-Report-

EV Market Segmentation

Identifies and discusses recent developments in electric mobility across the globe.

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Abstract

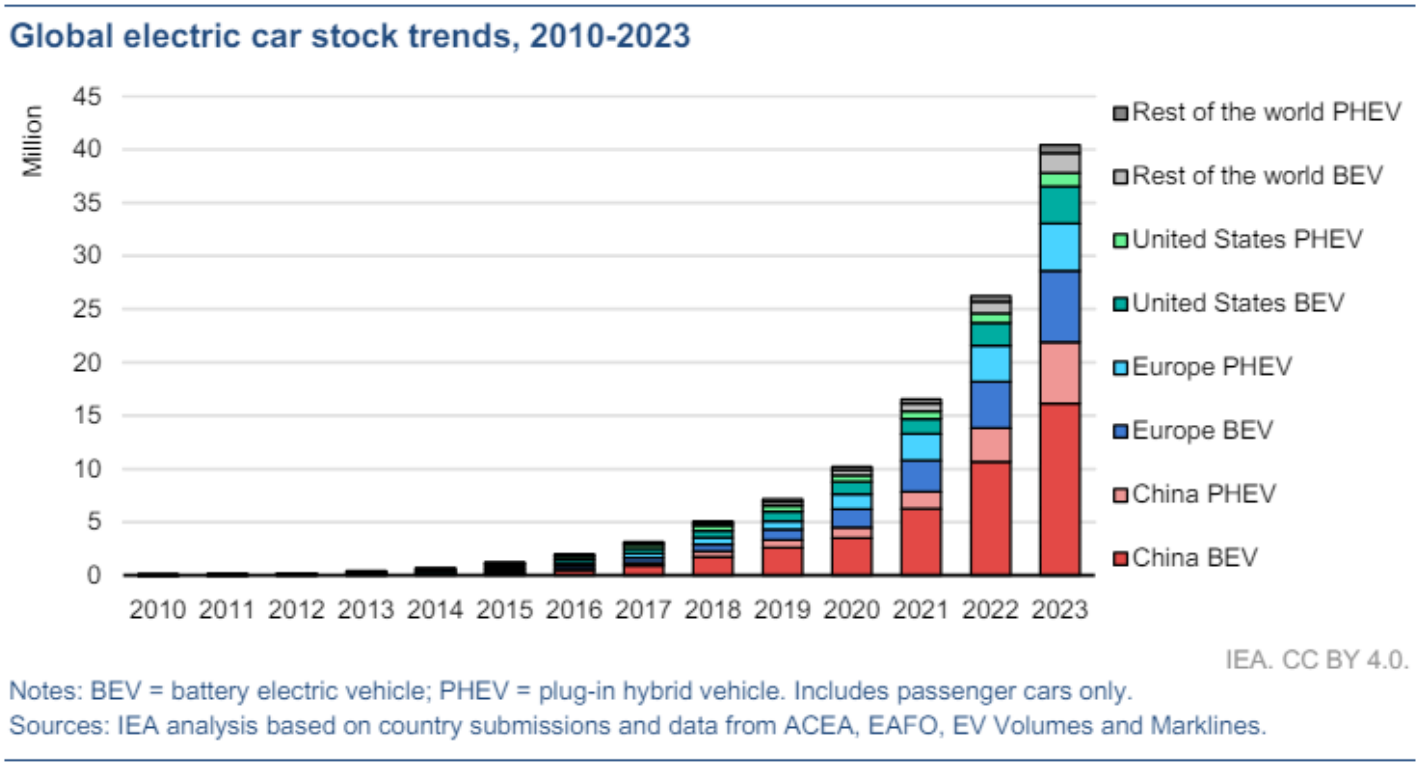
The Global EV Outlook is an annual publication that identifies and assesses recent developments in electric mobility across the globe. It is developed with the support of members of the Electric Vehicles Initiative (EVI). Combining analysis of historical data with projections – now extended to 2035 – the report examines key areas of interest such as the deployment of electric vehicles and charging infrastructure, battery demand, investment trends, and related policy developments in major and emerging markets. It also considers what wider EV adoption means for electricity and oil consumption and greenhouse gas emissions. The report includes analysis of lessons learned from leading markets, providing information for policy makers and stakeholders on policy frameworks and market systems that support electric vehicle uptake. This edition also features analysis of electric vehicle affordability, second-hand markets, lifecycle emissions of electric cars and their batteries, and grid impacts from charging medium- and heavy-duty electric trucks. Two online tools are made available alongside the report: the Global EV Data Explorer and the Global EV Policy Explorer, which allow users to interactively explore EV statistics and projections, and policy measures worldwide.

1. Trends in electric cars

Electric car sales Nearly one in five cars sold in 2023 was electric

Electric car sales neared 14 million in 2023, 95% of which were in China, Europe and the United States

Almost 14 million new electric cars1 were registered globally in 2023, bringing their total number on the roads to 40 million, closely tracking the sales forecast from the 2023 edition of the Global EV Outlook (GEVO-2023). Electric car sales in 2023 were 3.5 million higher than in 2022, a 35% year-on-year increase. This is more than six times higher than in 2018, just 5 years earlier. In 2023, there were over 250 000 new registrations per week, which is more than the annual total in 2013, ten years earlier. Electric cars accounted for around 18% of all cars sold in 2023, up from 14% in 2022 and only 2% 5 years earlier, in 2018. These trends indicate that growth remains robust as electric car markets mature. Battery electric cars accounted for 70% of the electric car stock in 2023.



