

Electric Vehicle Outlook 2023



BloombergNEF

This is an excerpt from BloombergNEF's 2023 Electric Vehicle Outlook. To find out more about the full report, please contact [our team](#).

Executive Summary

730 million

Number of passenger EVs on the road in 2040 in the Economic Transition Scenario

2029

Year road transport emissions peak

\$1.9 trillion

Charging infrastructure market opportunity between today and 2050 in the Economic Transition Scenario

The transportation and automotive sectors are undergoing a period of profound transformation. Electrification is now spreading rapidly in almost all segments of road transport, from passenger cars to commercial vehicles, buses and two- and three-wheelers. Each country has its own unique mix of vehicles and while progress varies across them, the overall direction of travel is increasingly clear.

Technology changes are at the core of this transition as battery prices have fallen dramatically over the last decade. Battery prices rose for the first time in 2022 but innovation in the area is not slowing down, with advances in areas like solid-state batteries, next-generation cathode and anode chemistries, and sodium-ion technology all reaching commercialization in the next few years.

Yet technology changes alone are not enough to keep the road transport sector on track for net-zero emissions by mid-century. Policymakers have an important role to play in driving the automotive market toward zero-emissions options, improving fuel efficiency, getting the power system ready for electric vehicles, and in reducing overall car dependency. Eliminating emissions from road transport will require all hands on deck, including automakers, battery manufacturers, charging companies, grid operators, miners, large fleet operators and consumers.

As momentum grows, new economic opportunities are taking shape. Batteries and electric vehicles have taken center stage in new discussions on industrial policy, with countries now competing to attract investment and build new clusters of high-value manufacturing. Meanwhile, regulators and grid operators are looking at ways to ensure EVs benefit the power system.

Electrification is not the only vector of change. Shared mobility, vehicle connectivity and, eventually, autonomous vehicles are also set to reshape automotive and freight markets around the world. Urbanization also continues its steady march, leading to increased concerns around vehicle congestion and urban air quality.

This report draws on BloombergNEF's team of sectoral and regional experts around the world. It updates our outlook for how road transport could evolve over the next 30 years. It includes analysis on EV adoption in passenger vehicles, commercial vans and trucks, two- and three-wheeled vehicles and buses globally. It also looks at other drivetrains, including hybrids, natural gas and fuel cells, and then explores the resulting impacts of all of these on electricity markets, oil demand, battery materials, charging infrastructure and CO2 emissions.

The key findings are as follows:

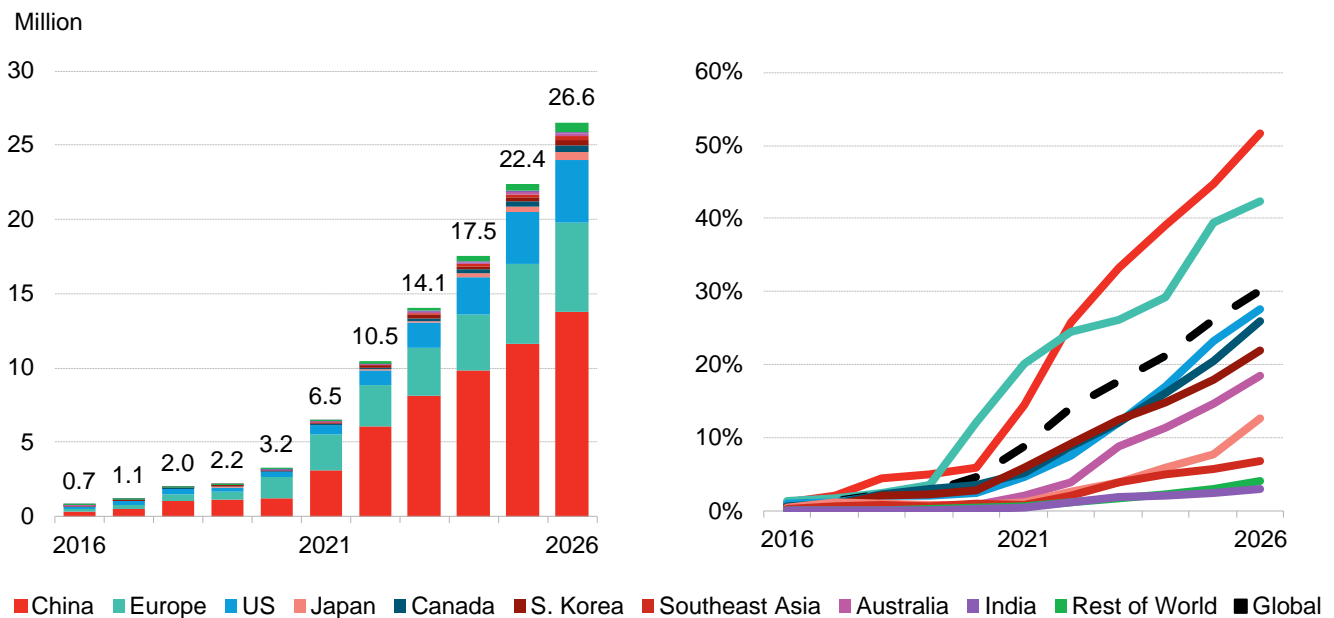
- **Direct electrification via batteries is the most efficient, cost-effective and commercially available route to fully decarbonizing road transport.** Fuel cell vehicles play a role in some hard-to-electrify long-haul trucking applications but play no meaningful role in the

