STATZON

# Electrifying the Future:

## A Comprehensive Handbook on the EV Market

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# Author

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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 was 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 e-mobility market
- Global electric bus market
- Global electric scooter market
- Global autonomous vehicle market
- Global battery market
- Europe EV market

# E-mobility: Electrifying the Way We Move

How do we define e-mobility? Gartner defines electro mobility, or e-mobility for short, as the use of electric powertrain technologies, IT technologies, and connected infrastructures to move a vehicle. Powertrain technologies include fully electric vehicles, plug-in hybrids, as well as hydrogen fuel cell vehicles that convert hydrogen into electricity.

The image of an electric vehicle, or EV, probably comes to mind when we talk about e-mobility. The rise of electric vehicles has been talked about in recent years. Euromonitor reported the registration of EVs has grown more than triple between the years 2017 to 2021 from 3.7 million units to 11.8 million units. It is clearly a fast-growing market.

However, it is important to remember that e-mobility is much more than just passenger cars. The development of e-mobility should also be accompanied by the development of transportation in all forms: e-buses, car sharing, e-scooters, e-bikes, bike paths, pedestrian areas, and others because reworking the mobility network means revolutionizing the culture that influences how people choose their mode of transportation.

## Basic breakdown of electric vehicles

Electric vehicles come in different types. Some electric vehicles can rely on fuel cells or gasoline generators to provide electricity instead of powerful battery banks. The unifying factor is that every electric vehicle includes an electric motor to drive the vehicle, either alone or in combination with a gasoline-reliant internal combustion engine (ICE).

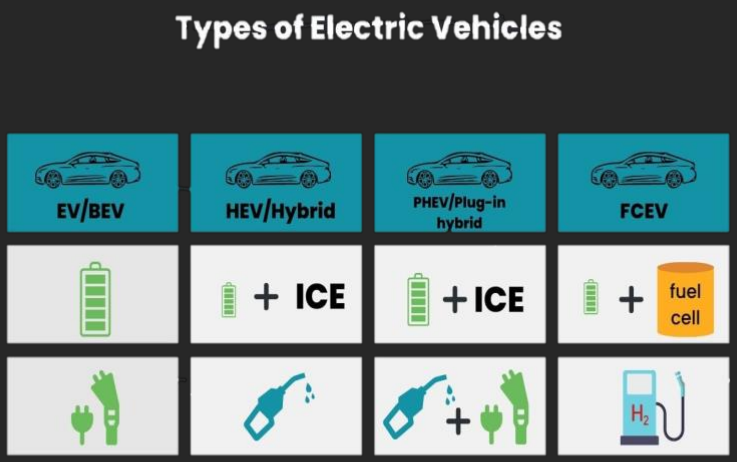
One very basic of EVs breakdown is the following:

**EV/BEV**: Electric vehicles/ Battery Electric vehicles. These are pure electric vehicles relying on a rechargeable battery as the power source to run the vehicle. They can be charged at a power station either at home or at a charging station.

**HEV**: Hybrid electric vehicles that use both electric power and the traditional internal combustion engine (ICE) that runs on gas. The electric batteries are charged autonomously through energy from the gas engine. It also uses regenerative braking, meaning the vehicle captures energy every time driver hits the brake and saves it for later use.

**PHEV**: Plug-in hybrid vehicles are a variety of hybrid electrics that can be plugged in to charge with a larger battery than normal hybrids (HEVs). The vehicle can be charged at home or at public stations just like an EV. For some people, this is a nice compromise as it gives you a taste of EV with the security of a gas tank when doing long trips.

**FCEV**: Fuel cell electric vehicles that run on compressed hydrogen that is combined with oxygen inside a fuel cell stack to generate electricity. No electric batteries are used in this type of vehicle




## How much cleaner is e-mobility compared to conventional transport mode?

When vehicles are running on electricity, they produce zero tailpipe emissions, but emissions may be produced by the source of electrical power such as a power plant. In areas that use relatively clean sources for electricity then the electric vehicles will have lower well-to-wheel emissions in comparison to conventional vehicles running on gasoline or diesel. In regions heavily dependent on coal for electricity, the well-to-wheel emissions will increase even when the vehicle is running fully on electricity.

Transport & Environment Organization found out that in the worst-case scenario, an electric car with a battery produced in China and driven in Poland still emits 37% less CO2 than cars running on gasoline. And in the best-case scenario, an electric car with a battery produced in Sweden and driven in Sweden, the emission is 83% less.

Another study by International Council and Clean Transportation (ICCT) was looking at the amount of greenhouse gas emissions created by EVs in different countries. Fully electric vehicles by far produced the lowest emissions compared to other cars with different types of powertrains. Medium-size EVs' greenhouse emissions are lower than comparable gasoline cars by 66%–69% in Europe, 60%–68% in the United States, 37%–45% in China, and 19%–34% in India.

## Vehicle's Well-to-wheels CO2 Emissions by Power Train

World Average (gCO2-eq/km)


Possible Range of Emissions (gCO2-eq/km)

| | |
|---|---|
| ICE | 151-245 |
| EV/BEV | 0-187 |
| HEV | 101-189 |
| PHEV | 44-187 |
| FCEV | 0-367 |

Source of data: International Energy Agency data 2021

## Barriers to EVs' adoption

As of today, electric cars are not yet riding the mainstream wave. A study by Appinio shows that only one out of ten drivers in the US drives a fully electric or plug-in hybrid. In fact, most non-owners have never even sat inside an electric car although the desire to try it out is great.

Range anxiety remains a barrier to the widespread adoption of EVs. Battery capacities of current EVs range from 17.6 kWh in the Smart EQ, which translates to a maximum of 58 miles drive, to 100 kWh in the Tesla Model S which offers a maximum range of 351 miles. More recently, Lucid Air became the world's longest-range EV offering 520 miles of driving range.

When it comes to the act of purchase, nothing is as important as the price. Electric vehicles are perceived as expensive, especially when people keep associating EVs with Tesla which positions itself as a luxury brand.

EVs have a higher up-front cost than gasoline cars but are less expensive over the course of their lifetime, mainly because electricity is relatively affordable. The average price of an EV in the US in 2022 is about USD 66,000. By comparison, mid-sized cars are about USD 32,000 and full-sized cars are USD 44,000. EV sticker price is more aligned with the price of a luxury car than mainstream.

Despite many forecasts saying the price of EVs will go down over the years, the pandemic actually increased the price of EVs even more due to shortages of batteries, lithium, and components like semiconductors. Demand for EVs is still strong, however, especially from affluent buyers, making manufacturers more inclined to produce luxury EVs.

Charging issues is another barrier to EV adoption. The issues include problems such as charging speeds, charger inaccessibility, cost of chargers, and charging variance by vehicles.

Charging points are relatively easy to find in urban settings. They are available on popular roadways, motorways, and service areas. The same cannot be said when a driver finds themselves in rural area. Locating a charging station in such area can be cumbersome and once user finds a station, they may face another problem with charger type or connector fit. Current OEMs often create a charging system exclusive only to specific EVs which can be confusing and intimidating for potential EV consumers.

## Batteries and chargers: important components of e-mobility

As electric vehicles gain popularity so does every other infrastructure and support solution that enables the vehicle to function. Battery, for instance, is a fundamental part of e-mobility. The cost of the battery accounts for 35%-45% of the EV's sticker price. Markets and Markets forecasted the market size for EV batteries will grow tremendously from USD 27.2 billion in 2021 to USD 84.2 in 2026. Today's key focus for OEMs is achieving the optimum battery life, reduced cost, faster charging, and bigger power.

Charging stations are an important infrastructure for e-mobility. Its availability can actually influence customers' purchase decisions. Although the number of stations has spurted over the years, they are not equally dispersed. Taking Europe as an example, 70% of all charging stations in the region are located in The Netherlands, Germany, and France. This is an opportunity for the market to keep growing. We can expect the market for EV's charging stations to grow from USD 7.9 billion in 2022 to USD 32.2 billion in 2032, based on data provided by Apollo Research Report's data.

Charging cables, another essential component for electric cars, are used to connect the car's charger to the charging station be it at home or in public. They come in several types that can determine the time you need to charge your vehicle. EV charging cable market size reached USD 400 million in 2021, according to Markets and Markets. This number is expected to rise to USD 2.2 billion by 2026.

## The move towards Mobility as a Service (MaaS)

New economic models have begun to consider sharing concepts as a way to gain profit. In a sharing economy, assets that are currently not being used such as parked cars and extra bedrooms can be rented out. With the growing success of rented items and services, new transportation options have come to the market.

The idea of MaaS is to replace the need to own a vehicle by integrating various forms of transport services into a single mobility service accessible on an "as-needed" basis. A MaaS operator facilitates a diverse mode of transport, be they public transport, car sharing, bike rental, or a combination thereof. For the user, MaaS provides a single application to access mobility with a single payment channel instead of multiple ticketing and payment operations.

Next Move Strategy Consulting estimated the market value of Maas which they divided into four different segments of product types: car rental, car-sharing, ride-hailing, and two-wheeler sharing. It is expected that the total market for MaaS will expand almost 20 times within the forecast period of 2021-2030, from USD 3.3 billion to USD 65.8 billion, registering a 39.5% CAGR.

## Autonomous Vehicles

Gartner defines an Autonomous Vehicle (AV) as one that can drive itself from a starting point to a predetermined destination in “autopilot” mode using various in-vehicle technologies and sensors, including adaptive cruise control, active steering (steer by wire), anti-lock braking systems (brake by wire), GPS navigation technology, lasers, and radar.

The transition to an autopilot, self-driving car will not occur so suddenly. As of today, most autonomous cars on the road fall into “semi-autonomous” category with only limited amount of “fully autonomous” vehicles still in testing phase.

The Society of Automotive Engineers (SAE) defines 6 levels of driving automation ranging from 0 (fully manual) to 5 (fully autonomous). Most cars produced in recent years have the option of Level 1 automation with a few reaching Level 2. Some companies have already announced their production of Level 3 personal autonomous cars, but these will only hit the market a few years from now. Level 4 and Level 5 developments are designed mostly for ride-sharing or public transport uses in mind.

The topics of EVs and Autonomous Vehicles (AVs) are inevitably intertwined. The shift to electric powered vehicles happens almost simultaneously with the development of progressively automated cars. Both concepts aim at a more sustainable means of transport and are being implemented greatly in the shared-mobility scheme. The trend of automation, electrification, and ridesharing are reinforcing one another and are integral parts of mobility of the future.

| Level | Driver Involvement | Features |
|---|---|---|
| Level 0 | No automation. Driver performs all driving tasks. | Warning or temporary assistance features such as emergency braking, blind spot warning, lane changing warning. |
| Level 1 | Driver Assistance. Driver controls vehicle with some driving assist features included in the vehicle design. | Lane steering OR adaptive cruise control. |
| Level 2 | Partial Automation. Driver remains engaged with driving tasks but enjoys vehicle's combined automatic functions | Lane steering AND adaptive cruise control that can be utilized at the same time. |
| Level 3 | Conditional Automation. Driver does not have to drive but needs to monitor the environment all the time and take control of the car shortly after being alerted. | Traffic jam chauffeur function. |
| Level 4 | High Automation. Driver may have the option to take control, but vehicle can perform all driving tasks under certain conditions. | Robotaxi or driverless taxi. Vehicle may or may not have pedals and steering wheel. |
| Level 5 | Full Automation. Driver may have the option to take control, but vehicle is capable of performing all driving tasks under all conditions. | Similar to Level 4 but features are not limited to certain conditions only. |

Sources: Statzon, ADB, BloombergNEF, AFDC, Lifewire, Transport & Environment, IEA, Appinio, Exro, Digital Trends, US DOE , iDate report on Future of Mobility, Virta, Interact Analysis, McKinsey, IEA, Worldbank blog, Gartner, SAE, IEA

