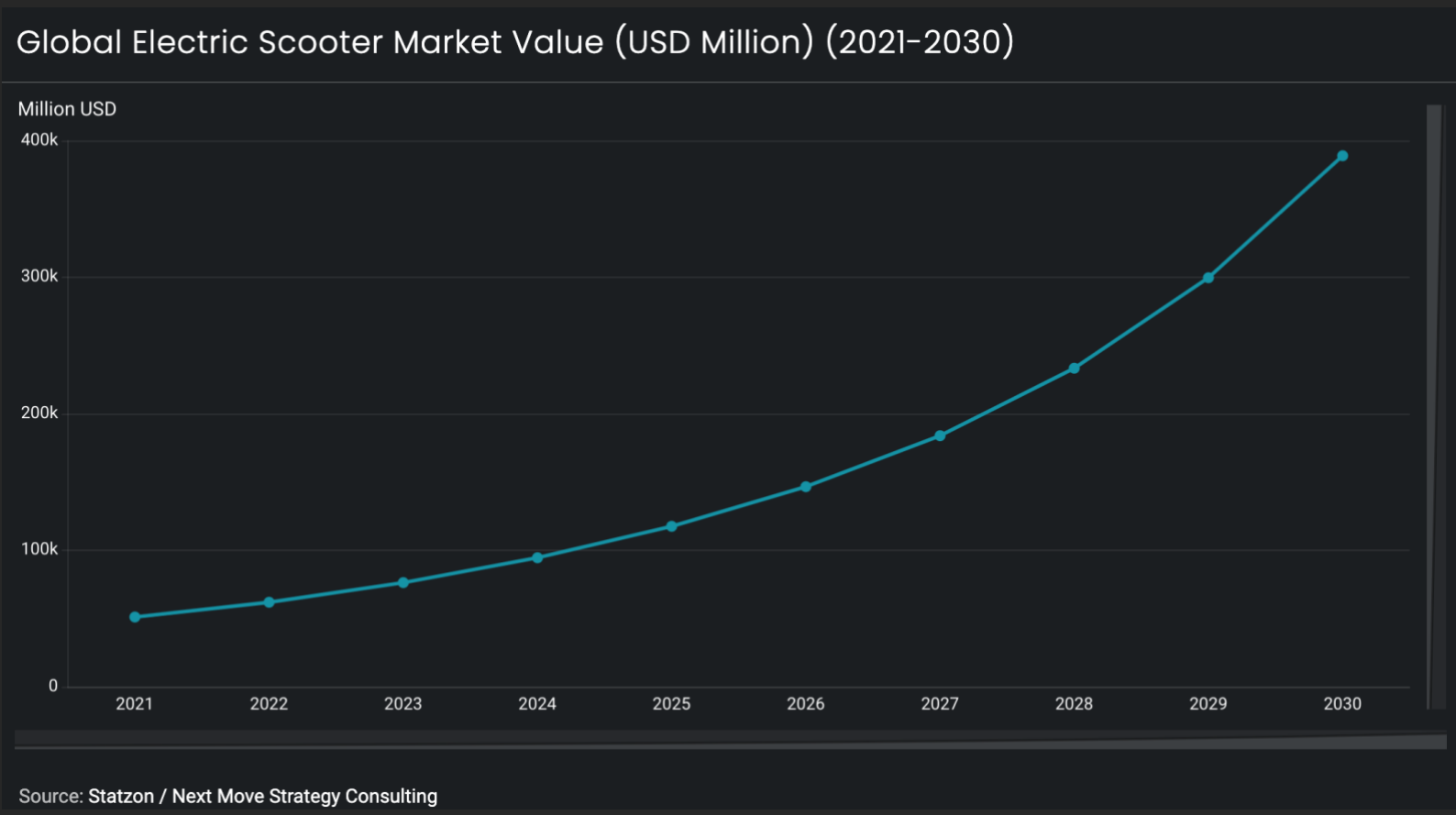
Sources: Statzon, Transport & Environment, ICCT, Sustainable Bus, Transition China, Global Times, CGTN, ING, Autonomy Paris, Electrek, Interact Analysis, Frotcom, BBC, IEA (1), IEA (2), ICCT, WRI, The Insight Partners' electric bus market report

Global Electric Scooter Market is Soaring at 25% CAGR

Electric two-wheelers, encompassing both electric motorcycles and scooters, represent a dynamic and rapidly evolving segment of the automotive industry. As a cleaner and more sustainable alternative to traditional gasoline-powered vehicles, these electric vehicles are gaining popularity worldwide, driven by advancements in battery technology, increasing environmental awareness, and supportive government policies. Their role in urban mobility is becoming increasingly significant, offering efficient, cost-effective, and eco-friendly transportation solutions for daily commuters and city dwellers.

Electric Scooter Market Size

Electric scooters have significantly dominated the electric two-wheeler market reflecting consumer preference for electric scooters as a preferred mode of urban transportation. According to Next Move Strategy Consulting, the global market for electric scooters is expected to accelerate at a 25.3% CAGR from 2022 to 2030. The market is anticipated to expand significantly, reaching an estimated value of USD 389 billion by 2030. This represents an increase of more than sixfold from its 2022 valuation of approximately USD 61.9 billion.



Electric scooters take up around 68% of the whole electric 2-wheeler market, based on data provided by Apollo Research Report. The other 32% is claimed by electric motorcycles. Within the whole e-mobility market, electric scooter is the second biggest segment after electric car, contributing around 18% of the total market share.

APAC Leads the Global Market, but Europe Strongest Growth Potential

Asia Pacific has the largest market share in the global electric scooter market thanks to significant investments in charging infrastructure and government subsidies for battery-powered scooters. The electric scooter market in this region was valued at USD 29.8 billion in 2022 and is expected to reach USD 162 billion by 2030 at a CAGR of 23%.

China, India, and South East Asia are the three biggest markets for electric scooters. China is the main market in the region with the biggest sales of electric scooters as well as the biggest manufacturing hub. In China, the world's largest market for electric vehicles, electric two- and three-wheelers are highly adopted. In 2021, about half of these vehicles sold were battery-powered, outpacing electric passenger cars. By 2022, China had approximately 350 million electric scooters, more than the number of private cars. These scooters are widely used not only in major cities but also in smaller cities and interior regions. For instance, in

Nanning, they make up nearly a third of all commutes, and in larger cities like Shenzhen and Shanghai, they account for over 20% of trips.