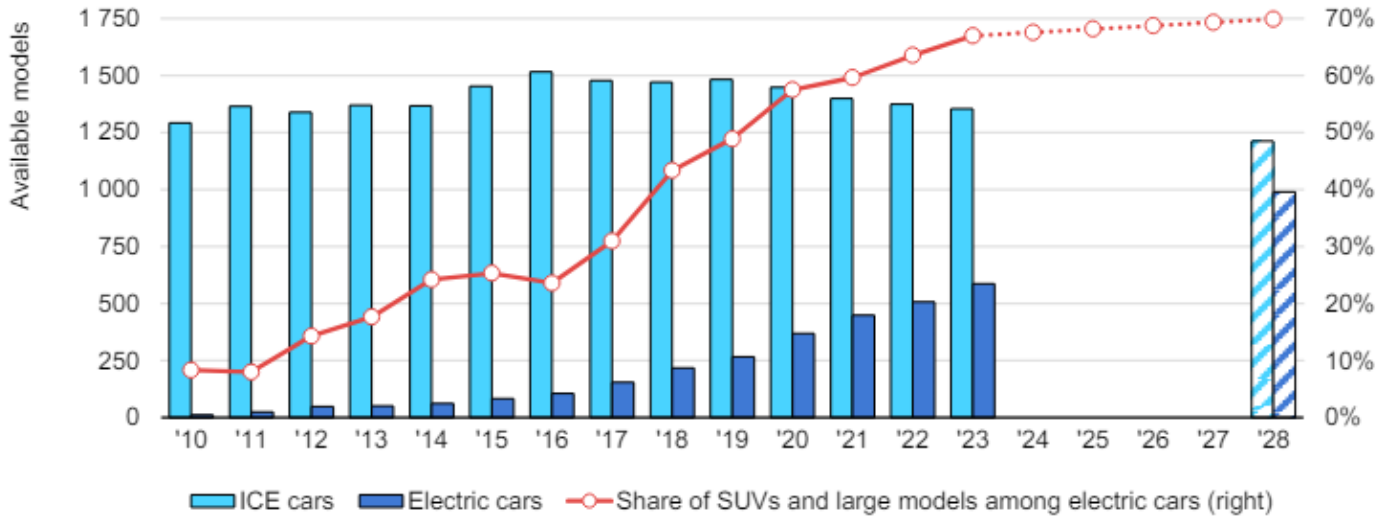
Electric car availability and affordability

More electric models are becoming available, but the trend is towards larger ones

The number of available electric car models nears 600, twothirds of which are large vehicles and SUVs

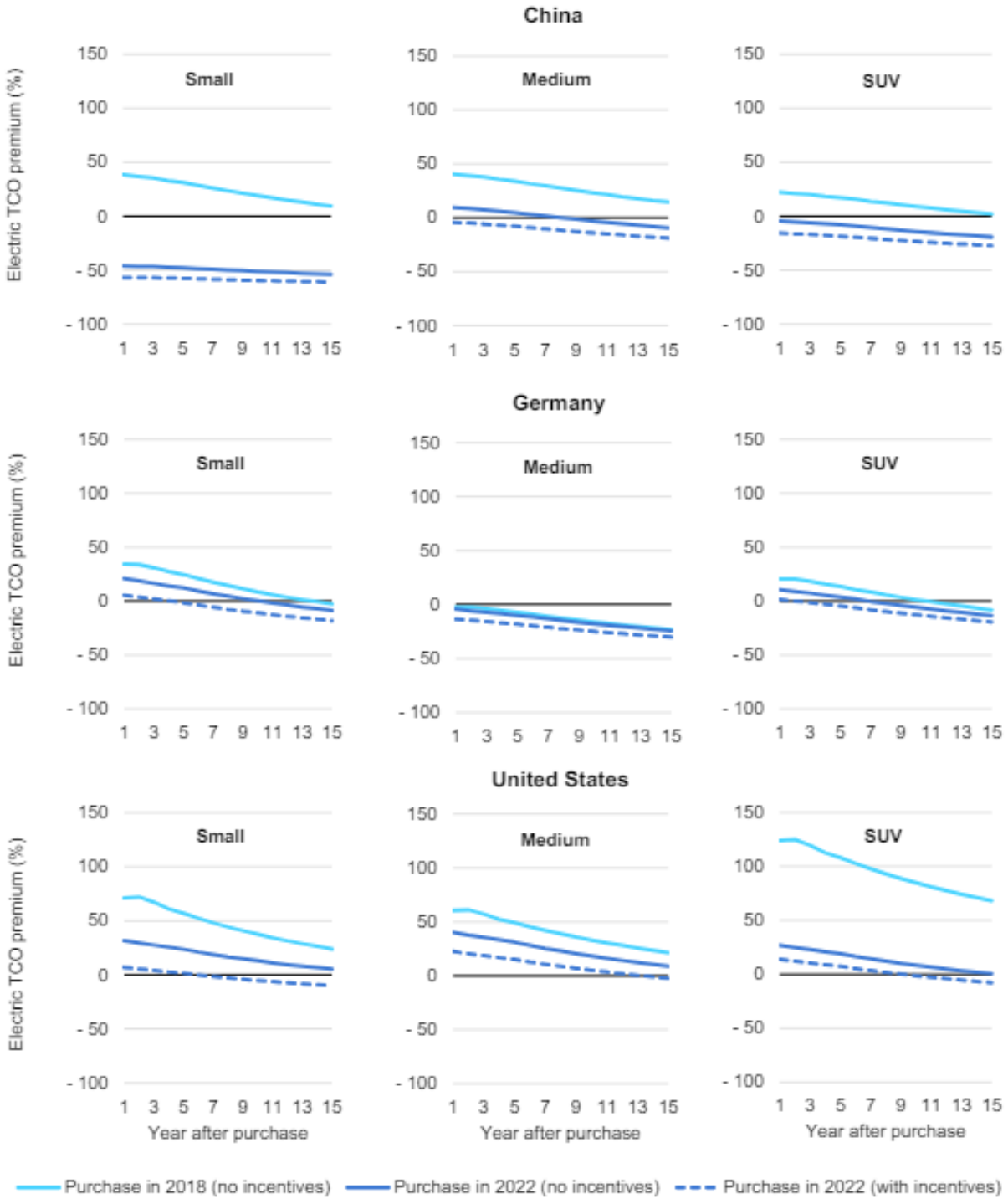
In 2023, the number of available models for electric cars increased 15% year-onyear to nearly 590, as carmakers scaled up electrification plans, seeking to appeal to a growing consumer base. Meanwhile, the number of fully ICE models (i.e. excluding hybrids) declined for the fourth consecutive year, at an average of 2%. Based on recent original equipment manufacturer (OEM) announcements, the number of new electric car models could reach 1 000 by 2028. If all announced new electric models actually reach the market, and if the number of available ICE car models continues to decline by 2% annually, there could be as many electric as ICE car models before 2030.

Car model availability by powertrain over 2010-2023 and in 2028 based on announced launches, and share of SUVs and large models among electric cars



Notes: ICE = internal combustion engine. SUVs = sports utility vehicle. ICE does not include hybrids. Electric cars include BEV and PHEV cars. Analysis based on models for which there was at least one new registration in a given year; a model on sale but never sold is not counted, and as such actual model availability may be underestimated. Large cars include E and F segments, multi-purpose vehicles and B segments with SUV body type. The SUV category encompasses segments C to F with SUV body type. The two columns for 2028 are based on electric model announcements, which are available only until 2028, and on a sustained decrease in the number of ICE models based on the trend over 2020-2023. Source: IEA analysis based on data from EV Volumes and Marklines.