# Global E-mobility Market

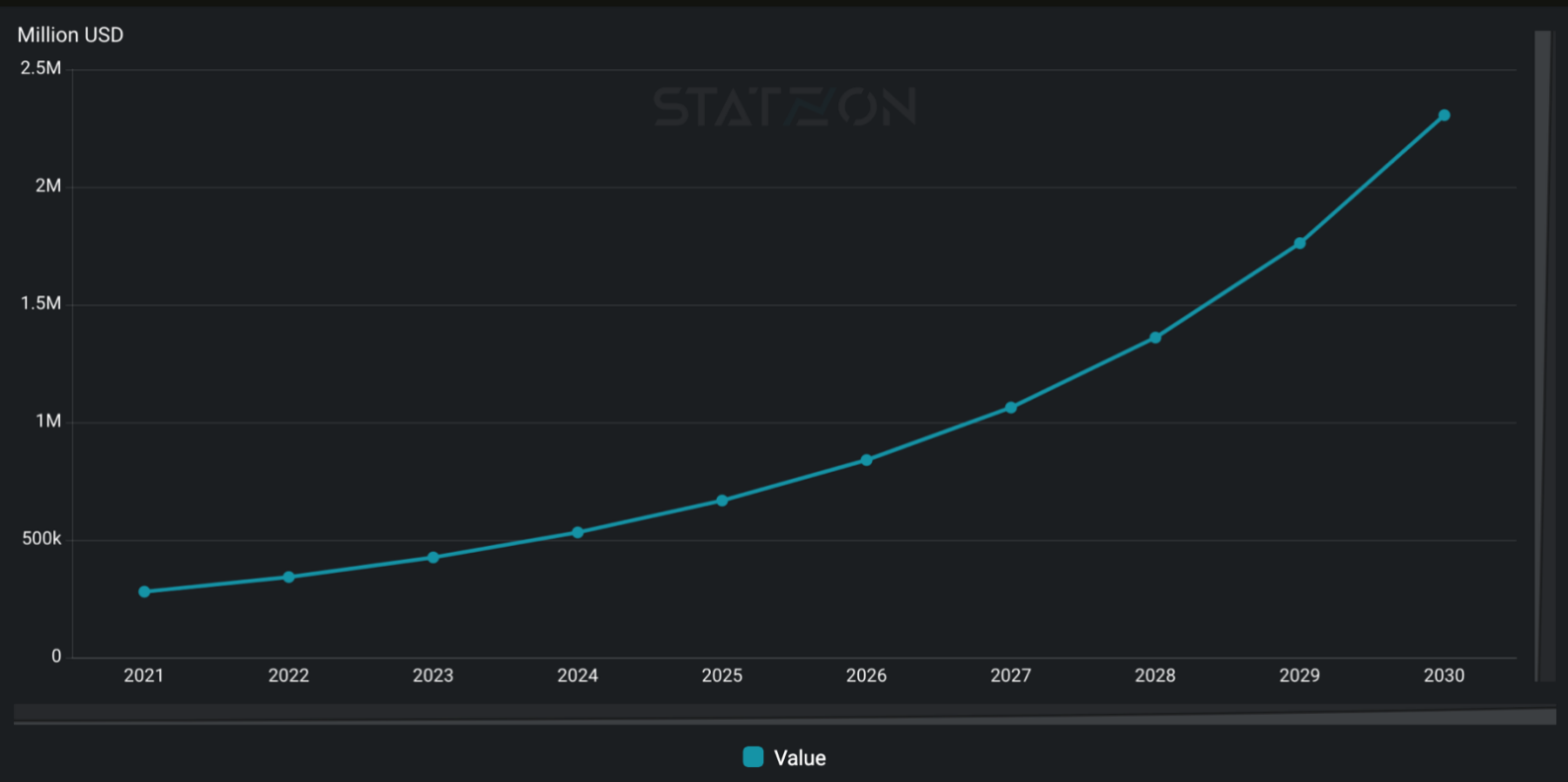
In their latest report, Next Move Strategy Consulting forecasted the global e-mobility market will reach USD 2.3 trillion by 2030. The firm included electric cars, electric motorcycles, electric scooters, electric skateboards, and electric wheelchairs into the term of e-mobility.

The 2021 market was valued at USD 279.5 billion, meaning the market will see an annual growth rate of 26.4% to reach the 2030 forecasted value.

The electric car segment accounted for over 65% share of the e-mobility market in 2021 and is estimated to retain its dominance over the forecast period with more or less the same size of market share. In terms of market value, this segment was worth USD 180.5 billion in 2021 and will reach a forecasted market value worth USD 1.5 trillion by 2030.

The electric scooter segment is the second biggest in the market with a revenue of USD 51 billion in 2021, taking up 18% of the market share. The other three segments are electric motorcycle with 13% market share, electric skateboard (2%), and electric wheelchair (2%).

Global E-Mobility Market Value (USD Million) (2021-2030)




Source: Statzon / Next Move Strategy Consulting

## Battery and voltage segmentation

Based on the use of battery, E-mobility market is segmented into sealed lead acid, Nickel Metal Hydride (NiMH), and lithium-ion (Li-ion). The Li-ion segment is dominating the market in 2021 and accounted for 52% of the market. The segment is expected to register a promising CAGR of 26.3% over the forecast period. After a dip in the market during the year 2020 caused by global industrial shutdowns, the e-mobility world is still facing a crisis of battery supply. This situation is predicted to last until 2023, according to Interact Analysis. Supply is so tight that EV manufacturers must first reserve the battery in advance before they their EV production plans. Despite the crisis, production capacity for lithium-ion batteries surpassed 1TWh for the first time in 202, and production rate is set to increase to follow the rising demands for electric vehicles.

In terms of voltage, the e-mobility market can be categorized into 5 segments which are: less than 24V, 24V, 36V, 48V, and greater than 48V. The 24V segment accounted for 27% of the total market share in 2021 or around USD 75.5 billion in market value. 24V batteries are commonly used for electric skateboards and bikes and they are often preferred for being lightweight, easy to install, and powerful. Demand for this segment will rise steadily, and it will continue to account for a notable market share until the end of the forecast period.

The greater than 48V segment is forecasted to witness significant growth until 2030, growing at a CAGR of 27%. Customers' demand for longer range has contributed to constant research and development of vehicles with larger voltage. This segment accounted for 24% of the market share in 2021 with a market value of USD 67.5 billion. By 2030 it will continue to retain its share of the market with a forecasted market value of USD 587 billion.

## Asia is leading the e-mobility market

Asia Pacific is at the forefront of e-mobility movement. This region is leading the market by gaining a market value of USD 137.5 billion in2021, in other words, it controls around 49% of the total market share. The rapid development of e-mobility markets in Asia is supported by strong policy actions on four fronts: official EV targets, restrictions on ICE production and sales, consumer incentives, and support for EV charging infrastructure (EVCI). Governments in mature markets such as China, Japan, and South Korea have established comprehensive policy frameworks to support the adoption of electric cars. Emerging markets such as India, Thailand, and Indonesia, are currently the largest micro e-mobility markets with highest numbers of 2-wheeler electric vehicles sales. India, for instance, surpassed China in 2017 to become the largest market for electric two-wheelers.

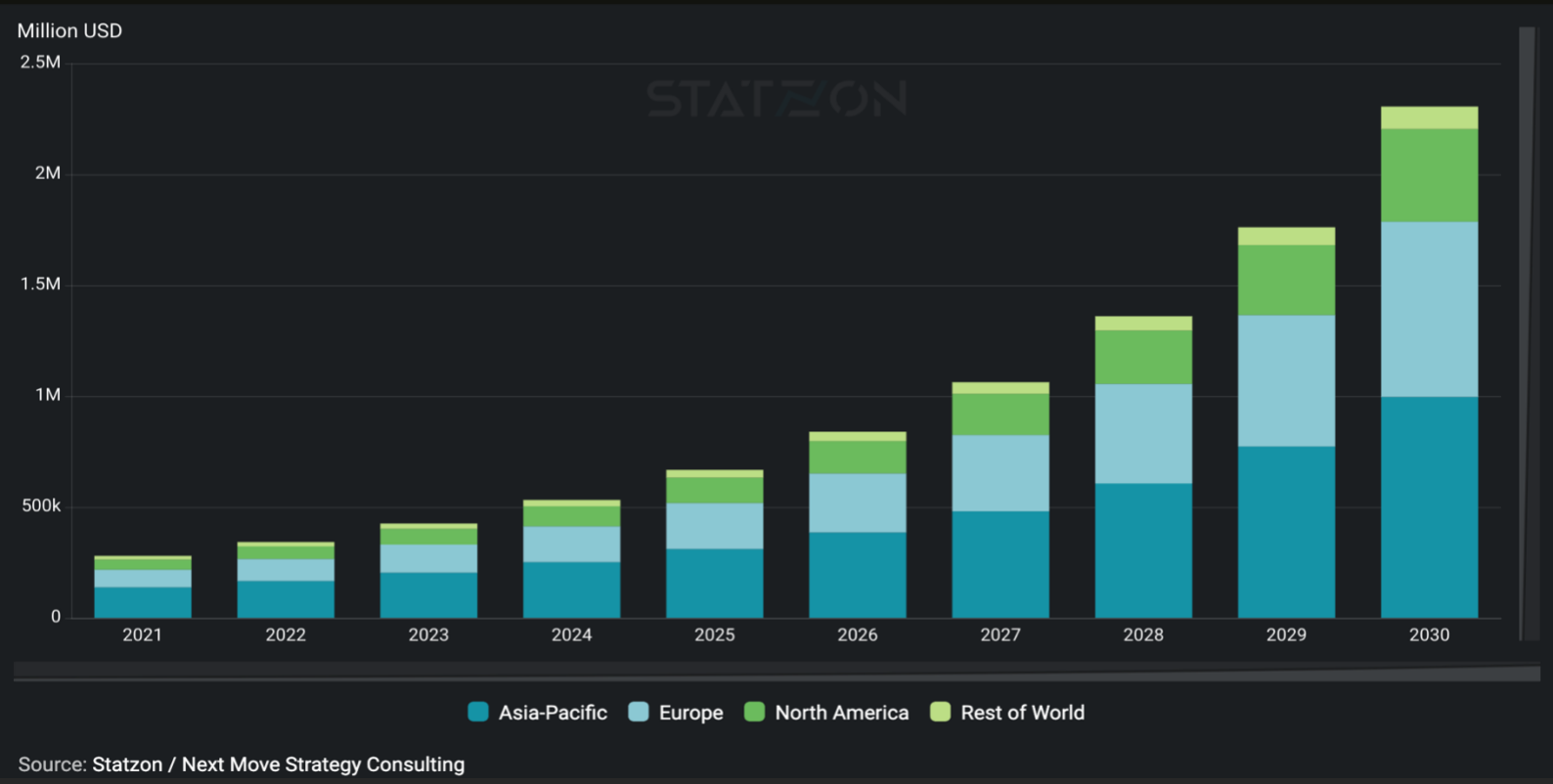
China still, however, holds the leadership position in the overall e-mobility market, not only in the region but also globally. As a country, China accounted for USD 93.2 billion in revenue or around 33% of the total market share. A market much bigger than any other country. More electric cars were sold in China in 2021 (3.3 million) than in the entire world in 2020. Granted, China takes benefits from its huge population which creates a high domestic demand for its local electric vehicle brands. Although they have not been exporting to Europe or the US, Chinese brands are on the rise during the last

couple of years and they have established solid positions both locally and regionally. In 2021, China's BYD rose 5 percent in market share, and Wuling's affordable electric car, Hongguang Mini EV, sold more than 400,000 units within a year of its debut.

Asia Pacific will face competition from the European market that is set to grow at 29% CAGR. The highest CAGR among other regions. In Europe, traditional carmakers are increasingly electrifying their product ranges. Since 2015, the government exerted a gradual tightening of CO2 emissions through 2030 as a move towards elimination of ICE. This ruling will make it almost impossible for manufacturers to make money from selling ICE cars they are forced to focus on producing and selling electric vehicles.

Europe e-mobility market was valued at USD 80 billion in 2021 or around 28.5% in terms of market share. The market will expand to gain 34% share by 2030 with forecasted market value of USD 790 billion. Germany is the leading market in Europe with a market size worth USD 24 billion in 2021. Home to big automotive manufacturers such as Volkswagen, Mercedes, and BMW, Germany wants to take a leading role in the production and use of electric vehicles in this e-mobility era. Rapid growth of electric car registrations in Europe can be attributed to government stimulus measures for those buying electric cars instead of traditional ICTs. Sales growth has also been boosted by tax benefits and subsidies applied in many European countries.