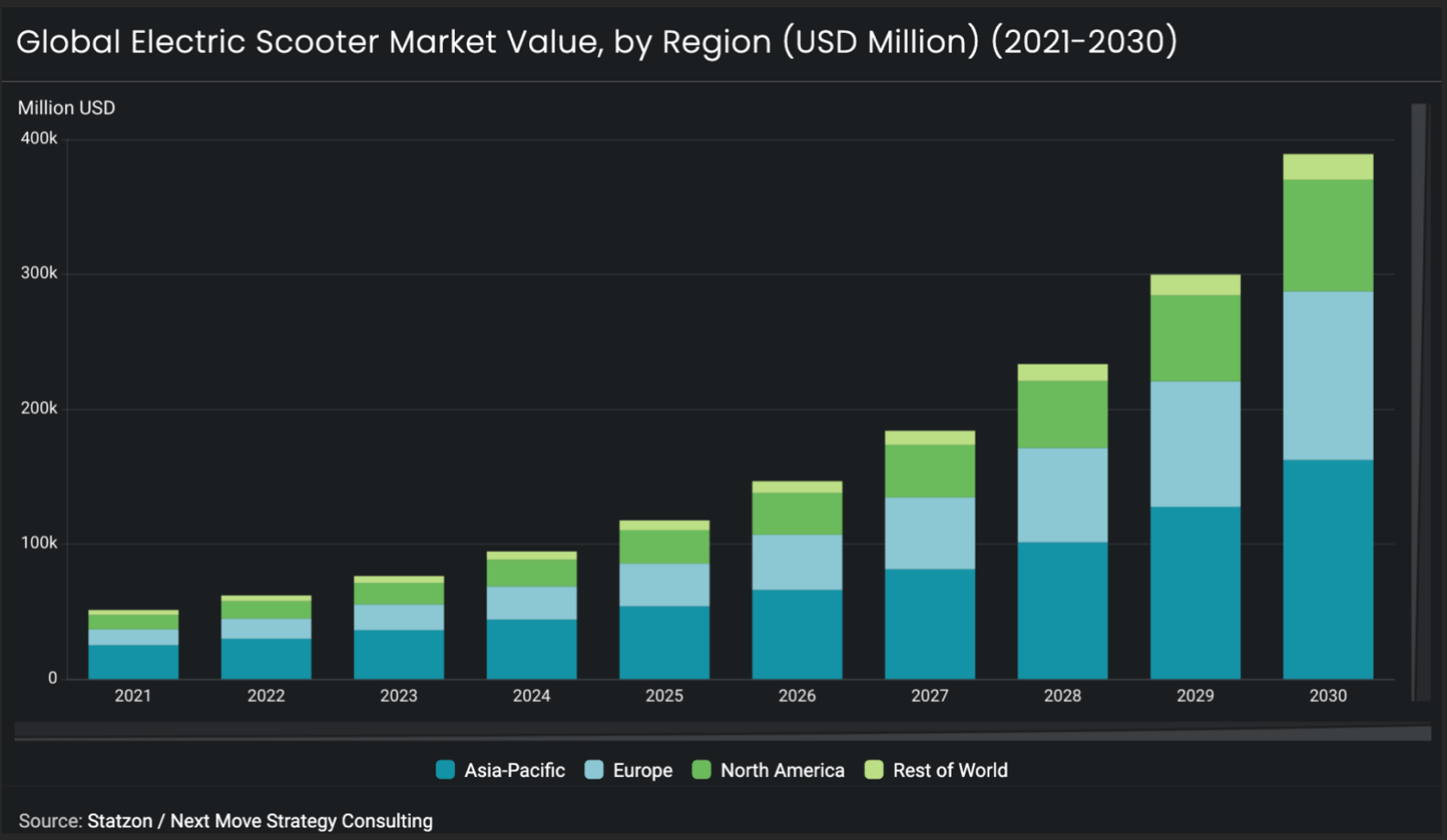
Meanwhile in India, the electric scooter market saw a significant increase in sales, reaching 652,643 units sold in 2022. This was a 347% jump compared to the previous year, making up about 4.5% of the total two-wheeler industry in India. With this growth, India became the second-largest market for electric scooters in the world, just behind China. The increase in sales was largely due to the support from the government subsidy program.

In other APAC countries like Indonesia, the Philippines, and Vietnam, sales of two-wheelers vastly outnumber cars. The shift towards electric two-wheelers is seen as a crucial step towards decarbonization and reducing urban air pollution.

Europe is the second biggest region in the global market, worth USD 14.9 billion in 2022. This region will experience the most robust growth at 30% CAGR during the forecast period. By 2030 Europe's market value will hit USD 125 billion, expanding its market share from 24% in 2022 to 32% by 2030. The adoption of electric vehicles remains at the forefront of many European countries' agendas toward reducing carbon emissions. Just as the sales of electric cars are soaring in this region, there is also a boom in the sales of electric scooters. More than half a million electric scooters roamed the European streets last June, up from 400,000 in February this year, according to modeling done by Zag, an online medium dedicated to reporting micro-mobility. With strong upward momentum in the market, electric scooter numbers could hit 600,000 by now.

Europe is the second biggest region in the global market, worth USD 14.9 billion in 2022. This region will experience the most robust growth at 30% CAGR during the forecast period. By 2030 Europe's market value will hit USD 125 billion, expanding its market share from 23% in 2021 to 32% by 2030.

In 2022, the European e-scooter market witnessed a remarkable surge, with Micro-Mobility for Europe (MMfE) reporting over 350 million e-scooter trips, a significant increase of 45.7% from the previous year, and a total distance of 640 million kilometers, marking a 36.8% rise from 2021. **Electric scooter safety concerns** are also being addressed in Europe and significant improvements in safety have been observed. The rate of injuries requiring medical attention dropped by nearly 20%, and the risk of fatality decreased by 17.7% compared to 2021. This is a promising development that can further encourage electric scooter adoption rates.



Sealed Lead Acid is Still the Most Preferred Option for Batteries

Based on products, the global electric scooter market can be categorized into folding, standing/self-balancing, and retro scooters. Although standing scooters have the highest penetration in terms of volume, the retro scooter segment is dominating the market in terms of value mainly because of its higher price point. Contributing more than 60% of the total market value, the retro scooter segment was valued at USD 38.6 billion in 2021. The folding scooter and standing/self-balancing scooter segments each claimed 12% and 25% share in the market, respectively, during the year 2021.

On the subject of batteries, sealed lead acid batteries are still the most popular option to be used by both electric motorcycles and scooters due to their robustness and low-cost benefits. Close to 75% of electric two-wheelers are running on this battery compared to the rest 35% that run on lithium-ion batteries. In terms of voltage, the 48V segment dominates the electric two-wheeler market, with more than 60% of electric scooters and motorcycles combined utilizing this voltage.

Sources: Statzon, China Daily HK, The Economist, MotorCyclesData, sixthone, MMFE

Electric Boat Market Set to Reach USD 10.7B by 2030

The wave of electrification has seamlessly sailed from land to water, marking the dawn of a new era in the boating industry. Manufacturers globally are navigating towards a cleaner future, ramping up the production of electric watercraft that range from pontoons to speedboats, ensuring emission-free products without compromising range and speed. This shift has not only attracted traditional titans such as Brunswick Corp. and Mercury Marine Corp. but has also spurred a plethora of innovative startups, pushing the boundaries of design and engineering in the sector. From the light sailboat IZIBoat, which even the inexperienced can power with an e-bicycle, to Candela's hydrofoiling technology that combines speed with silence, the electric boat market is brimming with advancements.