Difference in total cost of ownership for a battery electric vehicle and a conventional car purchased in 2018 and 2022, by country and segment, over time after purchase



Notes: TCO = total cost of ownership; SUV = sports utility vehicle. First owner cumulative cost of ownership with depreciation considered. Incentives include subsidies, vehicle purchase tax exemptions and tax credits. All calculation assumptions are listed in Table 1 located in the general annex of this document.

2. Trends in other light-duty electric vehicles

Electric two- and three-wheelers

India, China and Association of Southeast Asian Nations (ASEAN) countries are the biggest two- and three-wheeler (2/3W)9 markets worldwide. In 2023, sales of 2/3Ws in these markets, including both electric and ICE powertrains, reached 19 million, 17 million and 14 million units, respectively. Indonesia, Viet Nam, the Philippines and Thailand are the biggest markets among ASEAN countries, with sales of 2/3Ws far outnumbering sales of LDVs, highlighting their importance in the region. Likewise, the number of 2/3Ws in India is 157 per 1 000 people, compared with only 35 passenger cars. Despite having smaller 2/3W markets overall, 2/3Ws also play a critical role in Latin America and Africa for daily passenger and commercial transportation. Electrifying 2/3Ws is therefore a promising lever for decarbonising mobility and improving urban air quality in these regions. In 2023, the sales share of electric 2/3Ws was just 13% globally, while in terms of stock shares, 2/3Ws represent the most electrified road transport segment, with about 8% of 2/3Ws being electric. China sold the most electric 2/3Ws in 2023, with over 30% of the 2/3W sales being electric (decreasing from about 50% in 2022), followed by India (8%) and ASEAN countries (3%)

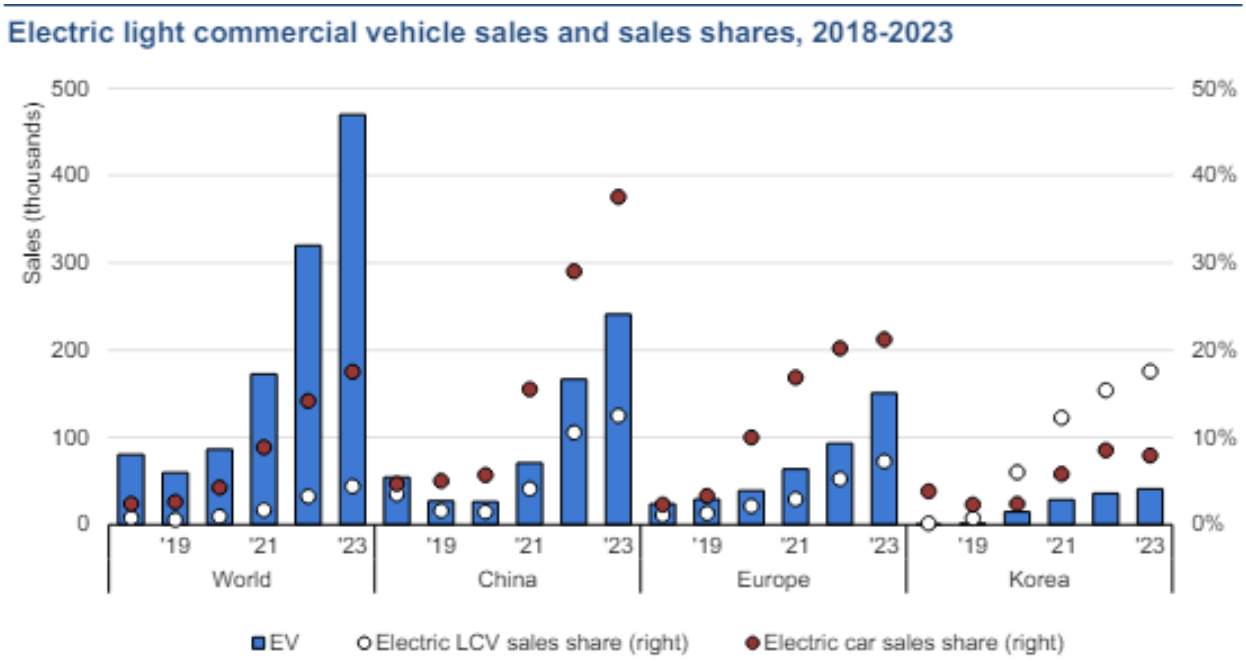
India overtakes China as the largest market for electric three-wheelers as global sales continue to grow

Globally, the three-wheeler (3W) market grew 13% in 2023, to reach 4.5 million sales, 21% of which were electric, compared to 18% in 2022. Almost 1 million electric 3Ws were sold in 2023, reflecting 30% growth compared to 2022. The market is highly concentrated, with China and India together accounting for more than 95% of all electric and 80% of conventional 3W sales. India overtook China in 2023 to become the biggest market for electric 3Ws, with over 580 000 sales. India saw its sales increase by 65% with respect to 2022, thanks to government financial incentives and resulting reductions in the cost of ownership of electric 3Ws. Sales in China declined 8% in 2023, to 320 000, making the country the second-largest electric 3W market.

Electric light commercial vehicles

One in twenty-five light commercial vehicles sold in 2023 was electric, following the path set by passenger cars

The market for electric light commercial vehicles (LCVs) continued to increase in 2023. Global electric LCV sales grew by more than 50%, and the sales share grew to just under 5%. Two of the biggest electric LCV markets, China and Europe, saw a large increase in sales in 2023, as part of a broader trend of increasing LCV sales – both electric and ICE. In China, electric LCV sales exceeded 240 000, and in Europe, the electric LCV market leapt by 60% to reach almost 150 000. As the electric LCV market matures, several OEMs have announced new electric models and new partnerships. Some of these new models are designed specifically for niche commercial activities, such as the B-ON Pelkan electric delivery van. In a partnership with Uber, Kia announced a modular van design with a body that can be swapped from shuttling to last-mile delivery depending on activity. The average range of new LCVs increased by 55% between 2015 and 2023. For example, the two most popular electric LCV models in 2015 (Nissan e-NV200 and the Renault Kangoo BEV) had a range of around 170 km. This compares to a much longer range – between 210 and 260 km – demonstrated by two very popular models (Hyundai Porter and Ford E-Transit) in 2023. Despite this increase, companies expanding their electric fleets have called for improvements in the accuracy of range labelling. Korea is the only country in which the penetration of electric LCVs is moving faster than electric passenger cars. In Korea, the Hyundai Porter and the Kia Bongo are the only electric LCV models sold. Both are produced by local manufacturers, and seem particularly suited for the Korean light freight market, which is characterised by shorter distances. These models are also favourably priced compared to ICE equivalents: The Kia Bongo 3 EV, for example, sells for around USD 25 000, including a subsidy of USD 7 700.