Global E-Mobility Market Value, by Region (USD Million) (2021-2030)



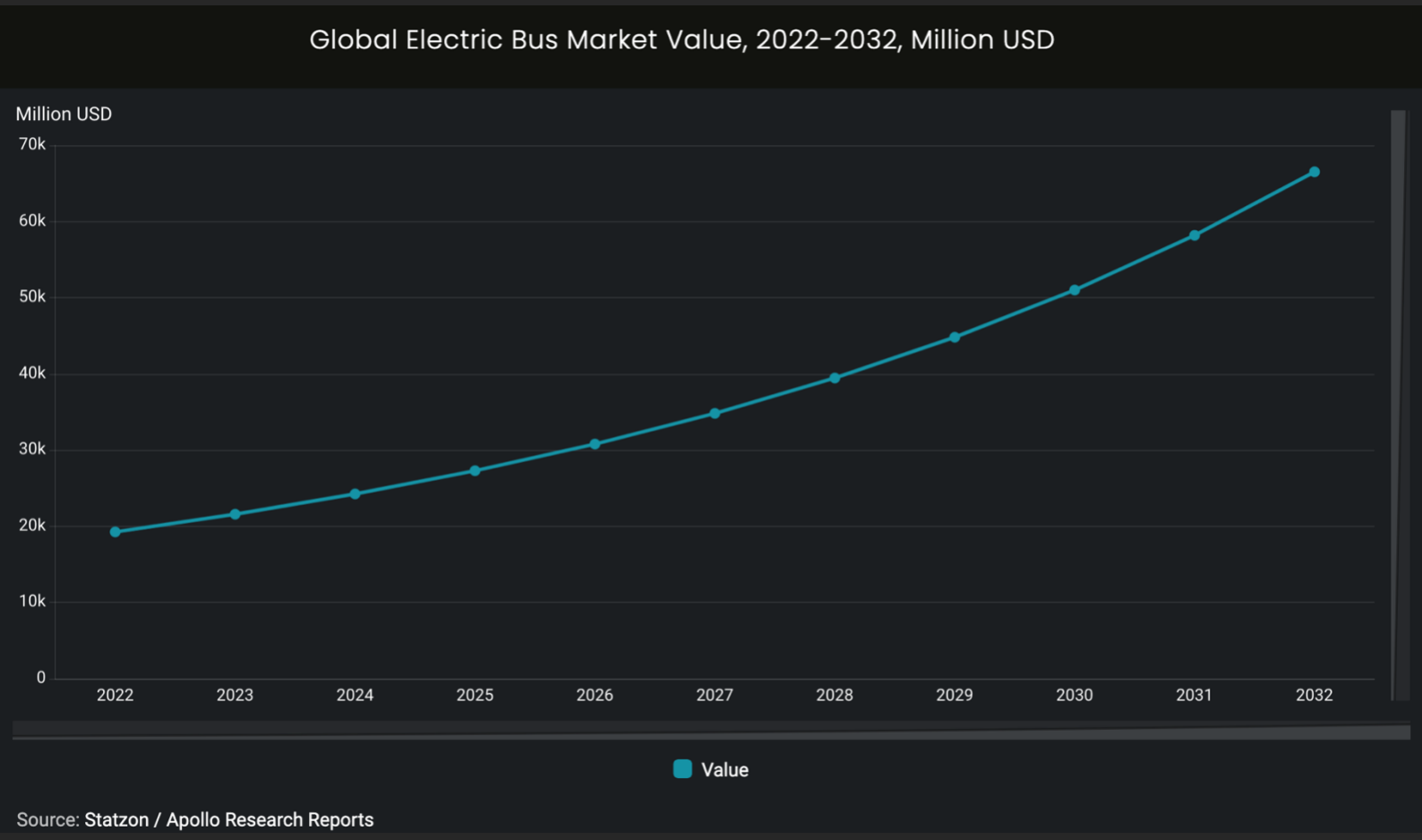

Source: Statzon / Next Move Strategy Consulting

## Global Electric Bus Market

Cities are increasingly adopting more electric buses with a deadline to phase out fossil fuel buses in the future. Nearly 25% of registered buses in 2021 were zero-emission, according to new data from Transport & Environment. Countries like Denmark, New Zealand, and The Netherlands have already set for 100% zero-emission bus procurements by 2025, while Costa Rica has a long-term goal to reach 100% bus fleet electrification by 2050.

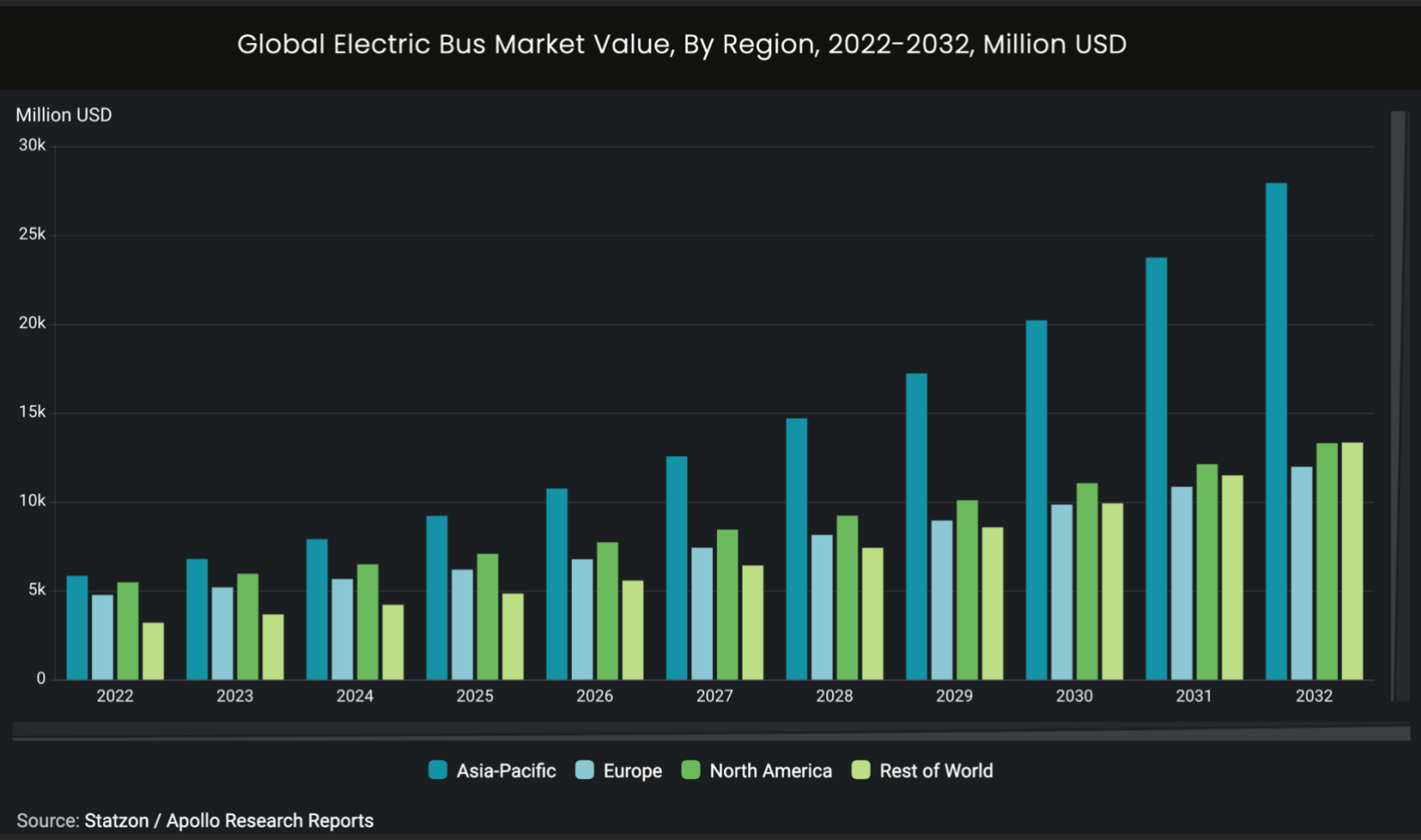
The global market for electric buses reaches USD 19.2 billion in 2022, based on an estimation by Apollo Research Reports. This number will grow at an annual rate of 13.3%, the market size will hit USD 66.5 billion by the end of the forecast period in 2032. Another market evaluation from The Insight Partners gives a more promising forecast. According to their research, the global market for electric buses is growing at 20.2% CAGR during the forecast period of 2021 to 2028. The market was valued at USD 29 billion in 2021 and is growing to reach USD 105 billion by 2028.

Other than the increasing government initiative to decarbonize public transportation fleets, the falling price of batteries has accelerated the adoption rate of electric buses by cities and countries. Batteries make up 40% of the cost of electric buses. With the cost of lithium-ion battery packs expected to go down by 52% between 2018-2030, the high initial cost to develop an electrified transport fleet can be reduced, and the growth of the electric bus market will be encouraged.



## China dominates the global electric bus market

Asia Pacific is the leading region in the global electric bus market. This region 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.

China has made remarkable progress in rolling out new energy buses (NEB), mostly consisting of battery electric buses. By the end of 2020, 54% of the country's bus fleet will be electrified, and several cities like Shenzhen, Tianjin, and Zhengzhou, to name a few, have achieved 100% of bus fleet electrification.

The shift from conventional fossil fuel-based vehicles to electric buses has made a positive difference in China. Once known as one of the most polluted cities, Beijing’s air and water quality have significantly improved. The number of days with heavy pollution in the Chinese capital was down to 10 in 2020 from 43 in 2015, a drop of nearly 80% in pollution.

In Europe, the market is accelerating slightly faster. Growing at a 21.6% CAGR, the highest among other regions, Europe market value is expected to increase from USD 1,5 billion in 2021 to USD 5,8 billion by 2028. New registrations of zero-emission buses outnumbered gas in almost every part of

Europe in 2021. 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. In most Western European countries, at least 22.5% of the total bus fleet should be zero emission by 2025, rising to 32.5% by 2030, for most countries within the EU, according to a 2021 report published by ING with the title "All Aboard Europe's Electric Bus Revolution".

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 non-profit World Resources Institute (WRI). The number is almost a 10-fold increase from August 2021 data when WRI began tracking school electric buses around the country.

## 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 more than 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. Cities are increasingly adopting more electric buses with a deadline to phase out fossil fuel buses in the future. Nearly 25% of registered buses in 2021 were zero-emission, according to new data from Transport & Environment. Countries like Denmark, New Zealand, and The Netherlands have already set for 100% zero-emission bus

procurements by 2025, while Costa Rica has a long-term goal to reach 100% bus fleet electrification by 2050.