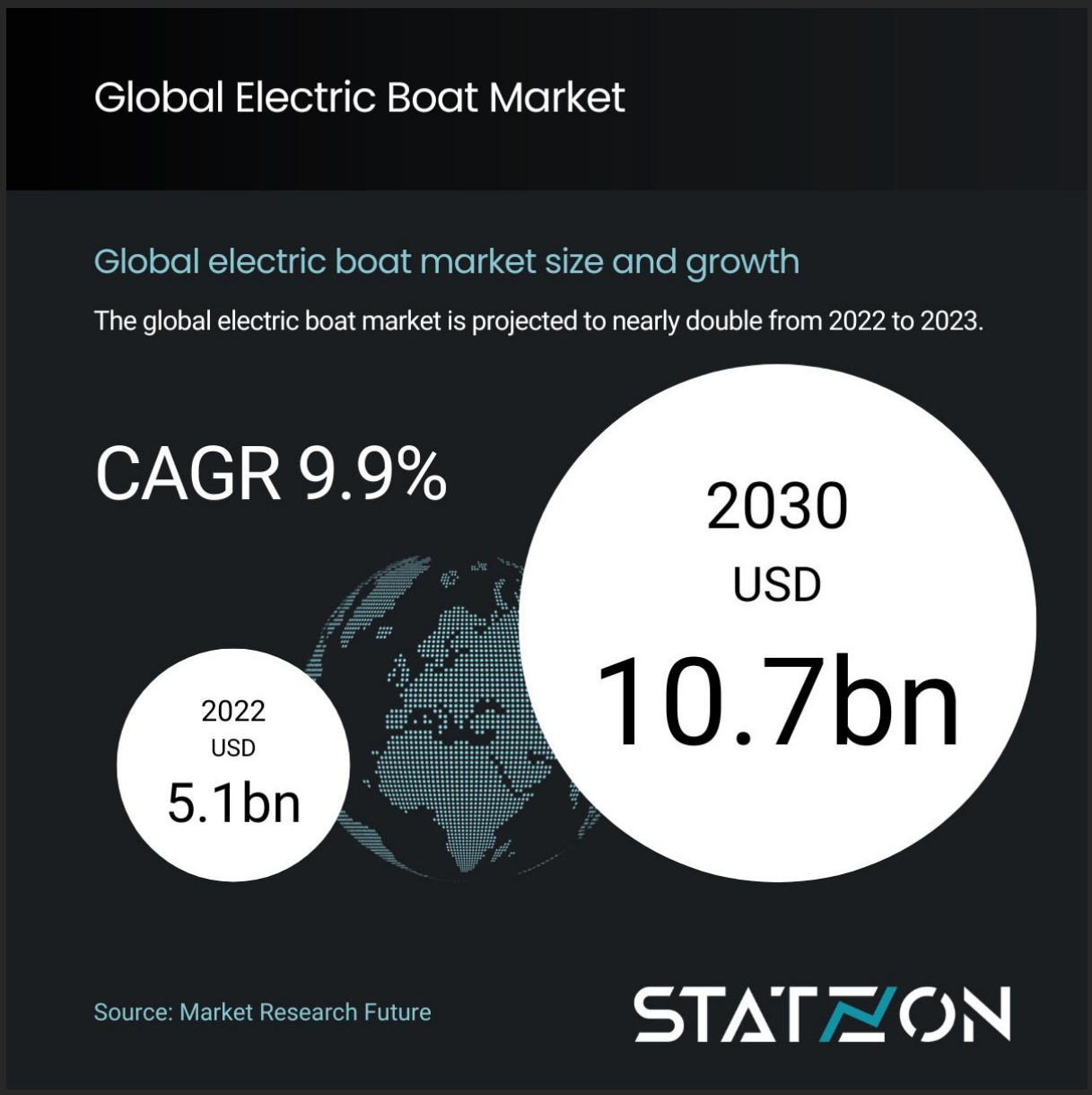
Significantly, Europe has emerged as the frontrunner in this electric revolution, with its countries integrating the boating sector into their climate-change mitigation plans. Governments are deploying various measures to decarbonize marine vehicles, as reflected in Amsterdam’s phasing out of diesel canal boats and Italy’s push towards electric boats. The impetus, however, stems from Europe’s robust seafaring economies and a commitment to reducing carbon emissions from transportation, which remains a substantial environmental challenge. Meanwhile, the U.S. is gradually catching up, with the focus primarily on land and air transport electrification. This progressive wave sets the stage for a comprehensive discussion on the burgeoning global market for electric boats, exploring the confluence of innovation, environmental concerns, and market dynamics.

Global Electric Boat Market Size and Growth

Valued at USD 5.1 billion in 2022, the global electric boat market is set for impressive growth, projected to nearly double to USD 10.7 billion by 2030, according to data from Market Research Future. Dominated by Europe, which held a 34.5% share in 2022, the market is expanding at a promising CAGR of 9.9% between 2023 and 2030. Following Europe's lead, North America and Asia-Pacific clinched 29.5% and 23.9% of the market share, respectively. A pivotal driver behind this surge is the global emphasis on emission reduction, bolstered by supportive government initiatives.

Moreover, the flourishing demand for recreational boating, especially in the tourism sector, acts as another robust market propellant. Offering unique customization opportunities, recreational boating captivates a wide tourist demographic, enhancing their marine experiences. The rise of boat-sharing platforms and organized tours has democratized access to boating, appealing to individuals who relish sea adventures without the tether of

ownership. With a combined focus on environmental sustainability and this expanded accessibility, the electric boat market is well-positioned for substantial global growth.



Electric Boat Market Hybrids and Battery Electric Boat

Examining the global electric boat market segmentation by propulsion type, it's evident that the hybrid electric boat segment is leading the charge, boasting a robust market value of USD 3.53 billion. The forecasts are promising, anticipating continued growth with a CAGR of 9.7%, aiming to reach USD 7.35 billion by 2030. On the flip side, pure electric boats made up approximately 30% of the total market in 2022, generating USD 1.5 billion. This segment is set to experience marginally accelerated growth, with a CAGR of 10.3%.

Passenger Carriages Dominate the Electric Market

Looking at the global electric boat market segmented by carriage type, the passenger segment stands out, holding 65% of the market in 2022, with a market value of USD 3.27 billion. This segment is anticipated to grow at a CAGR of 10.4%, aiming to reach USD 7.2 billion by 2030.

The growth in passenger electric boats is significantly driven by the tourism sector, as these boats are designed to transport people for recreational, tourism, or commuting purposes.

Conversely, the shift towards electric boats in the tourism industry is particularly driven by younger customers, especially millennials, who view mitigating climate change as a top priority. McKinsey has reported that 40% of millennials are voicing concerns regarding the environmental footprint of their boats, a sentiment echoed by 28% of Gen Xers and 24% of baby boomers. Additionally, interest in alternatively fueled recreational boats is significantly higher among millennials, with 60% expressing interest, as opposed to 45% of Gen Xers and 33% of baby boomers.