Notes: EV = electric vehicle; LCV = light commercial vehicle where weight is less than 3.5 tonnes. In China, LCVs include small-sized buses, some light-duty trucks and mini trucks. To better align with IEA classifications, a share of the light-duty trucks are considered as medium-duty trucks (defined here as having a gross vehicle weight greater than 3.5 tonnes and less than 15 tonnes).

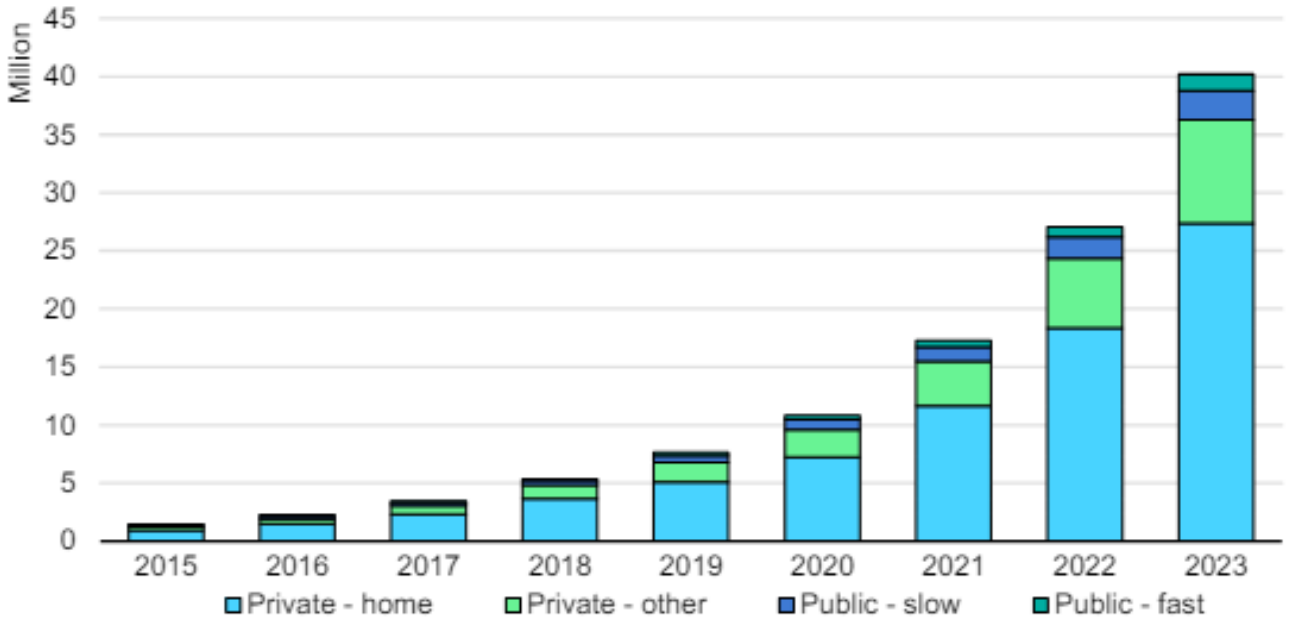
Sources: IEA analysis based on country submissions data from EV Volumes, and Interact Analysis.

3. Trends in electric vehicle charging Charging for electric light-duty vehicles There are almost ten times as many private chargers as public ones, with most owners charging at home

Home charging is currently the most common means of charging electric cars. EV owners with access to a private parking space that can be equipped for charging can charge overnight, which is not only convenient but also typically takes advantage of lower electricity prices while demand is relatively low. The availability of home charging varies substantially between regions and is linked to differences in urban, suburban and rural populations, as well as income bracket. In dense cities, where most people live in multi-unit dwellings, access to home charging is more limited and EV owners rely more heavily on public charging. This is most apparent in Korea, which is one of the world's most densely populated countries and has the highest ratio of public charging capacity to EVs. Though access to charging is different to actual use, it is a useful proxy for the levels of home charging among EV owners across countries. The share of EVs in new car sales is over 90% in Norway, whereas it stands at under 2% in Mexico, yet the shares of EV owners reportedly charging at home are similar, at 82% and 71%, respectively. The United Kingdom has one of the highest reported shares of access to home charging, at 93%, more than half of which are smart chargers.12 This is partly due to the United Kingdom being the first country to release smart charge point regulations, but, importantly, it

could also be attributed to the high share of early EV adopters that also own a home in which a charger can be installed. In India, 55% of consumers state that they have access to home charging today. Changes to building regulations in order to mandate chargers, as have been proposed by the European Union, are an effective way of increasing access over time, especially for people who live in rented accommodation.

Installed public and private light-duty vehicle charging points by power rating (public) and by type (private), 2015-2023



Notes: "Private – other" refers to charging points that are neither publicly accessible nor charging points at private residences. Home charging stock is estimated based on electric light-duty vehicle stock and regional assumptions on electric vehicle supply equipment (EVSE)/electric vehicle (EV) ratios.

Sources: IEA analysis based on country submissions.