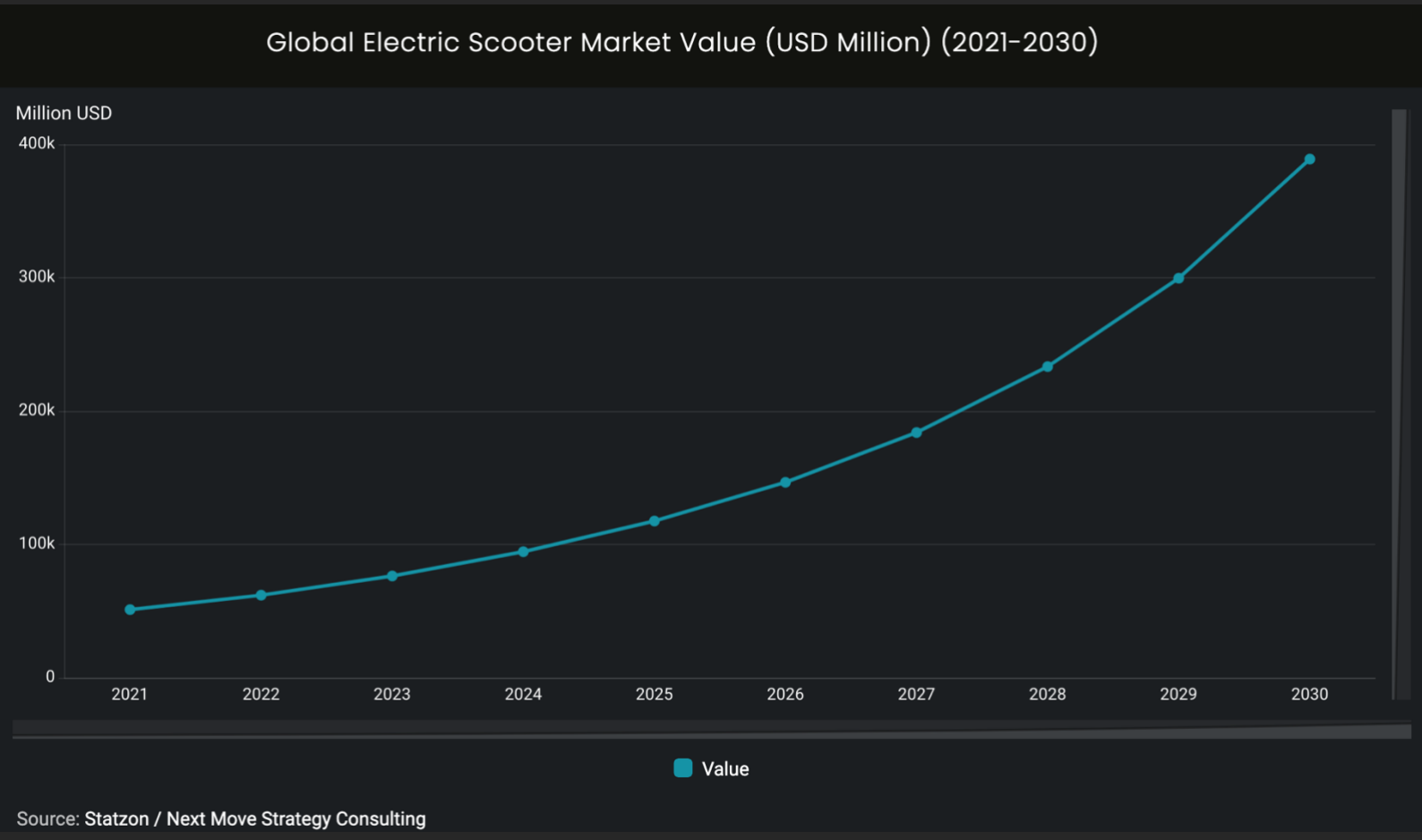
The global market for electric buses reaches USD 19.2 billion in 2022, based on an estimation by Apollo Research Reports. This number will grow at an annual rate of 13.3%, the market size will hit USD 66.5 billion by the end of the forecast period in 2032. Another market evaluation from The Insight Partners gives a more promising forecast. According to their research, the global market for electric buses is growing at 20.2% CAGR during the forecast period of 2021 to 2028. The market was valued at USD 29 billion in 2021 and is growing to reach USD 105 billion by 2028.

Sources: Statzon, Transport & Environment, ICCT, Sustainable Bus, Transition China, Global Times, CGTN, ING, Autonomy Paris, Electrek, Interact Analysis

# Global Electric Scooter Market

Electric scooters are conquering the city streets. It is a popular option for last-mile vehicles and a terrific way to avoid traffic jams in the city. In addition to that, people tend to perceive electric scooters as a greener transportation choice as well as being cool. It is no surprise that the adoption rate of these scooters is going up, both by municipalities and individuals. Electric scooters have become one of the fastest-growing micro-mobility options across the world.

According to Next Move Strategy Consulting, the global market for electric scooters is accelerating at a 25.3% CAGR. The market is predicted to reach USD 389 billion in 2030, an increase of 760% from the 2021 number, which was around USD 51 billion.




Source: Statzon / Next Move Strategy Consulting

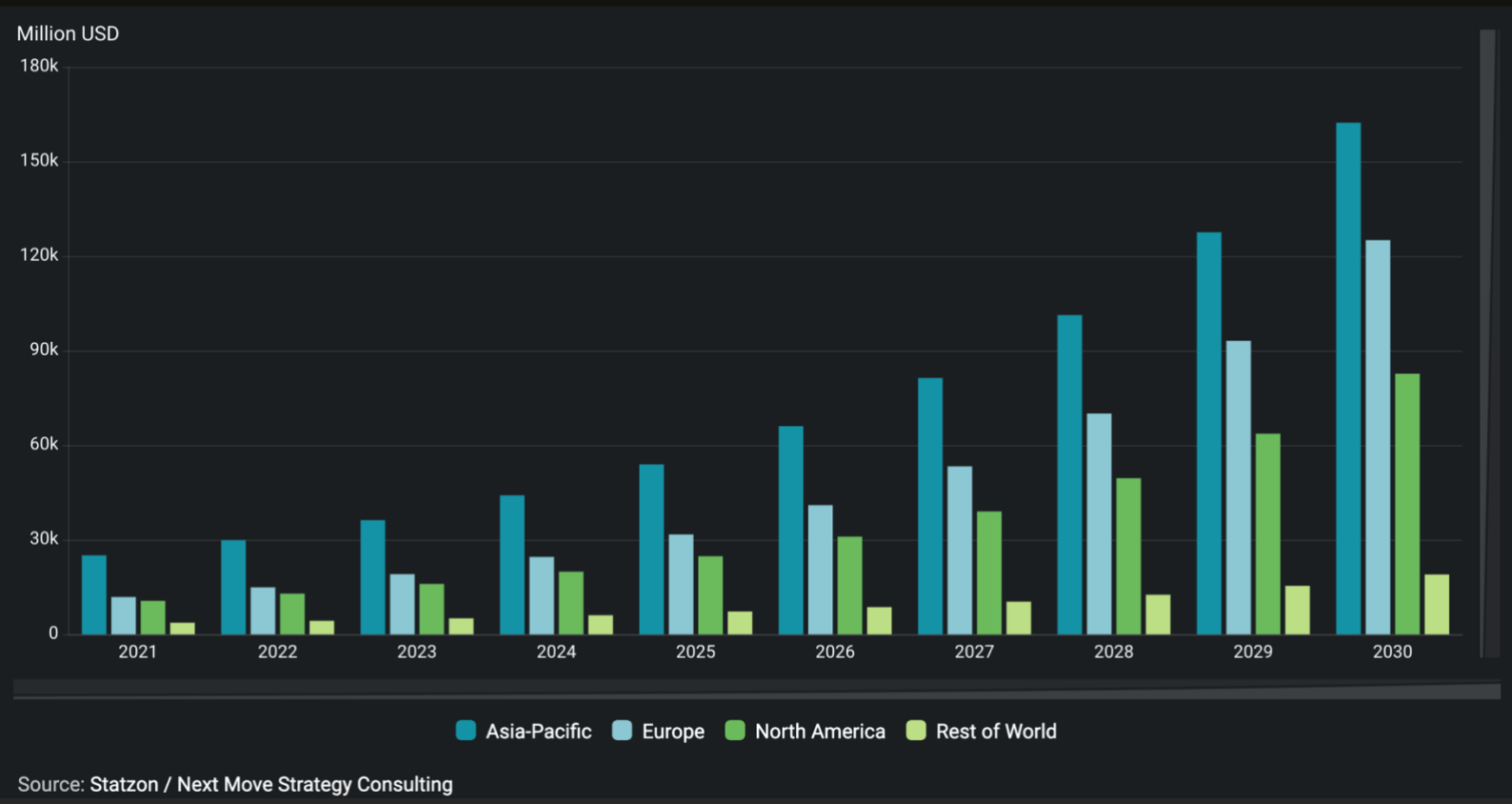
Electric scooters take up around 68% of the whole electric 2-wheeler market, based on data provided by Apollo Research Report. The other 32% is claimed by electric motorcycles. Within the whole e-mobility market, electric scooter is the second biggest segment after an electric car, contributing around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

## Asia Pacific leads the global market, but Europe shows the 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 global electric scooter market is expected to reach USD 25 billion in 2021 to USD 162 billion by 2030 at a CAGR of 23% during the forecast period

China is the main market in the region with the biggest sales of electric scooters as well as the biggest manufacturing hub. The country's annual sales of e-scooters exceeded 30 million units last year, and the total ownership of such scooters was close to 300 million by the end of last year. In China, more commuters are investing in their long-term daily transportation needs by purchasing e-scooters, further accelerating this huge market.

Global Electric Scooter Market Value, by Region (USD Million) (2021-2030)




Source: Statzon / Next Move Strategy Consulting

Europe is the second biggest region in the global market, worth USD 12 billion in 2021. 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. 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.

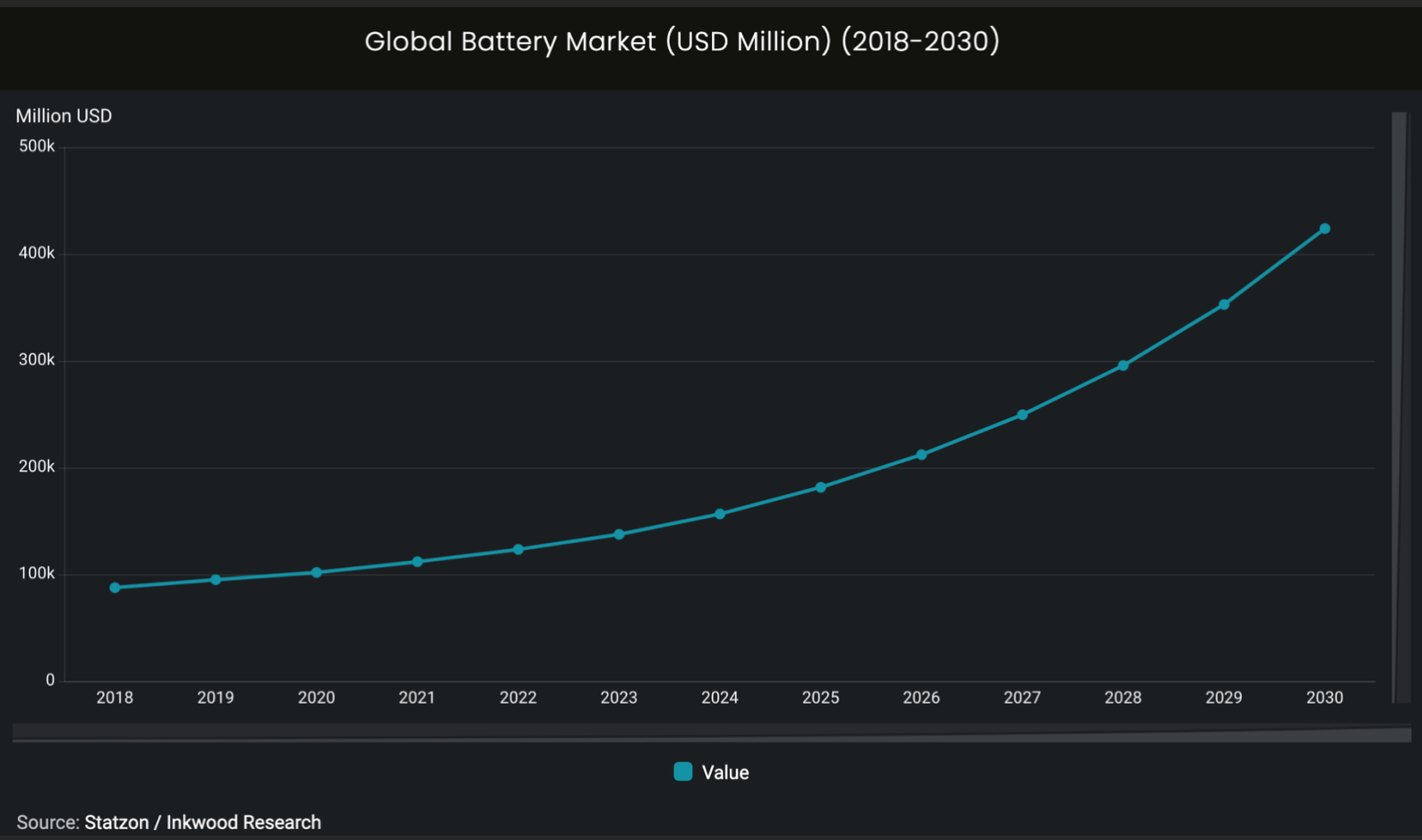
## Sealed lead acid is still the most preferred option for batteries

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 32 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. Around 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, Zagdaily

# Global Battery Market




Battery is the fifth largest segment within the electrical equipment market accounting for 6% of the total market share. The other segments are lighting equipment, power generation, transmission & control equipment, household appliances, and wires and cables.