Eco-Conscious Tourism and Electric Boat Adoption

Notable examples of this shift include Maid of the Mist in Niagara Falls, NY, which pioneered the use of electric catamarans in 2020, and eco-friendly tour companies like Silent Whale Watching in Iceland, Berlin Solar River Cruise in Germany, and Electric-powered eco safaris in Botswana. These companies utilize electric and solar-powered boats for minimal environmental disruption, offering a more sustainable experience for tourists. These initiatives signify the growing acknowledgment and adoption of electric boats in response to consumer demand for greener tourism experiences.

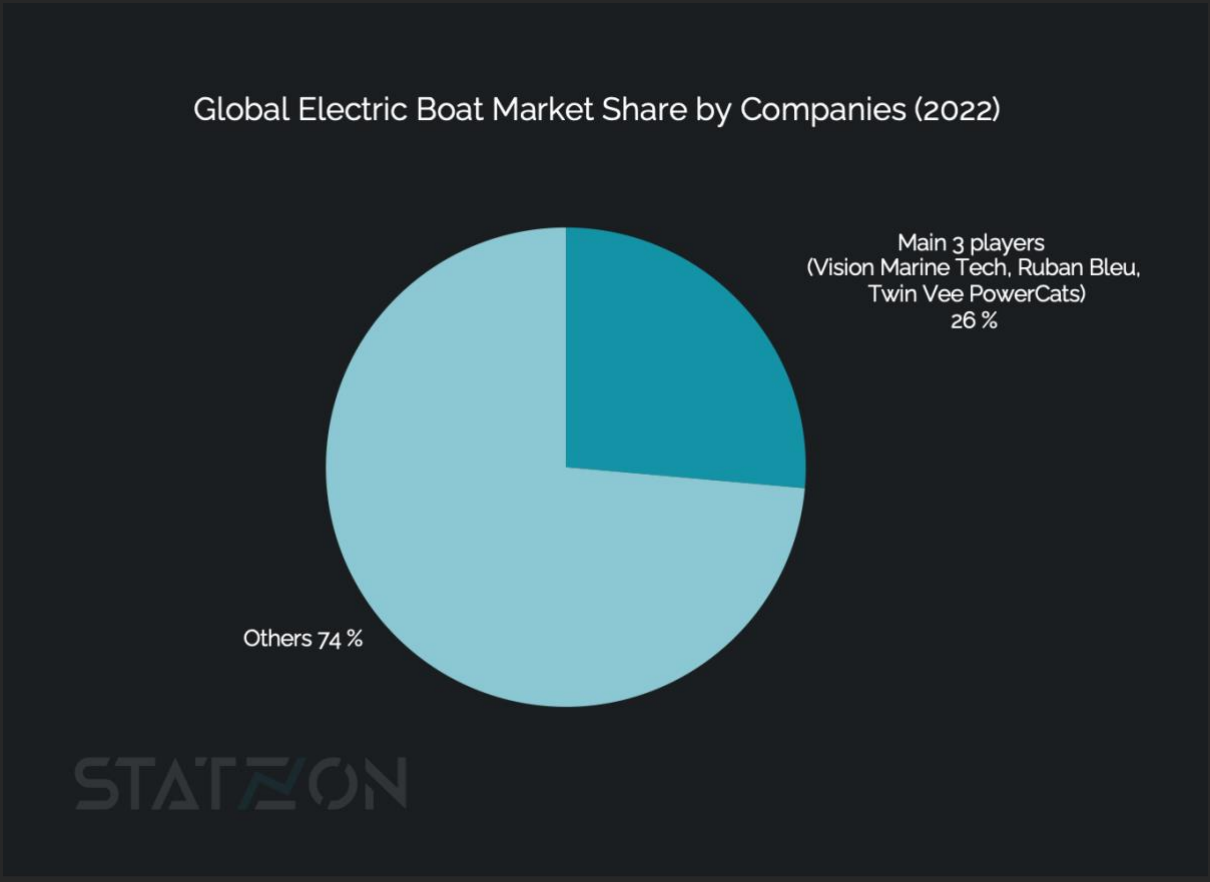
While the uptake of electric boats experiences a notable rise, especially within the passenger and tourism segments, certain hurdles like energy storage continue to persist. This challenge is particularly evident for larger entities such as cruise and freight companies, evidenced by the fact that the cargo segment currently constitutes only around 35% of the total market, as reported by The Insight Partners.

Developing batteries capable of powering larger vessels without significantly increasing weight is a key obstacle. However, the interest and ongoing research in this area suggest a promising potential for broader adoption of electric propulsion in marine travel, contributing to a cleaner and more sustainable future.

Electric Boat Market Share by Range

The electric boat market by range was prominently led by medium-range boats, capturing a 42% market share. They were closely followed by short-range boats accounting for 34%, and long-range boats holding a 24% share. Valued at approximately USD 2.1 billion, the medium-range segment is anticipated to experience a 10.0% CAGR, reaching around USD 4.6 billion by 2030. Similarly, short-range boats, valued at USD 1.7 billion in 2022, are on track for slightly higher growth at a 10.1% CAGR, with projections estimating a value of nearly USD 3.7 billion by 2030.

Top Companies in the Global Electric Boat Market



Source: Statzon/ Market Research Future

In the competitive landscape of the electric boat market, the intensity of rivalry is high, with major companies' market share being influenced by factors such as product differentiation, pricing, and innovation & technological advancements.

Vision Marine, Ruban Bleu, and Twin Vee PowerCats have been spotlighted by Market Research Future as the top three key players for their noteworthy product portfolios, extensive regional presence, and significant industry experience. Collectively, these companies control a substantial 26% of the overall market, highlighting their pivotal role in shaping the electric boat market. Additionally, names like Navalt, RAND Boats, Duffy Electric Boat Company, Nautique Boat Company, and GardaSolar are also recognized as key contributors, each bringing a unique approach to product range, performance, affordability, and eco-friendliness, thereby adding to the market's competitive dynamics.