4. Trends in electric vehicle batteries

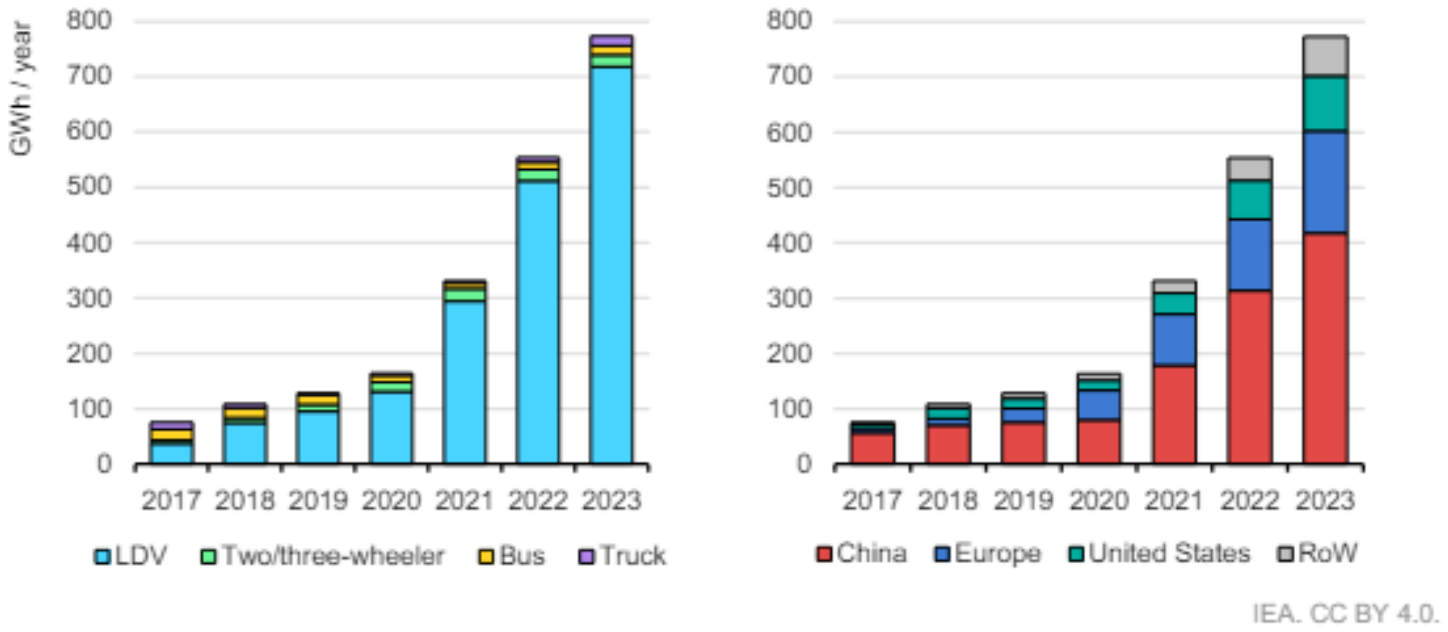
Battery supply and demand

Demand for batteries and critical minerals continues to grow, led by electric car sales

Increasing EV sales continue driving up global battery demand, with fastest growth in 2023 in the United States and Europe The growth in EV sales is pushing up demand for batteries, continuing the upward trend of recent years. Demand for EV batteries reached more than 750 GWh in 2023, up 40% relative to 2022, though the annual growth rate slowed slightly compared to in 2021-2022. Electric cars account for 95% of this growth. Globally, 95% of the growth in battery demand related to EVs was a result of higher EV sales, while about 5% came from larger average battery size due to the increasing share of SUVs within electric car sales. The United States and Europe experienced the fastest growth among major EV markets,

reaching more than 40% year-on-year, closely followed by China at about 35%. Nevertheless, the United States remains the smallest market of the three, with around 100 GWh in 2023, compared to 185 GWh in Europe and 415 GWh in China. In the rest of the world, battery demand growth jumped to more than 70% in 2023 compared to 2022, as a result of increasing EV sales. In China, PHEVs accounted for about one-third of total electric car sales in 2023 and 18% of battery demand, up from one-quarter of total sales in 2022 and 17% of sales in 2021. PHEV batteries are smaller than those used in BEVs, thereby contributing less to increasing battery demand. In recent years, Chinese carmakers have also been marketing more extended-

Electric vehicle battery demand by mode and region, 2017-2023



Notes: LDV = light-duty vehicle, including cars and vans; RoW = rest of the world.
Source: IEA analysis based on data from EV Volumes.

range EVs (EREVs), which use an electric motor as their unique powertrain but have a combustion engine that can be used to recharge the battery when needed. EREVs typically have a battery size about twice that of a PHEV, enabling a real-world electric range of around 150 km compared to 65 km for traditional PHEVs. With an ICE on board, EREVs can reach ranges of around 1 000 km when needed. In 2023, EREVs accounted for 25% of PHEV sales in China, up from about 15% in 2021-2022. Negligible EREV sales are recorded in other regions.

Battery prices Electric vehicle battery prices start falling again

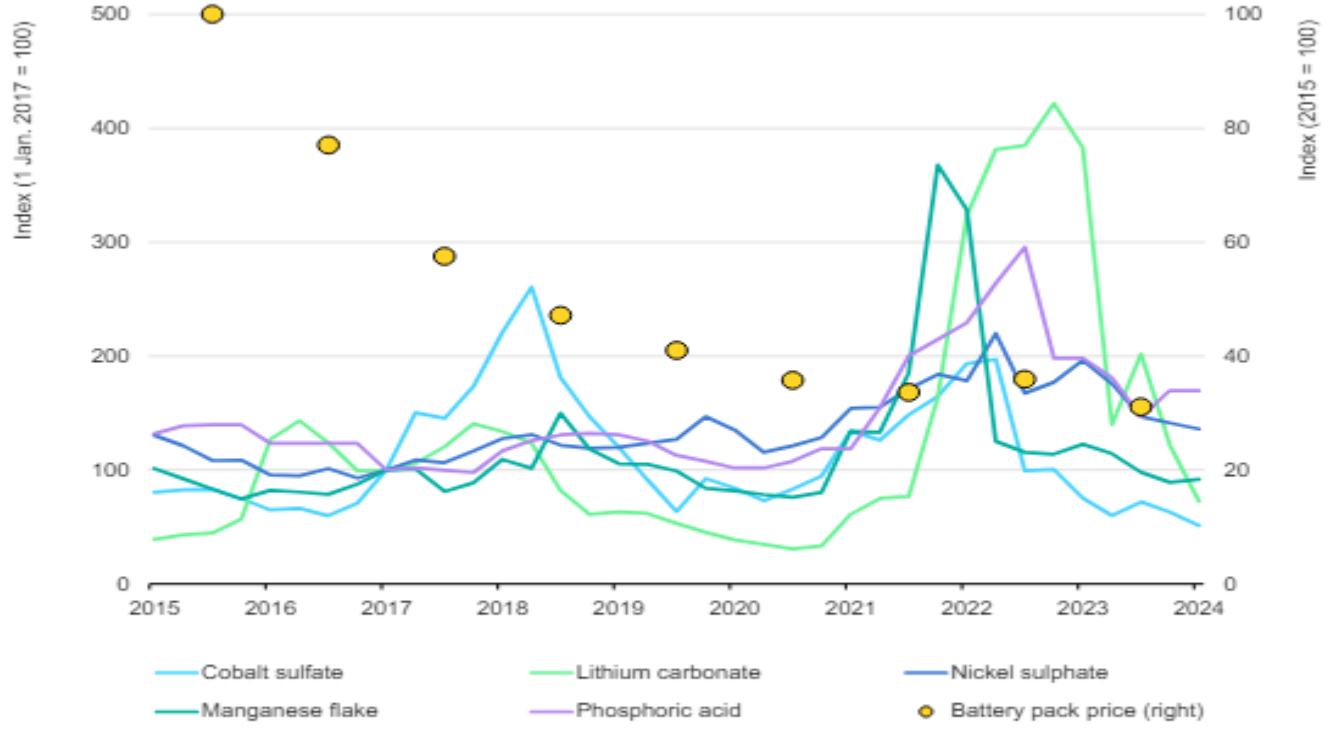
Stabilising critical mineral prices led battery pack prices to fall in 2023

Turmoil in battery metal markets led the cost of Li-ion battery packs to increase for the first time in 2022, with prices rising to 7% higher than in 2021. However, the price of all key battery

metals dropped during 2023, with cobalt, graphite and manganese prices falling to lower than their 2015-2020 average by the end of 2023. This led to an almost 14% fall in battery pack price between 2023 and 2022, despite lithium carbonate prices at the end of 2023 still being about 50% higher than their 2015-2020 average. The last year in which battery price experienced a similar price drop was 2020.