The global battery market was valued at USD 84 billion in 2021, according to market data from The Business Research Company. The firm predicted that the market would grow to USD 139 billion by 2026, registering a 10.6% CAGR. This is an acceleration from the previous five-year period when the market grew at 7.75% CAGR.

Inkwood Research, another firm within Statzon's data providers network, gave a higher estimation of the market where it reached USD 112 billion in 2021 and will hit USD 424 billion by 2030, growing at a more confident CAGR of 16.68% over the forecasted years of 2022 to 2030.

The market growth can be attributed to trends happening during recent years, most notably, the increased demand for clean energy, the move to gradually phase out fossil fuels, the rise of electric vehicles, higher penetration of marine batteries (batteries specifically designed to be used on boats) and factory automation that enables faster and more efficient production of batteries.

## The market for primary and secondary batteries

The battery market is segmented into primary and secondary batteries.

Primary batteries are small single-use batteries that generate electricity from the chemical reactions between the terminals and electrolytes. Typically, these are used in portable devices that require low current such as flashlights and watches.

Secondary batteries are rechargeable batteries mostly used in automotive, household, and industrial applications. This segment is dominating the market with an 84% share of the market and worth around USD 70 billion in 2021, while the primary battery segment gained around 16% of the market share, valued at USD 14 billion.

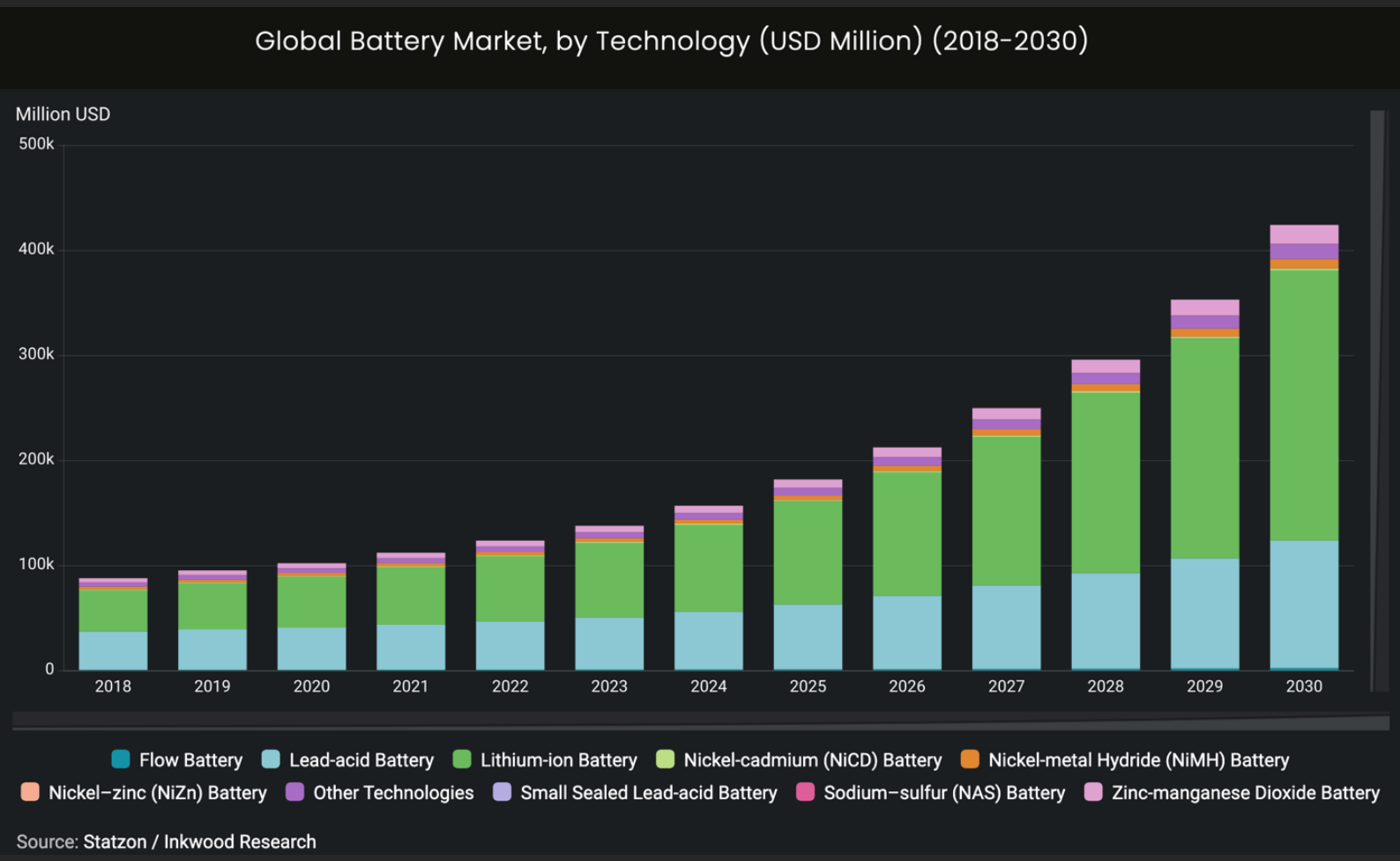
## Lithium-ion and lead-acid batteries are the most popular

Based on technology, Inkwood Research divided the battery market into 10 segments, of which the lithium-ion batteries held the largest market share in 2021, accounting for 49% of the market, valued at USD 54.6 billion. This segment will also grow the fastest, accelerating at a 19.5% CAGR. In 2030, the market for lithium-ion batteries is predicted to reach USD 257 billion, based on the forecast by Inkwood Research.

Lithium-ion batteries are an eco-friendlier alternative to traditional sources of energy, which has significantly boosted their usage in electric vehicles and grid storage facilities. The market for these batteries will also be boosted by the manufacturing, railway, and solar power sectors as the need for storage and power backup is likely to increase in the future.

The lead-acid battery is the second biggest segment in the market. In 2021 this segment is controlling around 38% of the market share, valued at USD 43 billion. This segment will experience a growth at 13% CAGR, and its market value will reach USD 121 billion by 2030. The reliability and affordable price of lead-acid batteries make them suitable for both consumer and industrial applications.

Another two big segments worth mentioning are the zinc-manganese dioxide battery segment which gained a market value of USD 5 billion in 2021 (4.5% of the total market share), and the nickel-metal hydrate (NiMH) battery segment, with USD 3.1 billion worth of market value or around 3% share of the total market.




## A closer look at the lithium-ion battery market

Lithium-ion batteries are part of our daily lives, commonly found on consumer electronics such as laptops, tablets, or mobile phones. A lithium-ion battery is a rechargeable battery that uses lithium ions as the main component of electrochemistry. This type of battery is popular for being lightweight and compact. It needs minimal maintenance and stands up well to repeated charging. Small lithium-ion batteries are widely used in portable electronic devices such as watches or mobile phones, while large ones have been developed to power electric vehicles.

As previously written, Inkwood Research estimates that lithium-ion batteries account for 49% of the total battery market, with a revenue of USD 54.6 billion in 2021. Markets and Markets valued the global lithium-ion battery market at USD 44.5 billion in 2022 and forecasted the market to grow to USD 135.1 billion by 2031, at a CAGR of 13.1%. Astute Analytica offered a more optimistic forecast where the market is valued at USD 60.3 billion in 2021 and projected to reach USD 185 billion by 2027, registering a 20.5% CAGR.

## Lithium-ion battery usage in e-mobility

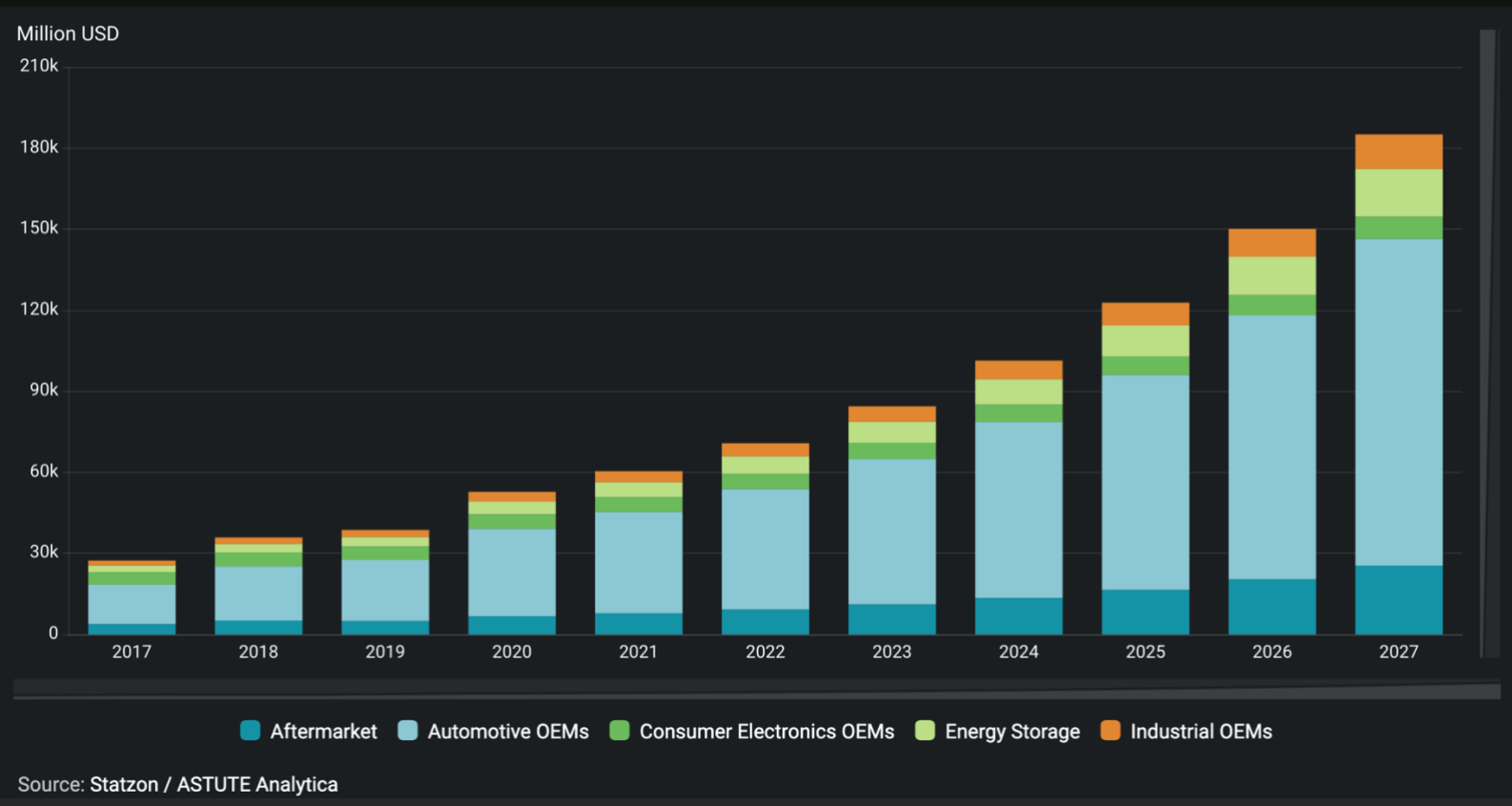
The growth of the lithium-ion battery market can be attributed to the increased use of these batteries in electric vehicles and the field of renewable energy. During the last several years, the sales of electric vehicles have experienced exponential growth. Euromonitor reported the registration of electric cars has grown more than triple between the years 2017 to 2021, from 3.7 million units to 11.8 million units. Next Move Strategy Consulting reported the e-mobility market size has reached USD 279 billion in 2021 and is anticipated to grow eightfold by 2030 to reach USD 2.3 trillion in which electric cars, electric motorcycles, electric bikes, electric skateboards, and electric wheelchairs are included within the term e-mobility.

The market growth of lithium-ion batteries electric is further augmented by other sectors, such as consumer electronics, medical applications, and grid storage. Lithium-ion batteries are currently the dominant storage technology used to support power grids in large facilities to ensure a steady supply of renewable energy.