passenger vehicle market. Synthetic fuels do not arrive at scale in time or at a price point needed to have a material impact on road transport.

- **EV sales continue to surge in the next few years, rising from 10.5 million in 2022 to almost 27 million in 2026.** The EV share of global new passenger vehicle sales jumps from 14% in 2022 to 30% in 2026. Shares in some markets are much higher, with EVs reaching 52% of sales in China and 42% in Europe. Some European car markets move even faster, with the Nordics at 89% and Germany at 59%. In the US, a major push from the Inflation Reduction Act means EVs make up nearly 28% of passenger vehicle sales by 2026, up from 7.6% in 2022. The EV adoption gap between wealthy and emerging economies continues to grow in the near term, but Japan significantly lags other wealthy countries.

The fleet grows even faster, rising from 27 million passenger EVs on the road at the end of 2022 to over 100 million by 2026.

Figure 1: Global near-term passenger EV sales and share of new passenger vehicle sales by market

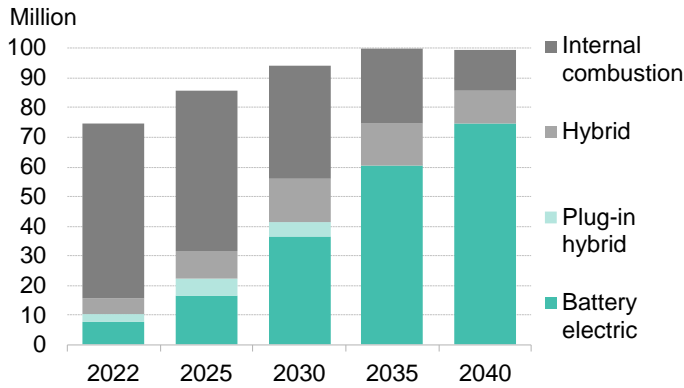


Source: BloombergNEF. Note: Europe includes the EU, the UK and EFTA countries. EV includes BEVs and PHEVs.

- **Combustion vehicle sales have peaked.** Sales of internal combustion vehicles peaked in 2017 and are now in long-term decline. By 2026, sales of combustion vehicles are 39% lower than their peak in 2017. The combustion vehicle fleet peaks in 2025.
- **The long-term picture is getting brighter, but challenges remain.** EVs reach 44% of global passenger vehicle sales by 2030 and 75% by 2040 in our Economic Transition Scenario. After increasing rapidly from 2022 to 2035, EV sales growth slows down slightly in the late 2030s in the main EV markets like Europe, China and the US as they begin to saturate. Although public charging infrastructure is growing at pace globally, it still presents a potential barrier to electrifying the last 10-20% of the market in many countries.