Source: Statzon, Market Research Future's report on global electric boat market, Slate.com, Wahington Post, ecotourism-world.com, McKinsey

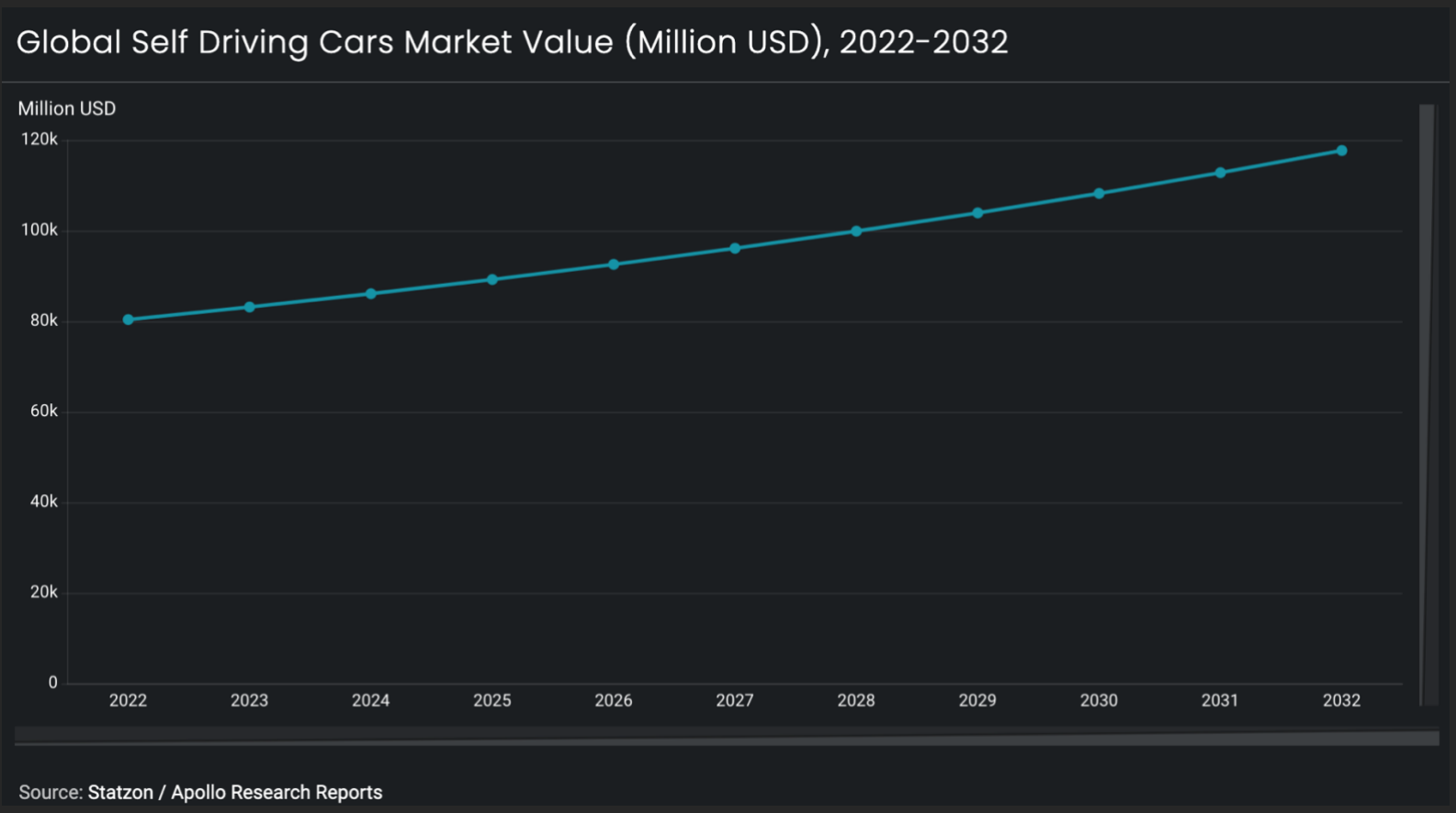
Global Autonomous Vehicle Market on A Slow Road to Full Potential

Autonomous vehicles have become one of the hottest topics in the automotive industry. Also known as self-driving cars, these vehicles are considered a breakthrough innovation with a potential market. Although it's an emerging market, and a vision of a fully self-driving car without human intervention will not be fully realized in the next few years, the market is already growing and thriving.

Global Self-Driving Car Market Size

The global autonomous vehicle market's value in 2022 was worth USD 80.3 billion and by 2032 will reach USD 117.7 billion at a 3.9% CAGR, according to market research conducted by Apollo Research Reports. The market's acceleration has been slower than anticipated, leading to investor frustration over the gradual progress in the development of driverless cars, despite previous ambitious goals and confident forecasts. This shift in investor sentiment has placed considerable strain on an industry previously supported by generous funding and flexibility. Responding to economic pressures and a shifting landscape, many automakers have scaled back their development plans for this technology.

Robot taxi services are already available in select markets, but widespread implementation of autonomous technology will not be realized anytime soon. Fully self-driving cars are expected to remain limited in certain geographical and climate areas for at least the next decade. In the next decade, as reported by S&P Global Mobility, autonomous technology is likely to be focused mainly on two areas: robot taxis operating within set boundaries and partially autonomous systems in personal vehicles, which will include safety features and still require some driver involvement.



Autonomous Vehicle Market by Autonomy Level

The autonomous vehicle market is segmented into semi-autonomous and fully autonomous categories. Semi-autonomous vehicles, including Levels 1 to 3, rely on shared responsibility between the driver and vehicle technology for driving and safety. Fully autonomous vehicles, classified as Levels 4 and 5, can operate without human intervention.

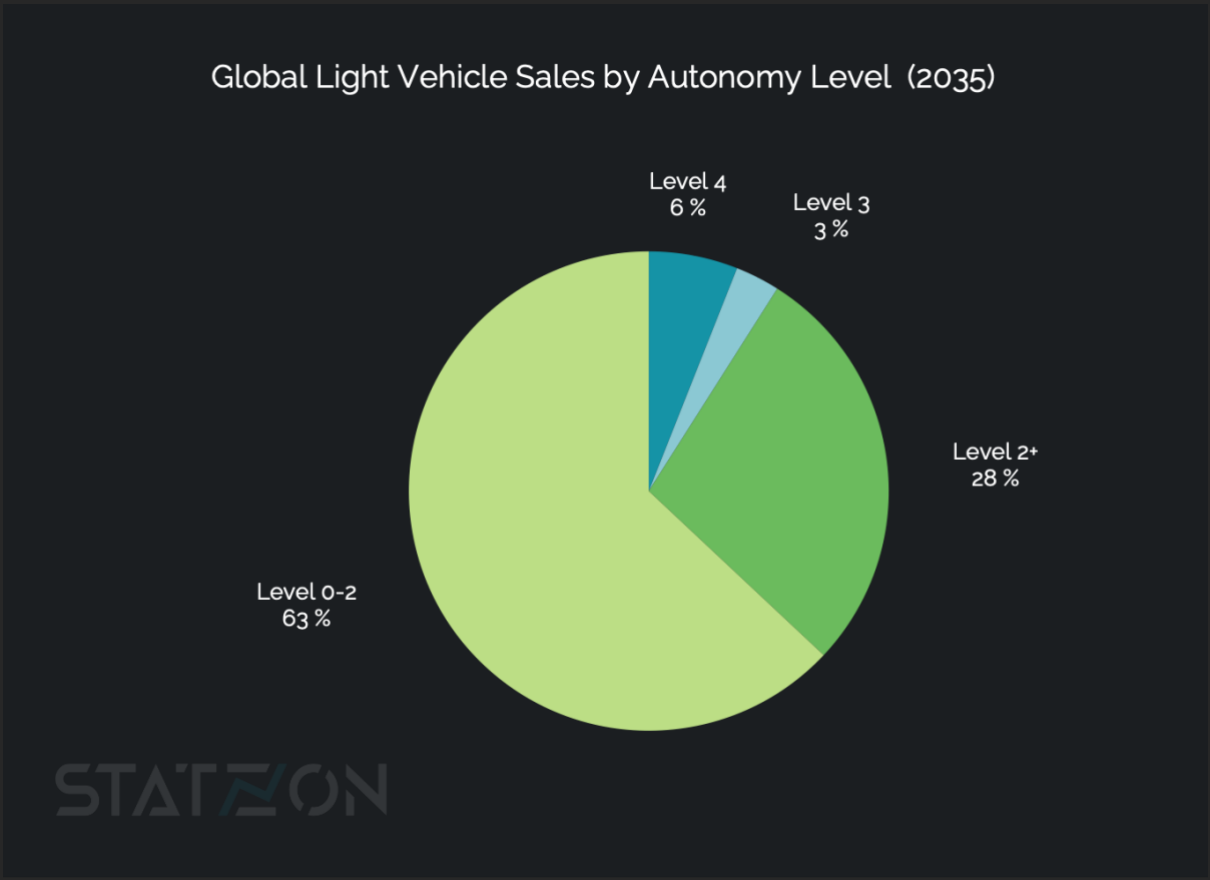
The current autonomous vehicle market is evolving around semi-autonomous driving. Definitely less emphasis is given to fully autonomous technological advancement.