## Lithium-ion battery segmentations

In terms of application, the automotive segment held the largest revenue share of over 51% in 2021, with a market value of USD 37.5 million. This segment will also witness the most lucrative growth over the forecast period with a 24.6% CAGR. Lithium-ion batteries are integral to the electric and hybrid electric vehicle market. Increased demands for electric vehicles subsequently expand the lithium-ion battery market. Growing awareness of renewable energy and zero-emission movements in Europe and North America has also favored the growth of both the electric vehicle and lithium-ion battery markets.

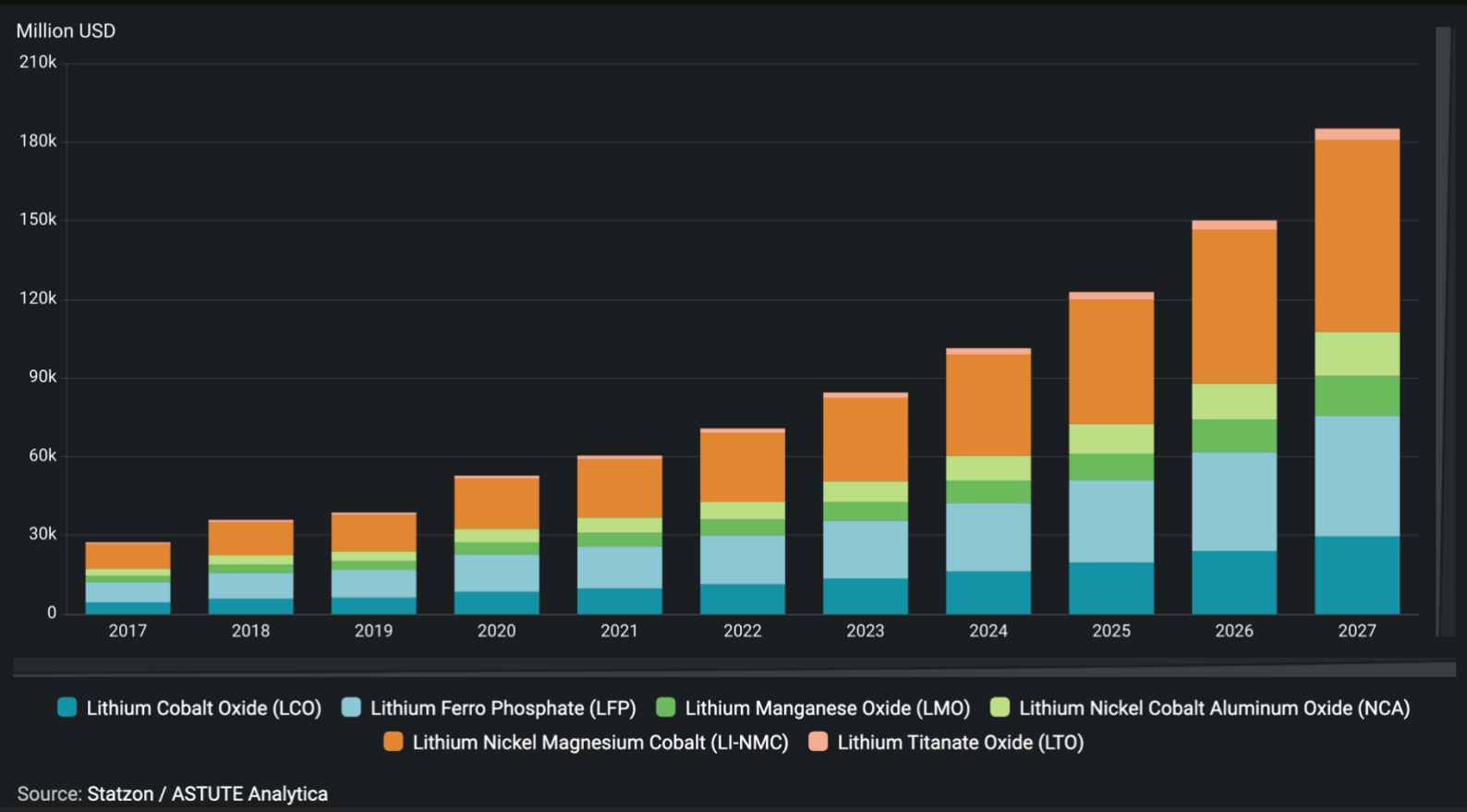
Global Lithium-Ion Batteries Market, by Application, 2017-2027 (Million USD)




Source: Statzon / ASTUTE Analytica

On the basis of type, Lithium Nickel Magnesium Cobalt (Li-NMC) segment accounted for the largest revenue share in 2021, controlling over 36% of the market share. Li-NMC is preferred by several big automotive manufacturers as it has the lowest self-heating rate compared to other types of lithium-ion batteries. Lithium Ferro Phosphate (LFP) and Lithium Cobalt Oxide (LCO) are the second and third biggest segments in the market, each with 31% and 19% market share, respectively.

Global Lithium-Ion Batteries Market, by Type, 2017-2027 (Million USD)




Source: Statzon / ASTUTE Analytica

When it comes to capacities, the 3 000 – 10 000 mAH segment is dominating the market, and it will keep its domination until the end of the forecast period since it is also the segment that has the most rapid growth. Growing at 22.3% CAGR, the market value for this segment will grow from USD 34.7 billion in 2021 to USD 116.2 billion by 2027, meaning it will expand its market share from 57% in 2021 to 64% by 2027.

## Key players in the global battery market

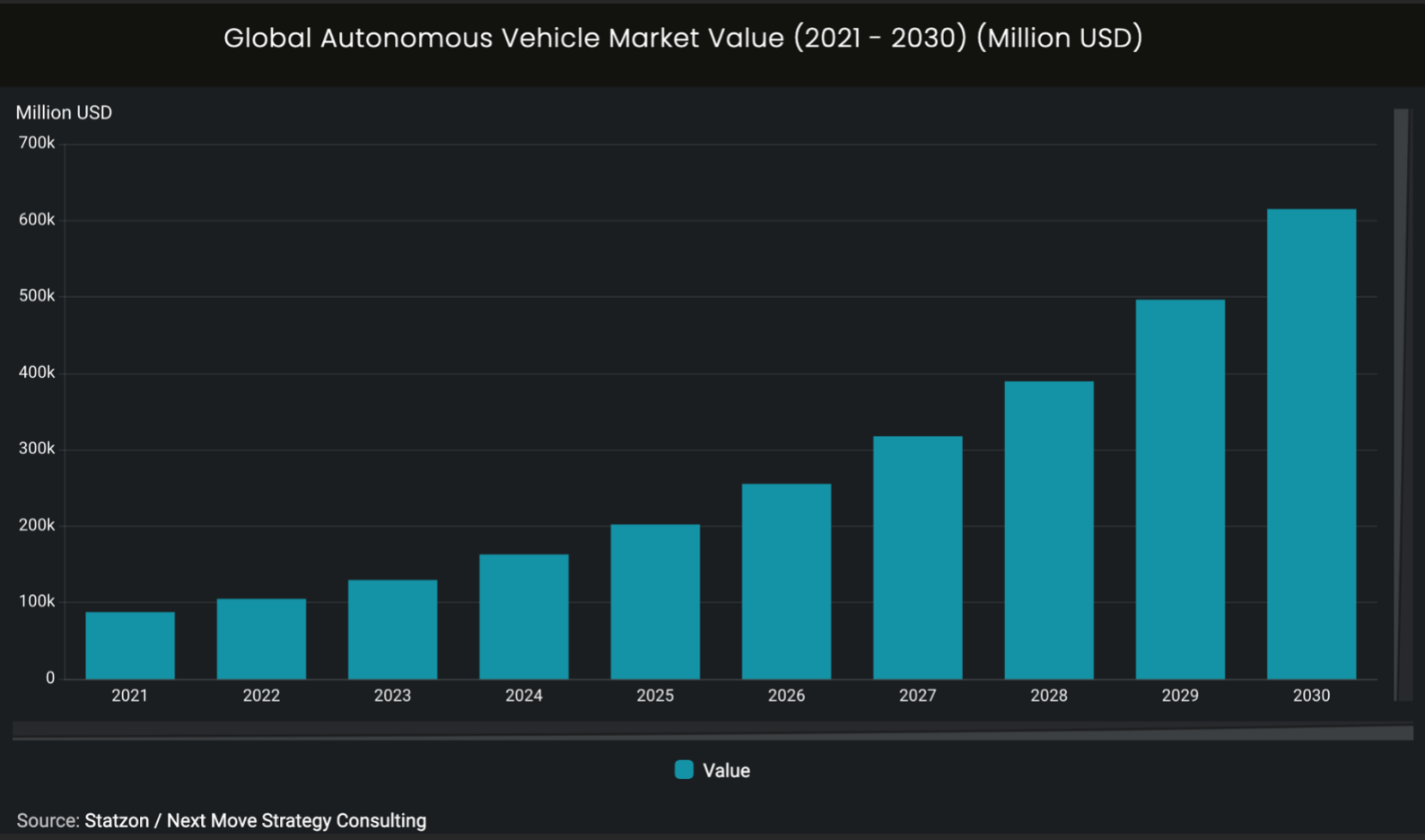
The market for batteries is highly fragmented, with the top ten biggest companies having a grip on more than 50% of the market. These companies are also involved in the usage and distribution of batteries. Samsung SDI, LG Chem, BYD, TDK, Panasonic, Yuasa, and A123 systems are some companies that made it to the major player list in the market.

Sources:

Statzon, Interact Analysis, Battery University

# Global Autonomous Vehicle Market

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 potential markets. Although it is 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.




The global autonomous vehicle market's value in 2021 was worth USD 87.6 billion and by 2030 will reach USD 614.9 billion at a 24.7% CAGR, according to market research conducted by Next Move Strategy Consulting. Robotaxi services are already available in select markets but getting to a full-scale commercial launch is still challenging mostly due to the lack of technology and regulatory support. Fully automated driving is expected to still be limited in certain geographical and climate areas for at least the next decade.

## Autonomous vehicle market segmentations

### By level of autonomous driving

In this segmentation, the autonomous vehicle market is classified into semi-autonomous and fully autonomous. Semi-autonomous means the responsibility for driving falls to the driver and the vehicle technology is used as a driver-aid and safety feature. This category includes Level 1 to Level 3 vehicles in the Society of Automotive Engineers (SAE) autonomous driving level. On the other hand, fully autonomous vehicles are capable of maneuvering without a human operator. These are Level 4 and Level 5 vehicles at SAE autonomous level.

The semi-autonomous segment is the highest contributor to this market generating USD 84.3 billion in 2021. This segment is anticipated to reach USD 524 billion by 2030, registering a CAGR of 23%. However, the fully autonomous segment will see a significant market growth at 42.9% CAGR during the forecast period. The market for this segment is valued at USD 3.3 billion in 2021 and is anticipated to reach USD 90 billion by 2030.

In their Smart Mobility report, UBS forecasted that by 2025, around 80% of all new cars would be equipped with some level of autonomy. Meanwhile, the development of fully autonomous vehicles is geared towards shared-mobility use. Large scale applications of this type of vehicle are likely to emerge in larger markets, more likely city centers, that have a higher volume of trips and a minimal risk of extreme weather.

### By type of mobility

Another segmentation is to classify the market into shared mobility and personal mobility. Today, utilization of autonomous cars is dominated by shared mobility. This will continue in the future as future ownership of personal cars will decline and trips will mostly rely on Mobility as a Service (MaaS) which includes public transport, ride-hailing, and shared mobility.

The shared mobility segment gained USD 65.7 billion in 2021, roughly 75% of the total market. This segment is expected to reach USD 396.7 billion by 2030, registering a CAGR of 22.6%.