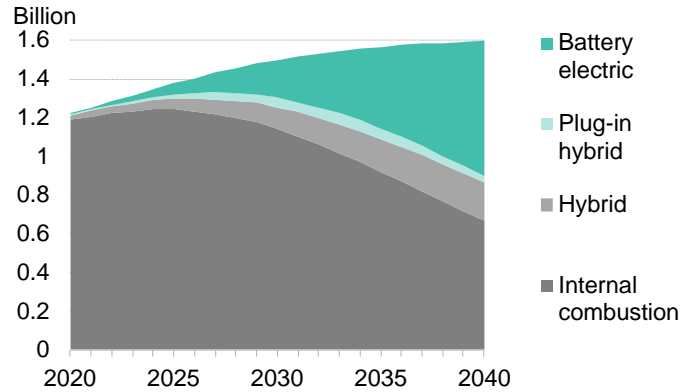
While EV sales exhibit a traditional 'S-curve' for adoption, each country and region starts on this trajectory at different times. The varied start time and slowdown points between countries mean that the global average appears more linear than any individual country. Despite rapid EV adoption, less than 50% of the global passenger vehicle fleet is electric by 2040.

Figure 2: Global passenger vehicle sales by drivetrain – Economic Transition Scenario



Source: BloombergNEF.

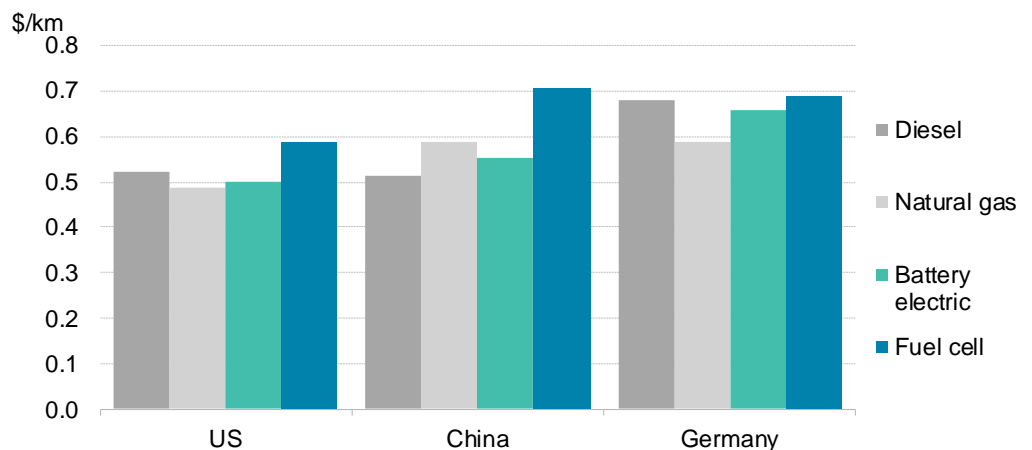
Figure 3: Global passenger vehicle fleet by drivetrain – Economic Transition Scenario



Source: BloombergNEF.

- Electrification is now spreading quickly to all areas of road transport.** Light commercial EV sales are set to rise quickly due to attractive economics, more models available, growing fleet commitments and city policies, reaching almost 70% of global sales by 2040, led by China. The economics of electric heavy trucks improve rapidly throughout the 2020s and become as cheap as diesel equivalents even for long-haul applications. However, fuel costs still matter and natural gas remains economically competitive. Fuel cell truck costs decline as well, but uncertainty on their trajectory is high. Overall road freight demand rises 46% from 2020 to 2040, highlighting the need for competitive zero-emissions options in this segment. Municipal buses are also electrifying quickly. Europe and the US begin to catch up with China in this market and EVs reach 36% and 24% of municipal bus sales respectively by 2026. Two- and three-wheeled vehicle sales also continue to rise in emerging economies and are set to be almost all electric globally by 2040.