Level 2 autonomy, featuring in systems like Tesla's Autopilot and General Motors' Ultra Cruise, is now a standard or optional feature in higher-end cars. These systems are advancing, gradually moving beyond Level 2. The transition from Level 2 to Level 3 represents a significant functional leap. Mercedes' Drive Pilot exemplifies this advancement, certified as the first Level 3 conditional automated driving system in the U.S. It allows limited eyes-off driving, requiring drivers to be ready to resume control quickly, and will be available in Mercedes S-Class and EQS sedans from the 2024 model year.

Drive Pilot stands out for its ability to operate in high-density traffic at speeds up to 40 mph, interpreting traffic signs and performing emergency maneuvers. This contrasts with many Level 2 systems that are limited to freeway driving. The deployment of Level 2+ and Level 3 systems is expanding, with forecasts suggesting they will constitute at least 31% of new

vehicle sales globally by 2035. These systems enable hands-off driving while requiring driver supervision, or complete disengagement in specific scenarios.

Level 5 autonomy, capable of matching human driving in any scenario, is not expected to be available before 2035. Research done by S&P Global Mobility indicates that while Level 5 remains distant, the implementation of technologies in Levels 2+, 3, and some Level 4 applications is progressing more rapidly and will likely be realized sooner. This indicates a market trend towards more targeted uses of autonomous technologies in the near term, with full autonomy remaining a longer-term goal.



Source: S&P Global

Autonomous Vehicle Market by System

Adaptive Cruise Control (ACC) and Adaptive Front Light (AFL) systems are integral components of self-driving cars, enhancing safety and driving efficiency. ACC allows vehicles to automatically adjust speed to maintain a safe distance from other vehicles, while AFL improves visibility during night driving by adjusting the headlights based on the vehicle's speed and steering. These systems are pivotal in the advancement and functionality of autonomous vehicles.

In 2022, the market value for ACC in autonomous vehicles was approximately USD 39.26 billion, a figure that is projected to grow to about USD 57.46 billion by 2032. This growth trajectory indicates a CAGR of approximately 3.9%, reflecting the increasing adoption and technological advancements in ACC systems within the autonomous vehicle industry. critical role in the operation and appeal of self-driving cars, encompassing advanced technology and being a key factor for consumers seeking comprehensive autonomous driving features.

Similarly, the AFL system, crucial for enhanced visibility and safety in self-driving cars, had a market value of around USD 19.41 billion in 2022. By 2032, it is forecasted to grow to approximately USD 28.49 billion, also with a CAGR of about 3.9%.

Additionally, the "other" systems segment in the autonomous vehicle market constituted approximately 22.7% of the total market value in 2022.

Autonomous Vehicle Market Share by Type of Mobility

Shared mobility is increasingly becoming the focal point in the autonomous vehicle (AV) industry, profoundly shaping AV system development. At the forefront of this transformation are robo-taxis, with companies like Cruise and Waymo leading the charge. These services, operating within precisely defined geofenced areas, are representative of the growing shift towards Mobility as a Service (MaaS). Waymo, having launched commercial services in Arizona suburbs, is now extending its testing to major cities in California. Similarly, Cruise is making strides with its public robo-taxi services in San Francisco and beyond.

The substantial costs associated with AV technologies, including cameras, radar, and lidar sensors, render them less practical for personal vehicles. However, they are proving invaluable for taxi and ride-sharing services that aim for round-the-clock operation. In 2022, the shared mobility sector eclipsed personal mobility in the AV market, securing a commanding 74% share. This dominance is anticipated to persist, with shared mobility expected to hold 65% of the market by 2030, continuing to overshadow personal mobility.

US and China Racing to Top Position

The US is the second-largest automotive market in the world and is currently at the forefront of the race toward fully automated vehicles. The country's self-driving vehicle market was valued at USD 17.2 billion in 2022 and is projected to reach USD 26.6 billion by 2032. The US has been a long-time leader in autonomous driving technology, steered by tech hubs on the west coast with companies like Uber and Tesla making headlines for both successes and failures. However, in 2022, China, with a market value of USD 7.8 billion, less than half of the US market, is rapidly advancing in the field of Advanced Driver-Assistance Systems (ADAS). The country is actively developing standards for assisted and autonomous driving and aims

to become a leader in intelligent connected vehicles by 2025, a sector still in its early stages.

In the first half of this year, new passenger cars featuring autonomous driving functions made up 42.4% of the nation's total passenger car sales, showing a notable year-on-year increase of 10%.

China already overtook the US as the world’s largest automobile market in 2009. The country certainly enjoys favorable regulations and policies allowing the testing of self-driving cars in many cities. The US, on the contrary, has states' state-specific regulations without any nationwide authorization for testing. When a self-driving test vehicle crosses from California into Nevada, for example, it must stop first to change plates so it can continue the test in the new state. The regulatory roadmap that will allow. self-driving cars to be deployed on a mass scale is still far from ready.

But China also has its own problem. Production of autonomous vehicles in China is highly dependent on chips designed by foreign companies, mostly US groups Nvidia, Qualcomm, and Intel. Chinese chip industry is on the rise led by companies like MetaX Integrated Circuits and Biren Technologies trying to compete with western production. Yet they are still years behind their US rivals.

Consumer Attitudes Toward Autonomous Driving

Are we ready for autonomous driving?

Although there remains a strong interest in autonomous driving, c Consumer attitudes toward autonomous driving have shown a cautious shift, with McKinsey's 2021 Autonomous Driving, Connectivity, Electrification, and Shared Mobility (ACES) survey revealing a decline in the willingness to consider adoption of self-driving cars. The survey showed that readiness to switch to a private AV dropped nearly ten percentage points, with only 26 percent of respondents in 2021 expressing a preference for fully autonomous cars, compared to 35 percent in 2020.