### By propulsion type

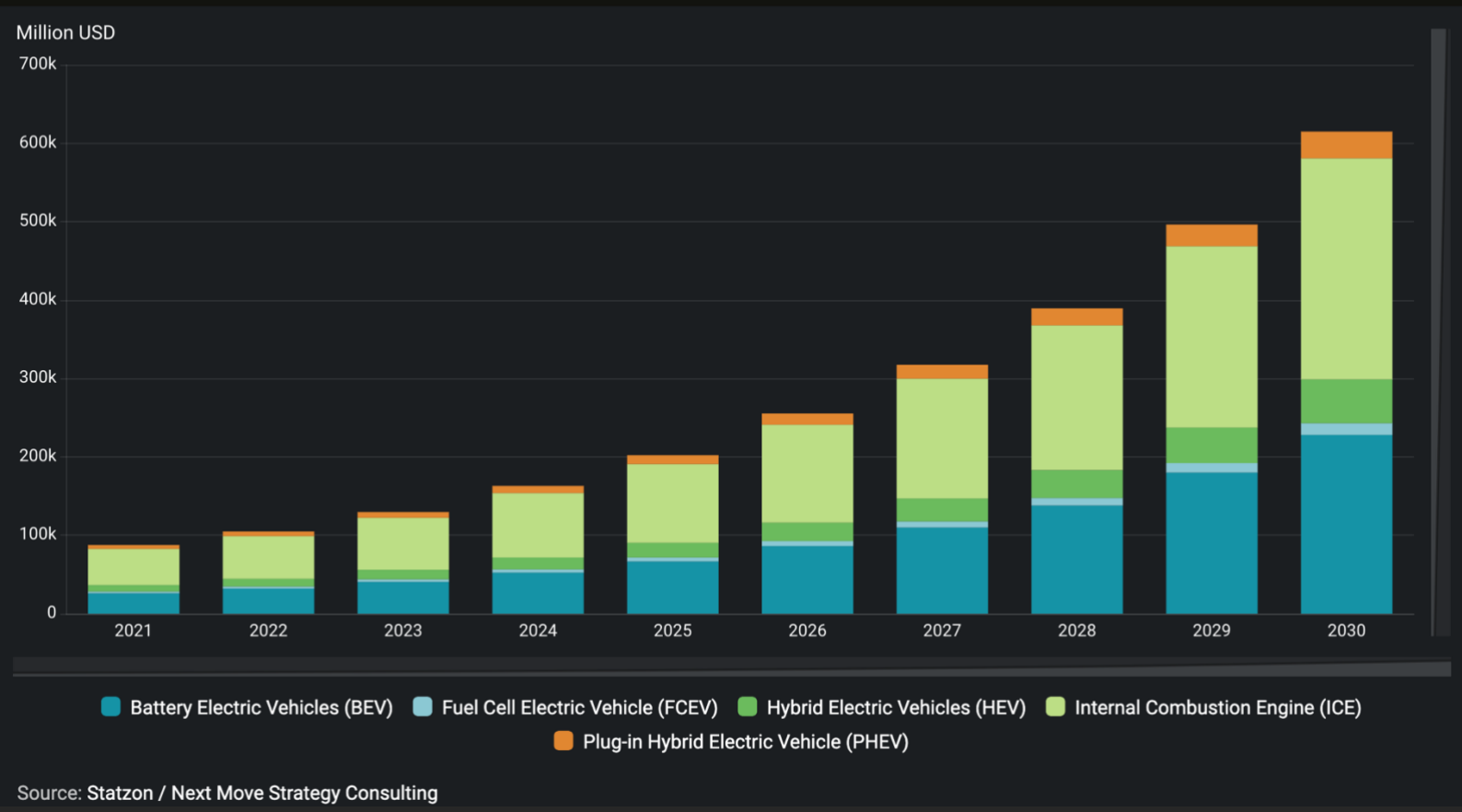
In this segmentation, the market is divided into Internal Combustion Engine (ICE), Battery Electric Vehicles (BEV), Hybrid Electric Vehicles (HEV), Plug-in Hybrid Electric Vehicles (PHEV), and Fuel Cell Electric Vehicle (FCEV).

ICE segment is currently dominating the market and valued at USD 46.1 billion in 2021. This segment is anticipated to reach USD 281.9 billion by 2030, growing at a 22.8% CAGR. However, the EV segment is catching up. The market for fully electric cars, or BEVs, is forecasted to reach USD 227.9 billion by

2030, accelerating with the highest CAGR of 27.8%. The ICE and BEV segments combined accounted for 82% of the market in 2021.

Autonomous and electric vehicles are inevitably linked. The shift to electric-run vehicles happens almost simultaneously with the development of progressively automated cars. Both concepts aim at a more sustainable means of transport and are being implemented greatly in the shared-mobility scheme. The trend of automation, electrification, and ridesharing are reinforcing one another and are integral parts of mobility of the future.

Global Autonomous Vehicle Market Value, by Propulsion Type (2021 - 2030) (Million USD)




Source: Statzon / Next Move Strategy Consulting

## 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 autonomous vehicle market was valued at USD 20.7 billion in 2021 and is projected to reach USD 123.8 billion by 2030, growing at a CAGR of 22.5%. 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. But China is gearing up to take over. Although in 2021 China gained USD 11.1 billion in terms of market value, roughly half the value of US market, it is not that far behind in terms of volume.

More than 2.8 million semi-autonomous and autonomous vehicles are estimated to be running on US roads in 2021. For the same year, China is estimated to have more than 2.2 million units of the same types of vehicles. The consulting company, McKinsey, has predicted that by 2040 autonomous vehicles will compose 40 percent of new vehicle sales in China.

China already overtook US as the world's largest automobile market in 2009 and it is now ambitious to get to the top position in the autonomous vehicle market. The country certainly enjoys favorable regulations and policies allowing testing of self-driving cars in many cities. US, on the contrary, has states' 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.

Sources: Statzon, The Verge, MIT, WE Forum, McKinsey (1), McKinsey (2), UBS, Financial Times (1), Financial Times (2)

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

EEA Global EV Outlook 2022 recorded 6.6 million units of EVs sold in 2021, double the amount from the previous year, a record in EV sales history. Almost 10% of all global car sales were electric in 2021 and EVs take 1,4% of all cars running on the world's roads, making the total number of EVs close to 16.5 million globally.

China, Europe, and the US are the three main regions where EVs are more accessible compared to other parts of the world. E-mobility has not yet taken off in developing countries. One reason is that, until recently, EVs have been simply too expensive compared to ICEs. This has presented a significant obstacle to adoption, both for governments in developing countries attempting to switch their fleets to more sustainable options and for consumers considering purchasing personal vehicles.

Publicly accessible chargers worldwide approached 1.8 million charging points in 2021, a third of that number were fast chargers. Nearly 500 000 chargers were installed in 2021, which is more than the total number of public chargers available in 2017.

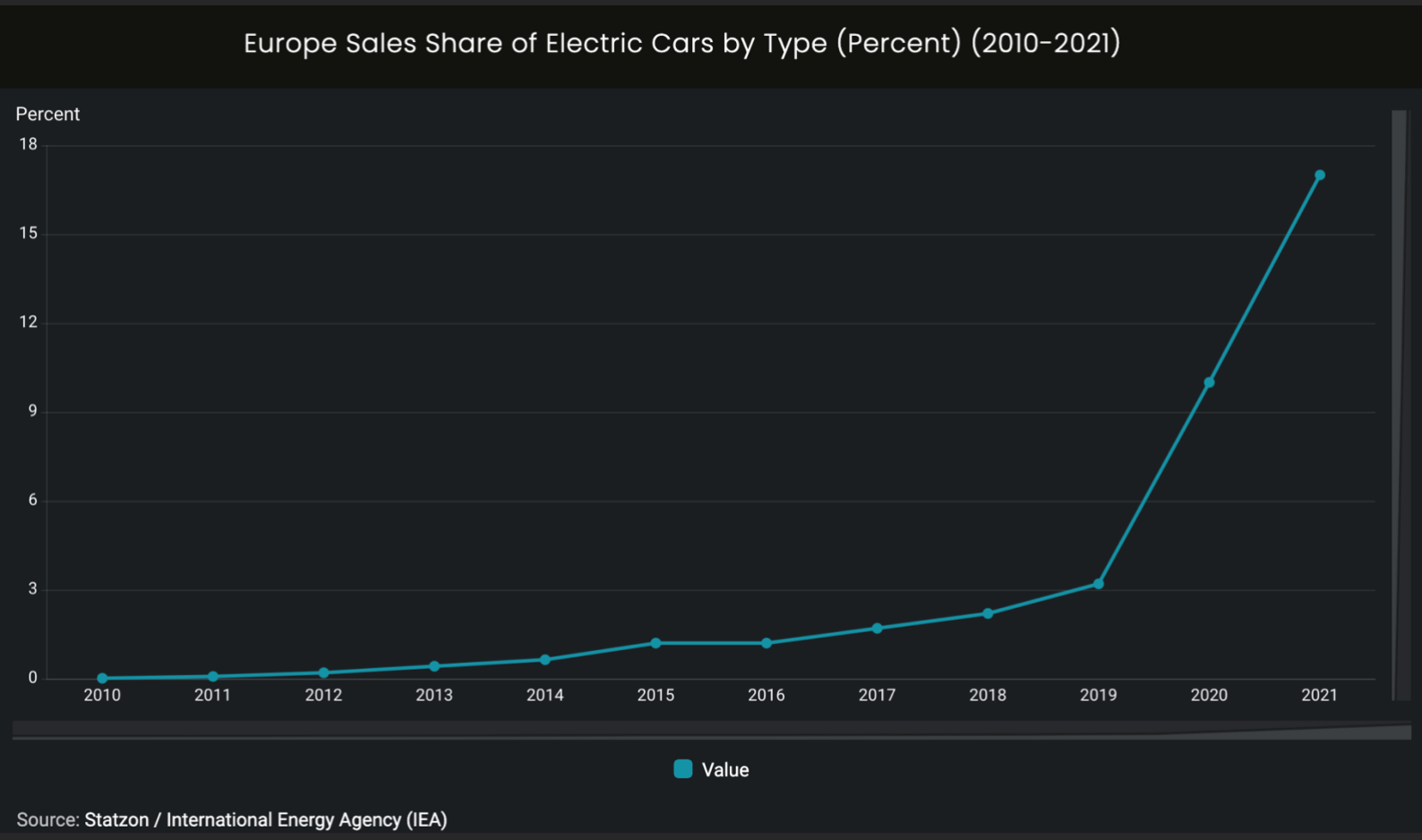
## Europe EV sales 2021

Europe has an ambitious goal to become a climate-neutral continent by 2050. In October 2022, the Council and the European Parliament reached a provisional political agreement aiming at a 100% carbon dioxide emission reduction target for new cars and vans by 2035. Although this legislation still needs to be approved formally to become law in the EU, approval by the Council and European Parliament is expected, with only minor changes.

Europe has been witnessing a steady increase in the number of new electric car sales annually, from 600 in 2010 to about 1,061,000 units in 2020.

In 2021, Europe experienced a notable boost in the adoption of electric cars and vans, in which sales of electric cars reached almost 1.7 million units, a 50% increase from 2020. This led to a rise in EV sales share from 10% to 17% in just one year.

Between 2016 and 2021, EV sales in Europe grew at 61% per year on average, which was the highest in any region in the world. This growth rate is higher than that of China, which had a CAGR of 58%, and the US, which had a CAGR of 32%.




Overall, there were about 5.5 million electric cars on European streets in 2021, tripling the stock of 2019. BEVs accounted for 55% of all electric car stock while the rest was attributed to PEVs. As a

comparison, BEVs are clearly dominating in China and US with 80% and 65% share, respectively, out of the total electric car stock in those two countries.