Figure 4: Total cost of ownership of heavy-duty truck in long-haul duty cycle in 2030



Source: BloombergNEF. Note: The heavy-duty truck is modeled on a Class 8 vehicle with 800 kilometers of real-world driving range.

- **Reaching net-zero road transport emissions by 2050 is still possible but much faster progress is needed.** The gap between BNEF’s Economic Transition Scenario and the Net Zero Scenario is smaller than in any of our previous projections. This is due to new stronger policy support in the US, early EV progress in a few emerging economies like India, Thailand and Indonesia, growing global investment in charging infrastructure and the battery supply chain, and technology innovations like sodium-ion batteries.

A stronger push is still needed. Heavy trucks in particular are far behind the net-zero trajectory and should be a priority focus for policy makers. Grid investments, grid connections and permitting processes also need to be streamlined to support the large number of charging points needed for the transition.

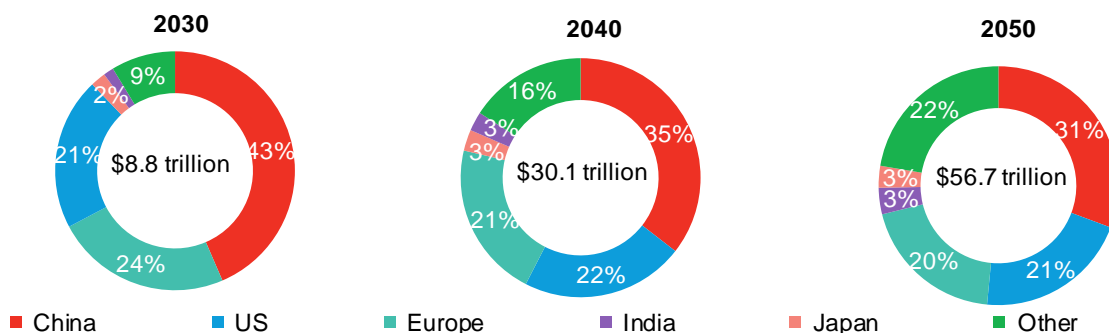
Table 1: Road transport segment progress toward net zero

Segment	Current share of road transport CO2 emissions	Current estimated global fleet size	Zero-emission vehicle (ZEV) fleet share in 2050 – Economic Transition Scenario	Level of policy intervention needed to hit Net Zero Scenario (100% ZEV share) by 2050
Three-wheeled vehicles	<1%	119 million	95%	On track
Two-wheeled vehicles	5%	1 billion	78%	Almost on track: minor additional measures needed
Municipal buses	1%	3.5 million	87%	Almost on track: minor additional measures needed
Light commercial vehicles	11%	165 million	76%	Positive trajectory: moderate additional measures needed
Passenger vehicles	53%	1.3 billion	70%	Positive trajectory: moderate additional measures needed
Medium + heavy commercial vehicles	30%	82 million	32%	Not on track: strong additional measures needed urgently

Source: BloombergNEF, various government sources. Note: Fleet size represents vehicles of all drivetrain types and are estimates based on various sources and BNEF data. Some values rounded. Current emissions and fleet size data are for 2022.

- **The shift to electrification creates a very large economic opportunity.** The cumulative value of EV sales across all segments hits \$8.8 trillion dollars by 2030 and \$57 trillion by 2050 in the Economic Transition Scenario. This jumps to over \$88 trillion by 2050 in the Net Zero Scenario. EVs and batteries are now a central part of many countries’ industrial policy and competition to attract investment is likely to increase in the coming years.