This trend is further corroborated by the J.D. Power 2023 US Mobility Confidence Index (MCI) Study, which indicates a continuous decrease in autonomous vehicle acceptance for the second consecutive year. The MCI index score for consumer AV readiness fell to 37 (out of 100), which was 5 points lower than the score in 2021. This decrease in confidence is attributed to limited public knowledge about AV technology and negative media coverage focusing on robotaxi and testing failures.

However, the J.D. Power study also highlights the impact of firsthand experience on consumer perceptions. Consumers who have ridden in a robotaxi in cities like Phoenix or San Francisco showed a significantly higher MCI index score of 67, almost double that of those who haven't had such experiences. This suggests that direct interaction with AV technology can greatly enhance consumer comfort and trust.

The study also notes that consumer comfort with AVs is higher in regions like the West of the U.S., where there is more familiarity with AV testing and deployments. Despite these

regional variations, there is a general trend towards increased skepticism and a need for more education and positive exposure to improve consumer acceptance of autonomous vehicles.

JD Power also noticed misconceptions about autonomous vehicle capabilities. While many can accurately identify available AV delivery services and robotaxis, there's a misunderstanding about the automation level of personal vehicles, with 22% incorrectly identifying Tesla's "Autopilot" as fully automated.

In terms of market readiness, the McKinsey ACES survey reveals diverse consumer attitudes towards autonomous driving (AD) features pricing, depending on their driving habits and needs. Frequent drivers, for example, tend to see more value in AD features, while parents primarily using cars for short trips may be less enthusiastic. This variation in consumer preferences suggests the importance of offering different pricing options in the market.

To cater to these varied needs, OEMs and dealerships could consider implementing flexible pricing models. These could include a fixed one-time fee for certain AD features, subscription-based services for ongoing use, and even pay-per-use options, such as an hourly rate for specific functionalities like a traffic jam pilot. The survey indicates that consumer preferences are split: 20% of interested respondents favor a subscription model for ADAS features, nearly 30% prefer a pay-per-use approach, and about 25% are interested in the ability to upgrade their vehicle with additional ADAS features after purchase.

Sources: Statzon, The Verge, MIT, WE Forum, McKinsey (1), McKinsey (2), McKinsey (3), UBS, Financial Times (1), Financial Times (2), programbusiness.com, S&P Global, usnews.com, China Daily, JD Power, wardsauto.com

Electric Mobility in 2024: Emerging Trends and Innovations

As we step into 2024, major markets including Europe, the United States, and China will continue their steadfast transition to electric mobility, building upon the successful and steady acceleration witnessed in recent years. Other global markets are also expected to follow suit, embracing the shift towards electric vehicles. This year is set to be a defining moment for the EV industry, spotlighting a range of promising trends and forecasts that are shaping the future of transportation worldwide

Connectivity

The advancement of connectivity and digitalization in the automotive industry is shaping up to be a key trend, holding significant potential to influence consumer preferences and driving experiences. According to a 2021 McKinsey study, Chinese consumers are particularly receptive to these features, willing to pay twice as much as their Western counterparts for connected car technologies. This trend suggests that while electrification might become a standard expectation, the real game-changer could be the consumer-friendly, connected features of vehicles. In China, for example, 56% of consumers expressed a willingness to switch car brands for better connectivity.

Further highlighting the importance of connectivity, a 2023 survey by The Bureau of Energy Efficiency (BEE) found that 85% of electric two-wheeler users appreciated IoT features for enhancing their daily commutes. Smart mobility solutions, integrating data from GPS, traffic cameras, and weather forecasts, are set to streamline travel by providing efficient routes, reducing travel time and road congestion.

Vehicle-to-vehicle (V2V) communication is another aspect of this connected landscape. It allows cars to share information about speed, position, and direction, enhancing safety through early collision warnings and supporting autonomous driving features. In emergency situations, V2V communication can play a crucial role in preventing accidents and saving lives.

Digitalization and Display

The latest cars are increasingly catering to the digitally-savvy driver, with vehicle interiors transforming into digital hubs, akin to "smartphones on wheels." This transformation

is evident in the reduction of hard keys, the introduction of larger displays, and an enhanced focus on the passenger experience. Car manufacturers and suppliers are exploring various methods to display information within the vehicle, ranging from dashboard-spanning displays to tablet-like screens in various orientations. The role of hardware in providing a digital experience is growing, but the software powering these systems is becoming equally crucial.

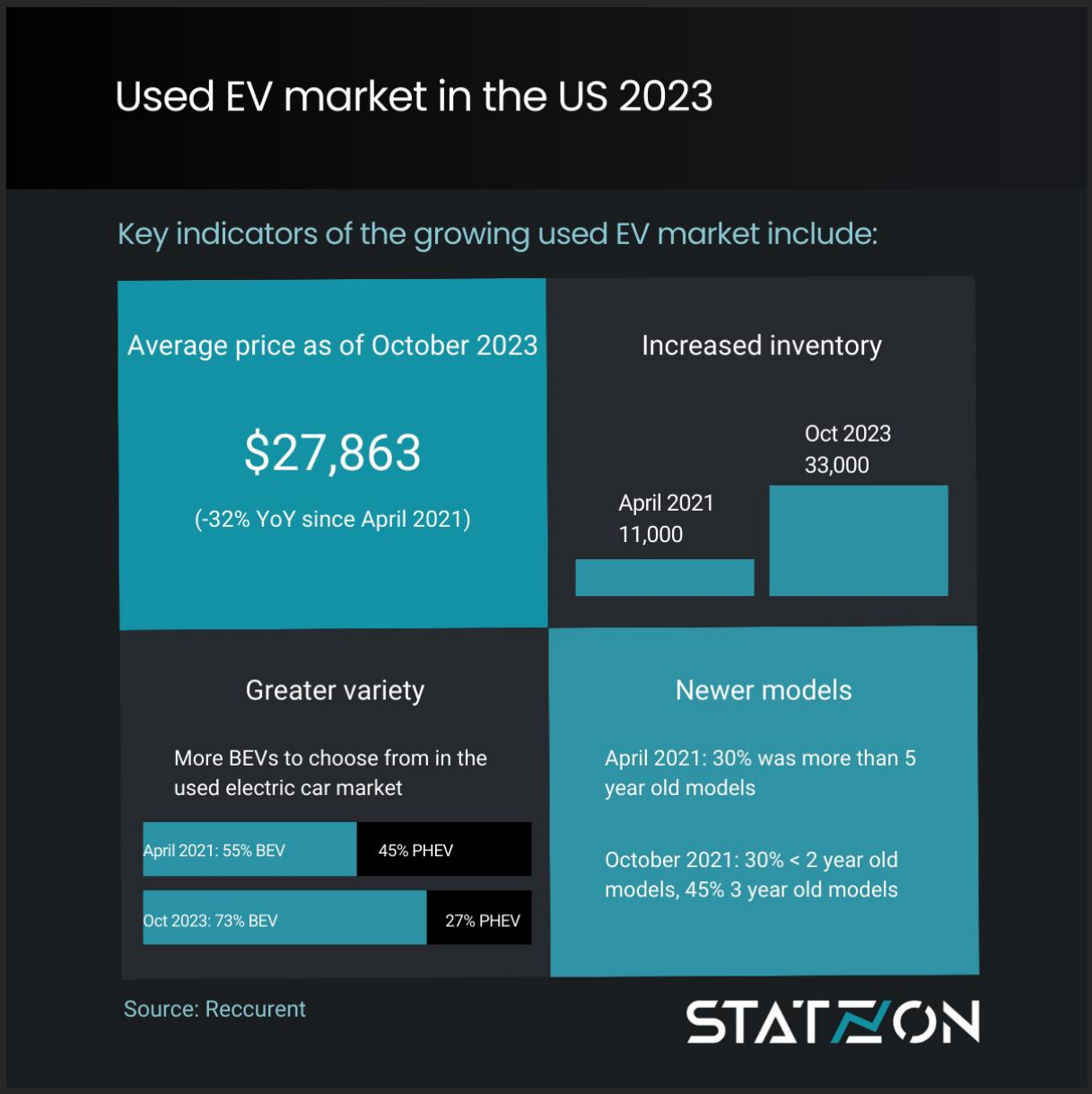
In 2024, expect to see electric vehicles (EVs) seamlessly woven into broader smart ecosystems. They'll communicate with smart home devices and smartphones, offering real-time updates on traffic and weather. This trend of digitalization is not just about integrating advanced technology; it's about reshaping the driving experience to mirror the convenience and interconnectedness we've become accustomed to in our digital lives.