6. Trends in the electric vehicle industry

Price of selected battery metals (left) and lithium-ion battery packs (right), 2015-2024



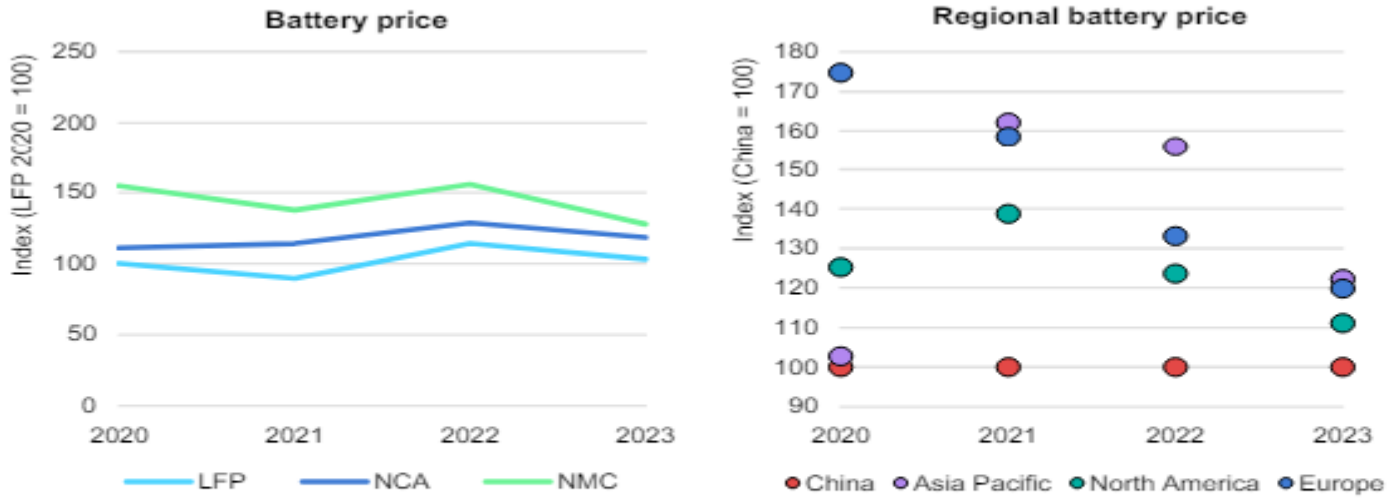
Note: "Battery pack price" refers to the volume-weighted average pack price of lithium-ion batteries over all sectors.
Sources: IEA analysis based on data from Bloomberg and Bloomberg New Energy Finance Lithium-Ion Price Survey (2023).

Electric vehicle company strategy and market competition

Electric vehicle companies perform well in financial markets, but volatility and competition raise concern

Since 2019, the stocks of EV companies – including vehicle and battery manufacturers and companies involved in the extraction or processing of battery metals – have consistently

Average battery price index by selected battery chemistry and region, 2020-2023



Notes: LFP = lithium iron phosphate; NMC = lithium nickel manganese cobalt oxide; NCA = lithium nickel cobalt aluminium oxide. Asia Pacific excludes China. Each year is indexed with respect to China price (100). Battery prices refer to the average battery price in a given region, including locally produced batteries and imports.

Sources: IEA analysis based on data from Bloomberg New Energy Finance.

outperformed general stock markets, major traditional carmakers, and other segments of clean technology. Return on investment has increased more over the 2019-2023 period for these companies than it has for others, in relative terms. The combined market capitalisation of pure play EV makers boomed from USD 100 billion in 2020 to USD 1 trillion at the end of 2023, with a peak over USD 1.6 trillion at the end of 2021, though this trend was primarily driven by Tesla. The market capitalisation of battery makers and battery metal companies also increased significantly over the same period. Behind this overall upward trend, however, there has been significant volatility. Supply chain disruptions and battery metal price fluctuations – notably in the wake of Russia's invasion of Ukraine – as well as increasing competition, price wars among OEMs and expectations of slower relative annual growth as major EV markets mature, and of possible consolidation, are having an important downward impact on investor confidence and EV stocks. For example, Tesla's shares were on average 15% lower in 2023 than in 2021-2022; BYD's average stock also fell 15% in 2023 relative to 2022; and the combined market capitalisation of pure play EV carmakers fell by nearly 20% on average relative to 2022, while that of major incumbent carmakers remained flat. Many emerging EV players – such as VinFast from Viet Nam, Polestar from Europe, and Canoo, Fisker, Lucid and Nikola from the United States – are missing sales targets and trading low. Fiercer competition and shrinking profits also have an impact upstream, among EV battery makers: in the first weeks of 2024, CATL was trading near a three-year low, with a market capitalisation at its lowest point since the end of 2020. In the first quarter of 2024, the combined market capitalisation of pure play EV players fell below that of major incumbents, even if their financial stock performance remained robust.

Key financial indicators for major car, battery, mining and cleantech companies

Notes: EV = electric vehicle; ICE = internal combustion engine; ACWI = All Country World Index. Data through Q1 2024 included. Performance is measured via arithmetic returns, which refer to the sum of quarterly returns on a given stock (capital gains and dividends). The area highlighted in yellow represents a credit crisis, and in blue, a recovery period for capital markets followed by the pandemic-induced credit shock in Q1 2020. The red highlight shows the months following Russia's invasion of Ukraine. Weekly financial performance of selected EV, battery and battery mineral and metal companies is plotted against the major conventional carmakers, the broader public equity market benchmark (MSCI ACWI), and the S&P Renewable Energy and Clean Technologies benchmark, at an index level. The major conventional carmakers index is equal-weighted, giving equal importance to each constituent company regardless of market capitalisation or share (BMW, Ford, GM, Honda, Hyundai, Kia, Mercedes-Benz, Nissan, Renault, Stellantis, Toyota, and Volkswagen). The EV index consists of ten pure play EV companies (BYD, Fisker, Leap, Li Auto, Lucid, Nikola, NIO, Rivian, Tesla, and XPeng), and the battery index of eight battery and component manufacturing companies (Contemporary Amperex Technology, Ecopro BM, Eve Energy, Gotion High-tech, L&F, LG Energy Solution, Panasonic Holdings, and Samsung SDI), weighted based on the shares of these companies within the Bloomberg EV Price Return Index. The battery mineral and metal index includes over 40 companies selected in the S&P Global Core Battery Metals Index. Financial performance and market capitalisation do not necessarily reflect actual profits or losses, but rather investor expectations of future returns.