Figure 5: Cumulative global EV market opportunity by region – Economic Transition Scenario

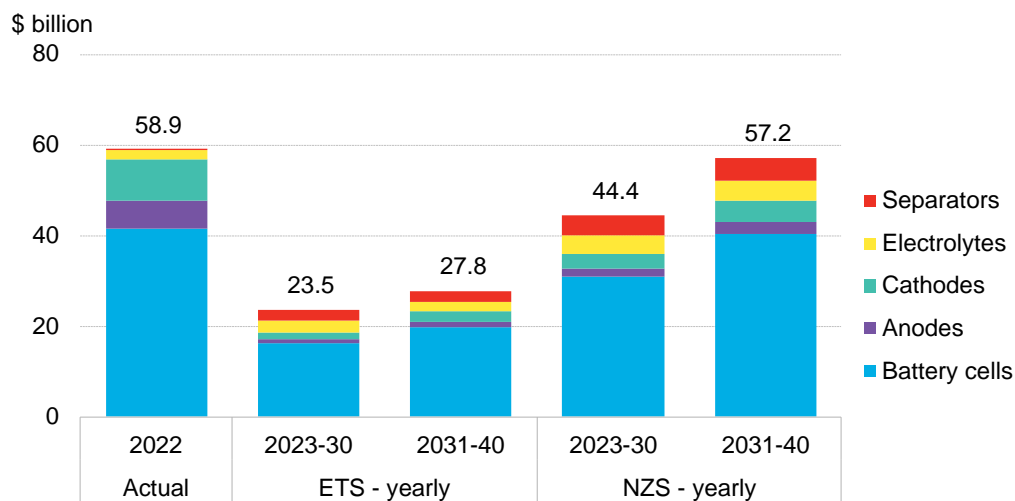


Source: BloombergNEF. Estimates are cumulative spending starting in 2023. Dollars are in real 2022.

- Large investments are needed in all areas of the battery supply chain.** Annual lithium-battery demand grows rapidly, approaching 5.7TWh annually by 2035 in our Economic Transition Scenario. Meeting this demand requires large but achievable increases in materials, components and cell production. There is over 7.4TWh of nameplate cell manufacturing capacity planned by 2025. This is more than projected demand in the same year, but actual excess supply will be lower due to varying utilization rates, commissioning delays and abandonments.

Increasingly, governments and automakers are seeking to localize their respective supply chains through a number of policies ranging from direct subsidies to battery ‘passports’. Sustained investment will be required in the second half of the decade to keep up with demand. At least \$188 billion needs to be invested in battery cell and component plants by the end of the decade.

Figure 6: Annual battery factory investment by scenario

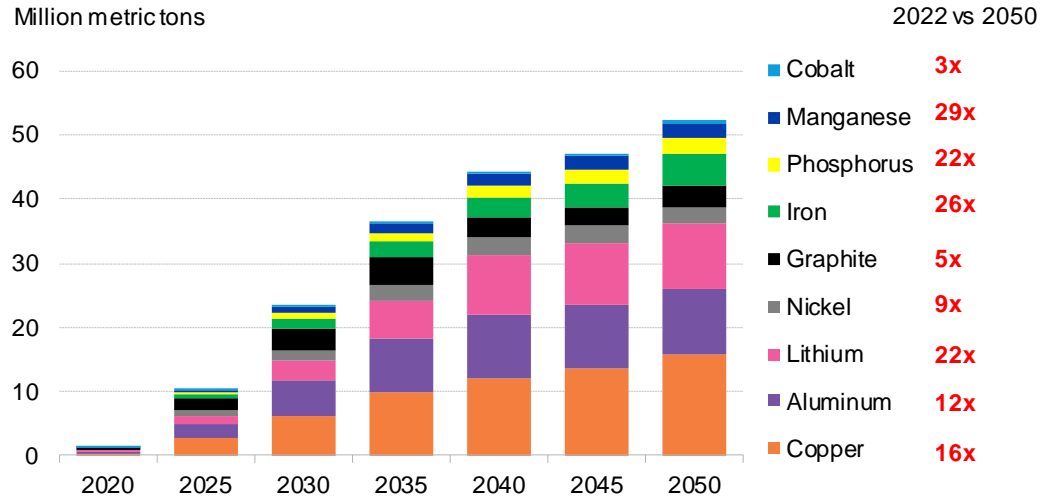


Source: BloombergNEF. Note: ETS = Economic Transition Scenario. NZS = Net Zero Scenario. Battery factory requirements include investment needed to meet EV demand as well as stationary energy storage.