Used Cars Electrification

As electric vehicle (EV) sales begin to stabilize, especially in early adoption markets, the role of used EVs in boosting the transition to greener transportation modes becomes increasingly prominent. The initial surge in EV demand was largely driven by the anticipation of the end of subsidies and incentives, particularly for orders placed for electric cars in 2021 and 2022. Markets like Norway, known for their early adoption of battery electric vehicles (BEVs), are now witnessing a clear increase in used car sales activities. As many early adopters are now opting for newer, more technologically advanced EVs, increasing the availability of used EVs in the market. This trend is creating a vibrant second-hand EV market, offering more affordable options for those interested in electric mobility but deterred by the cost of new models.

Countries like the US are actively encouraging the shift to electric vehicles (EVs) by making the used car market more appealing. The U.S. Inflation Reduction Act is a key example of this, offering credits that significantly reduce the cost of acquiring a new or used EV. By focusing on both new and second-hand EV markets, the Act catalyzes the expansion of EV adoption, tapping into the considerable potential of the used vehicle sector to drive forward sustainable transportation. This is particularly impactful given that in the U.S., the used vehicle market constitutes a significant portion of the automotive sector, representing about 65 percent of annual passenger vehicle sales and leases.

The average price of a used electric car in the US according to Reccurent's price index is USD 27,863 - the lowest since 2021, reflecting a significant 32% YoY reduction. This price reduction is accompanied by key developments in the used EV market, including a substantial increase in available inventory and a shift towards a greater proportion of BEVs compared to plug-in hybrids (PHEVs).



Influx of Chinese EVs

Predictions of an influx of Chinese BEVs into Europe have been around for quite some time. As China's electric vehicles become increasingly affordable, the opposite trend is happening in Europe and the US with EV prices on the rise. This difference in pricing dynamics makes Chinese EVs particularly appealing in the European market. Europe's situation is unique compared to the U.S., where the Biden administration's tax credits for EVs are contingent on North American-made battery components, an incentive absent in Europe. Additionally, Mexico is emerging as a strategic location for Chinese EV manufacturers, reflecting their growing influence in the global EV market.

China's expansion in the European car market has been both rapid and significant. As of September 2023, Chinese brands represented nearly 4% of the EU's battery-electric vehicle sales, a dramatic rise from just 0.4% three years prior, according to ACEA. This surge is especially evident in the pure battery electric car sector. By September 2023, Chinese manufacturers had sold 86,000 battery electric vehicles in Europe, almost equalling their total sales for the entire previous year. When hybrid vehicles are taken into account, the market share of Chinese brands in Europe rises to 5.6%, encompassing both pure electric and hybrid vehicles. This marks a significant increase from a modest 1.1% in 2020, as per data from Bloomberg.

The appeal of China's EVs is not limited to pricing; they also compete in terms of quality and performance. For instance, China can produce electric cars with substantial horsepower at a more affordable price than the European average. An example is the BYD Seal, a midsize sedan with 204 hp, offered in China at a price comparable to the Renault Twingo Equilibre in Europe.

The Shift to Cheaper Batteries

The automotive industry's shift towards more cost-effective EV batteries in 2024 is set to be a pivotal factor in making electric vehicles more accessible to the mass market. Lithium Iron Phosphate (LFP) batteries are gaining traction due to their lower production costs and the scarcity of cobalt, a key component in lithium-ion batteries. This shift plays a key role in helping EV firms continue cutting prices and developing more attractive pricing strategies for the mass market.

Lithium-ion batteries, particularly those using nickel, cobalt, and manganese (NMC) or aluminum (NCA), have been the mainstay for EVs due to their high performance and range. However, LFP batteries are now emerging as a viable alternative. In the Chinese market, LFP batteries are already predominant, and their adoption is beginning to increase in North America and Europe.

Market leaders like Tesla and BYD are pivoting towards these less expensive battery technologies. Tesla already announced in October 2021 that it was switching to LFP batteries for its standard range models, both Model 3 and Model Y. While it still relies on nickel-based chemistries (predominantly NCA) for its high-range and performance models, Tesla's shift to LFP, including its plans to incorporate these batteries in its future semi-trucks and buses, marks a significant change.

BYD is also making significant strides by developing sodium-ion batteries, offering a more budget-friendly alternative to traditional lithium batteries. Moreover, the German luxury car brand has set a 2024 target to start adopting LFP batteries, with BMW following suit by investing in LFP technology for a 2025 release.

Ford is not far behind in this trend, with plans to equip the 2024 Mustang Mach-E with LFP packs, expanding on the usage seen in some of its Standard Range models. NIO is also part of this movement, having recently introduced an LFP battery pack option for its ES6 and ES8 models.

General Motors (GM) is joining the shift with plans to incorporate LFP packs in the updated Bolt EV. Similarly, Hyundai Motor Group is actively developing its own cost-effective LFP batteries, aiming to lessen its reliance on batteries made in China.
Hyundai anticipates completing its LFP battery development by 2024 and plans to implement them in various vehicles, including small and entry-level electric cars and mid-priced EVs, starting in 2025.

Source: Forbes (1), Forbes (2), autovista24, AutoEXPRESS, McKinsey, Korea Herald, Euromonitor, Bloomberg, Recurrent

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