Source: IEA analysis based on Bloomberg.

6. Outlook for electric mobility

Scenario overview

In this part of the report, we focus on pathways to electrify road transport over the period to 2035, expanding the time horizon by five years compared with previous editions of the Global EV Outlook. A scenario-based approach is used to explore the outlook for electric mobility, based on recent market trends, policy drivers and technology developments. The purpose of the scenarios is to assess plausible futures for global electric vehicle (EV) markets and their

potential implications. The scenarios do not make predictions about the future. Rather, they aim to provide insights to inform decision-making by governments, companies and other stakeholders about the future of EVs. The projections in the Stated Policies Scenario (STEPS) and Announced Pledges Scenario (APS) consider historical data through the end of 2023, as well as stated policies and ambitions as of the end of March 2024. The Net Zero Emissions by 2050 Scenario (NZE Scenario) is consistent with the 2023 update to the IEA Net Zero Roadmap and the World Energy Outlook 2023. Deployment of electric vehicles is projected by road transport mode and by region. Regional results are presented for the STEPS and APS, while the discussion of the projections in the NZE Scenario focuses on global results. These projections are then compared to announcements by original equipment manufacturers (OEMs) and battery manufacturing capacity expansion announcements. These scenario projections incorporate GDP assumptions from the International Monetary Fund and population assumptions from the United Nations.

Stated Policies Scenario

The Stated Policies Scenario (STEPS) reflects existing policies and measures, as well as firm policy ambitions and objectives that have been legislated by governments around the world. It includes current EV-related policies, regulations and investments, as well as market trends based on the expected impacts of technology developments, announced deployments and plans from industry stakeholders. The STEPS aims to hold up a mirror to the plans of policy makers and illustrate their consequences.

Announced Pledges Scenario

The Announced Pledges Scenario (APS) assumes that all announced ambitions and targets made by governments around the world are met in full and on time. With regards to electromobility, it includes all recent major announcements of electrification targets and longer-term net zero emissions and other pledges, regardless of whether these have been anchored in legislation or in updated Nationally Determined Contributions. For example, the APS assumes that countries that have signed on to the Conference of the Parties (COP 26) declaration on accelerating the transition to 100% zero emissions cars and vans will achieve this goal, even if there are not yet policies or regulations in place to support it. In countries that have not yet made a net zero emissions pledge or set electrification targets, the APS considers the same policy framework as the STEPS. Non-policy assumptions for the APS, including population and economic growth, are the same as in the STEPS. The difference between the APS and the STEPS represents the “implementation gap” that exists between the policy frameworks and measures required to achieve country ambitions and targets, and the policies and measures that have been legislated.

Net Zero Emissions by 2050 Scenario

The Net Zero Emissions by 2050 Scenario (NZE Scenario) is a normative scenario that sets out

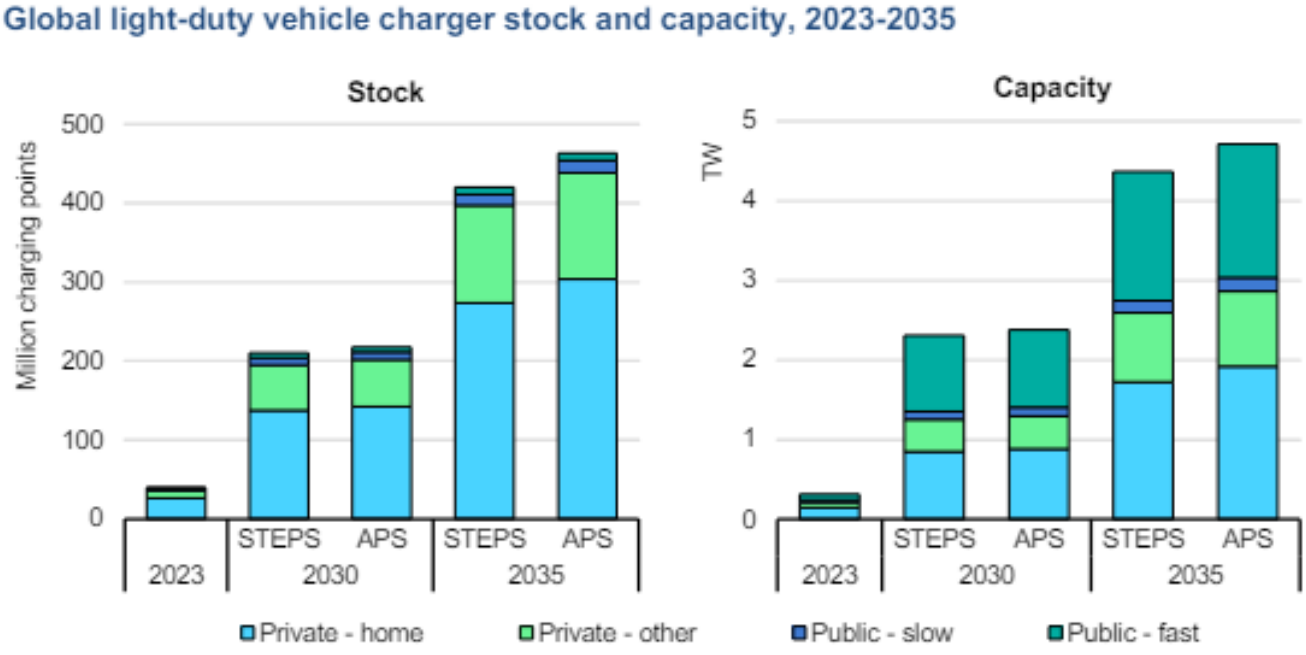
a narrow but achievable pathway for the global energy sector to achieve net zero CO2 emissions by 2050. The scenario is compatible with limiting the global temperature rise to 1.5°C with no or limited temperature overshoot, in line with reductions assessed by the Intergovernmental Panel on Climate Change in its Special Report on Global Warming of 1.5°C. There are many possible paths to achieve net zero CO2 emissions globally by 2050 and many uncertainties that could affect them. The NZE Scenario is therefore a path and not the path to net zero emissions. The difference between the NZE Scenario and the APS highlights the "ambition gap" that needs to be closed to achieve the goals under the 2015 Paris Agreement.