Under the Net Zero Scenario, new demand for lithium-ion batteries is 1.7 times that of our Economic Transition Scenario, reaching 244TWh cumulatively by 2050. Thanks to increasing reserves and a reduction in use in batteries, cobalt and nickel reserves are now enough to supply both our Economic Transition and Net Zero Scenarios. Lithium looks more challenging and currently known reserves would be depleted in our Net Zero Scenario even with recycling.

New battery chemistries and reductions in pack sizes can help offset this pressure. Scaling new resource development and refining capacity will be key to keep up with demand in any given year.

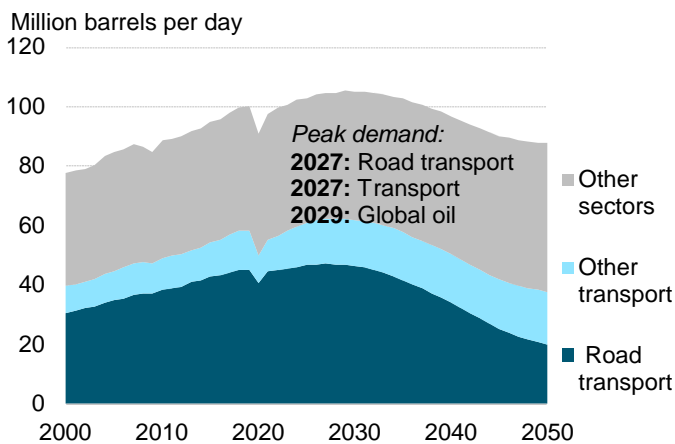
Figure 7: Annual metals demand from lithium-ion batteries under the Net Zero Scenario



Source: BloombergNEF. Note: Lithium is expressed in million metric tons lithium carbonate equivalent (LCE). Demand occurs at the mine mouth, one year before battery demand. Multiples between 2022 and 2050 are based on annual demand in the given year.

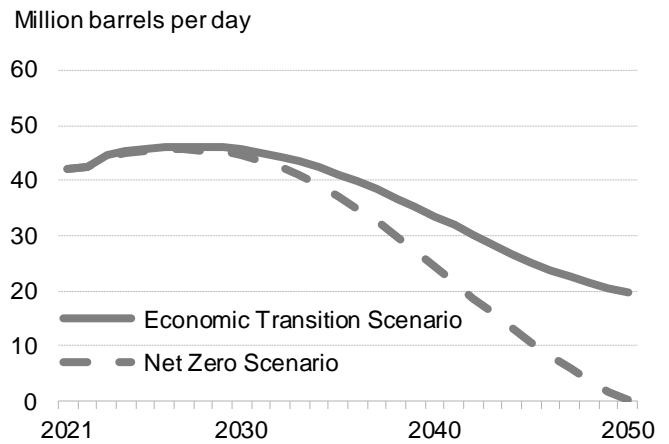
- Oil demand from road transport is very near its peak.** Electric vehicles of all types are already displacing 1.5 million barrels/day of oil demand. This rises dramatically in the years ahead, leading to a peak in overall road fuel demand in 2027. Demand in the US and Europe has already peaked, while demand in China is set to peak in 2024. Global oil demand from two-wheelers, three-wheelers and buses has also already peaked and demand from passenger cars is set to peak in 2025. Commercial vehicles take longer to shift as heavy trucks continue to rely on diesel to move booming freight demand.

Figure 8: Global oil demand – Economic Transition Scenario



Source: BloombergNEF. Note: Includes biofuels.

Figure 9: Oil demand from road transport by scenario



Source: BloombergNEF. Note: Includes biofuels.

In the Economic Transition Scenario, oil demand from road transport declines to 33.5 million b/d in 2040, some 21% lower than 2022 levels. Fuel efficiency improvement of combustion vehicles and the uptake of shared mobility also play an important role in reducing oil demand.