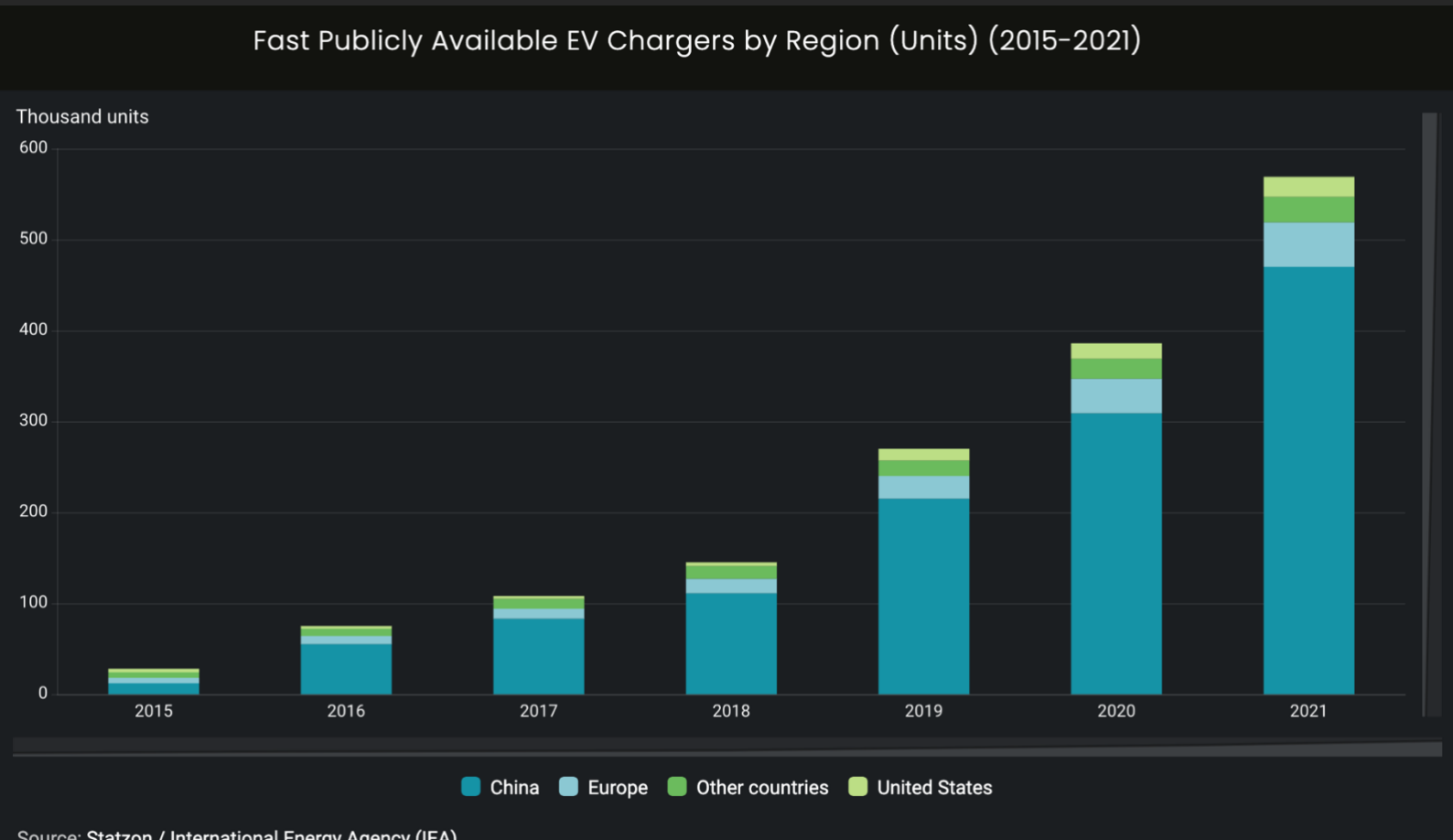
Non-plug-in hybrids took up around 19% of the total sales of new cars in 2021. These cars use both a traditional gasoline engine and an electric drive system, but they are powered exclusively by gasoline. Although they produce lower emissions compared to gas-only vehicles, they are not included in most reports about electric cars or lower-emission cars.

## Public charging stations availability

Most EV users usually install home EV charging stations. However, the number of publicly available charging stations has been increasing throughout the years to cope with the soaring market demand for electric vehicles.

Europe had over 370 000 publicly available charging points in 2021. The number is expected to grow to 1.3 million by 2025 and 2.9 million by 2025.

Slow chargers accounted for around 300 000 of all publicly available charger points in 2021. The availability of public fast chargers is a lot less, but this type of charger is being rolled out much faster.



There will be close to 50 000 units of fast chargers in 2021, 30% more than in the previous year. On average, the European Union offers five fast public chargers for every 100km and one public charging point per 7.5 EVs.

A 2014 EU-appointed commission mandated a ratio of 10 EVs per public charging point (PCP) and most countries within the EU already fall under that recommendation. Countries like the Netherlands, Spain, Lithuania, and Italy reached a ratio of 5 EVs or less per PCP. Sweden and Finland will need to improve their situation since they still exceeded 10 EVs per PCP in 2021.

## Which countries in Europe have the most electric cars?

Germany leads in terms of numbers with more than 1.3 million electric cars roaming the country's roads for the year 2021. The United Kingdom is in second place with 750 000 units, followed by France (720 000), Norway (630 000), the Netherlands (390 000), and Sweden (300 000).

Countries with the highest market share for new electric car sales in 2021 in Europe are Norway (86%), Iceland (72%), Sweden (43%), Denmark (35%), Finland (31%), the Netherlands (30%), and Germany (26%) followed by France (19%), Italy (9%) and Spain (8%).

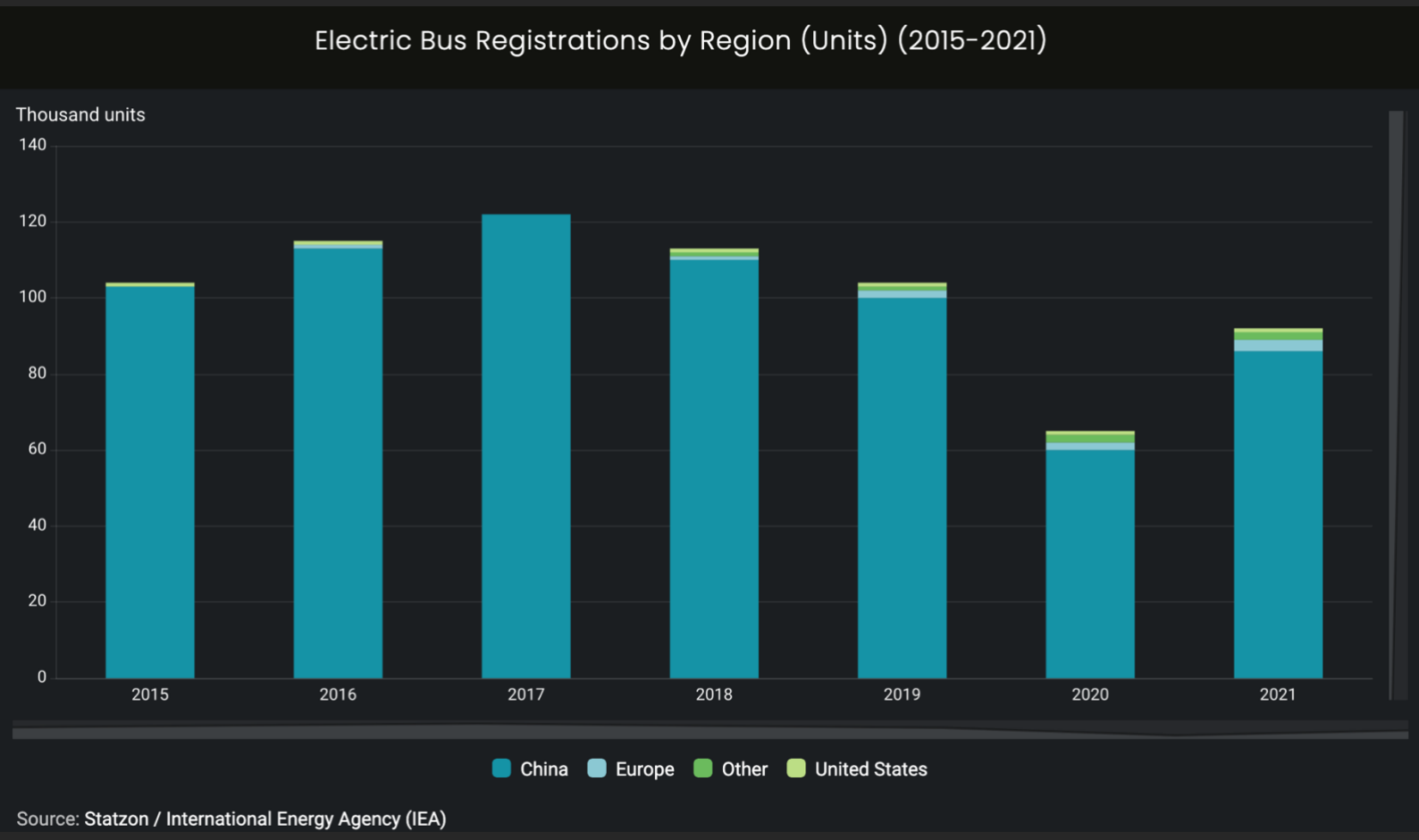
BEVs accounted for 65% of new car sales in Norway for 2021. PHEV sales share was the highest in Iceland (36%), Sweden (25%), and Norway (22%).

The Netherlands, Germany, and the United Kingdom are the top three countries with the highest penetration of public chargers, with each country having 85 000, 54 000, and 51 000 units, respectively, in 2021. Italy is in fourth place with 22 000 units, followed by Norway with almost 20 000 units of public chargers for the same year.

In terms of fast charging, the top five countries with the highest number of public fast charging points are Germany with 9200 units, the United Kingdom with 7700 units, Norway with 6 200 units, France with 4 500 units, Spain with 2600 units, and the Netherlands also with 2600 units.

## Electric bus market share in Europe

Transitioning to electric public transport is often considered the initial step towards a more environmentally friendly transportation system. Despite an ambitious zero-emissions goal, Europe is still way behind China when it comes to electrifying the public transport fleet. China acquired 86 000 new electric buses for their fleet in 2021, making it a total of over 650 000 electric buses in the country. All European Union countries combined only had around 9000 units in 2021, based on a report by ICCT. But growth looks promising for Europe. Sales of electric buses reached 3000 in Europe for the year 2021, a 67% increase from the previous year. Although the sales share of electric buses in Europe is still relatively small, around 10% in 2021, this will change soon, with many European countries committed to reaching 100% zero-emission bus fleets by 2035.




Some countries are doing better than others in 2021, such as Finland with its 50% sales share of electric buses, the Netherlands with 45%, and Denmark with 35%. Some other countries such as Greece and Portugal still have below 2% share for the sales of electric buses in 2021, still, a long way to go to comply with the Clean Vehicles Directive that mandates at least 41 percent of bus acquisitions made by 31 December 2025 must be clean vehicles for the EU country members.

# Europe's CO2 emissions from new passenger cars

Passenger cars are responsible for 12% of CO2 release in Europe, and total domestic transport makes up 22% of greenhouse gas emissions in the continent. EU regulation sets a fleet-wide target of 95 g/km for 2020-2024. This target will get even stricter for 2025-2030.

The average emissions from new passenger cars registered in Europe slightly increased in 2017-2019, up to 122.3 g/km, but then fell to 107.5 g/km in 2020 but picked up again in 2021 to reach 114.7 g/km for EU-27 + Norway. This is still above the 95 g/km target set in 2020. Only several countries kept their emissions from new passenger cars to stay below the target.

In 2021, the average CO2 emissions from new passenger cars in the Netherlands were 95.1 g/km, 92,6 g/km in Denmark, 88.3 g/km in Sweden, and 80.3 g/km in Iceland. The rapid adoption of electric cars is the main reason these countries have such low emissions levels. Norway set a ground-breaking record with an average CO2 emission of only 27.6 g/km. The country's sales share of electric cars is 86% for the year 2021.

Also in 2021, automakers faced a momentous change. This is the first year manufacturers' CO2 performance was determined using the WLTP instead of the New European Driving Cycle (NEDC). The Worldwide Harmonized Light-Duty Vehicles Test Procedure, or WLTP, is seen as a more precise depiction of consumption and emissions during everyday usage, considering the specific vehicle model, equipment, and options.

The 2020 fleet-wide target of 95 g/km over the NEDC was converted to manufacturer-specific WLTP targets based on manufacturers' average vehicle mass and average WLTP to NEDC CO2 emissions ratio in 2020. Flexible compliance mechanisms, such as super-credits and eco-innovation credits, were also translated to WLTP in 2021. Based on this new calculation, the European Environmental Agency data shows the average CO2 emission from new passenger cars is 115 g/km, which is 16 g/km lower than the previous year.

According to EU legislation, manufacturers can act individually or group together as pools to meet their CO2 emission targets. All manufacturer pools appeared to have met their 2021 targets except for two pools, Mazda-Subaru-Suzuki-Toyota and Renault-Nissan-Mitsubishi, that required flexible compliance mechanisms to do so.

Sources: Statzon, ACEA, EEA, Virta, ICCT

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