7. Outlook for electric vehicle charging infrastructure

Light-duty vehicle charging

Public charging could increase sixfold by 2035, helping mass-market consumers switch to electric

Large-scale adoption of EVs hinges on the simultaneous roll-out of accessible and affordable charging. The early adopters of electric cars have tended to live in single-family detached



homes with affordable and convenient access to home charging. As a result, most charging to date has been private (at home and other private locations). At the same time, public chargers have tended to be installed in urban areas, where utilisation rates are likely to be higher. Looking forward, however, chargers must also be installed outside of urban areas to enable continued adoption beyond cities and suburbs. In a 2021 survey of EV drivers in the United Kingdom, over 90% of the respondents reported having access to home chargers, whereas a 2023 study showed that only 55% of Indian consumers had such access. The build-out of

charging in workplaces and publicly accessible areas will be key for increasing adoption among groups without access to home charging. Charging speed – slow or fast – is also an important consideration for consumers looking to switch to electric, especially when considering a vehicle for long journeys. Charging services should also be easy to use, reliable and transparently priced. Further, ensuring interoperability is important when making investments in charging infrastructure and services, so that a wide customer base is able to benefit. In the STEPS and APS, the global number of public charging points exceeds 15 million by 2030, up four-fold compared to the almost 4 million operating in 2023. By 2035, this number reaches almost 25 million in the APS, a sixfold increase relative to 2023. Among today's major EV markets, China is where the population's access to home charging is most limited and where public charging has been most widely rolled out as a result. China accounted for 70% of global public LDV charging in 2023 and is expected to remain a leader with a similar share in 2035 in the STEPS. While the current availability of public chargers in China already appears to be above the global average infrastructure. The number of electric LDVs per public charging point increases from around 10 in 2023 to around 15 in 2035 in the APS, remaining lower than other major markets. Currently, China has one of the highest shares of fast chargers out of total public charging stock, at around 45%. In both the STEPS and APS, the stock of public fast chargers reaches around 7.5 million in 2035, almost six times 2023 levels. The number of slow chargers reaches 8.2 million in 2035 in the APS.

8. Outlook for battery and energy demand

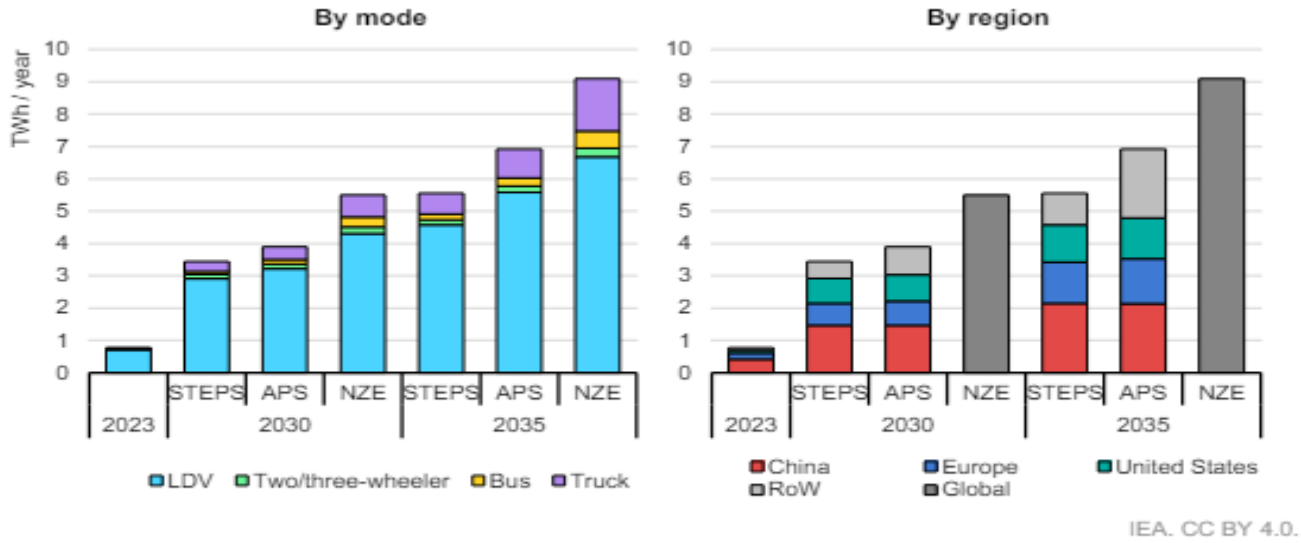
Battery demand

Battery demand for electric vehicles jumps tenfold in ten years in a net zero pathway

As EV sales continue to increase in today's major markets in China, Europe and the United States, as well as expanding across more countries, demand for EV batteries is also set to grow quickly. In the STEPS, EV battery demand grows fourand-a-half times by 2030, and almost seven times by 2035 compared to 2023. In the APS and the NZE Scenario, demand is significantly higher, multiplied by five and seven times in 2030 and nine and twelve times in 2035, respectively. To put this in context, in the APS in 2035, there could be as much EV battery demand per week as there was in the entire year of 2019. Cars remain the primary driver of EV battery demand, accounting for about 75% in the APS in 2035, albeit down from 90% in 2023, as battery demand from other EVs grows very quickly. In the STEPS, battery demand for EVs other than cars jumps eightfold by 2030 and fifteen-fold by 2035. In the APS, these numbers reach tenfold by 2030 and more than twenty-fold by 2035. Battery requirements differ across modes, with a 2/3W requiring a battery about 20 times smaller than a BEV, while buses and trucks require batteries that are between 2 and 5 times bigger than for a BEV. This also affects trends in different regions, given that 2/3Ws are significantly more important in

emerging economies than in developed economies. As EVs increasingly reach new markets, battery demand outside of today's major markets is set to increase. In the STEPS, China, Europe and the United States account for just under 85% of the market in 2030 and just over 80% in 2035, down from 90% today. In the APS, nearly 25% of battery demand is outside today's major markets in 2030, particularly as a result of greater demand in India, Southeast Asia, South America, Mexico and Japan. In the APS in 2035, this share increases to 30%. Stationary storage will also increase battery demand, accounting for about 400 GWh in STEPS and 500 GWh in APS in 2030, which is about 12% of EV battery demand in the same year in both the STEPS and the APS.

Battery demand for electric vehicles by mode and region, 2023-2035



Notes: STEPS = Stated Policy Scenario; APS = Announced Pledges Scenario; NZE = Net Zero Emissions by 2050 Scenario; LDV = light-duty vehicle, including cars and vans; RoW = Rest of the world.

Electricity demand

Electric vehicles could account for 6-8% of total electricity demand by 2035, up from 0.5% today