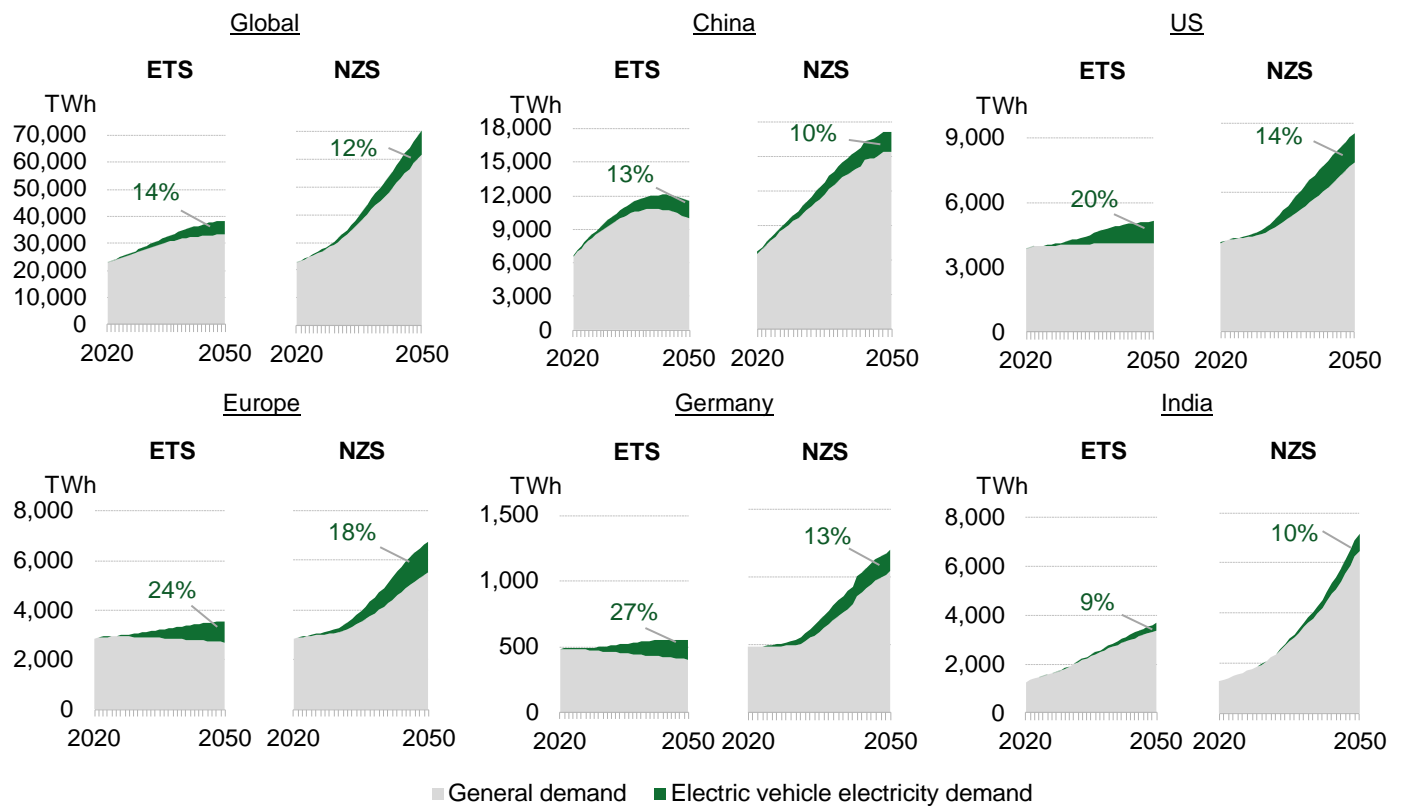
The fall in oil demand does not necessarily mean a collapse in oil prices. If investments in new supply capacity fall faster than demand, prices could remain elevated and volatile.

The Net Zero Scenario sees a much sharper decline in oil demand en route to a full phase-out from road transport in 2050.

- Additional electricity demand from EVs is part of a broader electrification push to reach net zero.** Global electricity demand from all types of EVs increases five times from 210TWh in 2022 to 1,027TWh in 2030 in the Economic Transition Scenario, before a further tripling in demand to 3,251TWh in 2040. EVs add about 14% to global electricity demand in 2050 in the Economic Transition Scenario, but only 12% in the Net Zero Scenario despite more vehicles on the road. This is because the Net Zero Scenario includes additional electricity demand from electrification of heating, industry and electrolyzer use for hydrogen production used in other sectors. For more, see our New Energy Outlook ([web](#) | [terminal](#)). In some fast-growing countries like India EVs add just 9-10% to total electricity demand.

Over \$1 trillion in cumulative investment in EV charging infrastructure is required globally over this period. There are growing reasons for optimism that this can be achieved, with some countries now building chargers ahead of the required pace. The required charger investment is still small compared to overall auto sales. For example, China requires \$453 billion of cumulative investment in charging infrastructure to 2040, compared to automotive sales revenue from domestic car sales and exports of \$750 billion in 2022 alone.

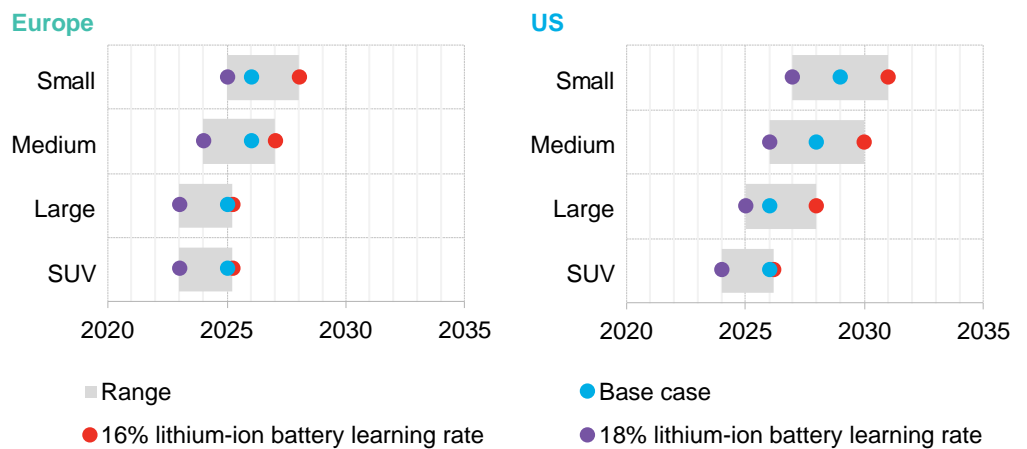
Figure 10: Electricity demand outlook for selected regions by scenario



Source: BloombergNEF. Note: Uses general electricity demand projections from BNEF's New Energy Outlook 2022. This is final energy consumption and excludes any losses in transmission. Percentages refer to percentage of EV electricity demand of total in 2050. Net Zero Scenario includes additional demand from electrification of heating, industry, and electrolyzer use for hydrogen.

- This year's EV Outlook includes five new Thematic Highlights, each of which explores a different part of the transition in vehicle markets around the world. The topics are:
 - EV price parity under different battery price scenarios
 - Will average EV ranges keep rising?
 - Emerging battery technologies: sodium-ion batteries, solid-state batteries, and next-generation anode technologies
 - High-powered charging for trucking fleets
 - The impact of autonomous vehicles
- **EV price parity is getting closer but progress varies by segment and country.** Prices for lithium-ion batteries increased for the first time in 2022 and are likely to remain elevated in 2023. This delays the upfront price parity of battery electric vehicles with combustion cars. Despite the near-term increase, EVs still reach up-front price parity with comparable combustion vehicles, without subsidies, by the end of the decade in most segments. Even in BNEF's base-case scenario there is a wide variation in purchase economics between geographies, dictated by the differences in the average battery size of BEVs sold or how price-sensitive any given car market is. While electric SUVs in Europe start achieving price parity as early as 2025, BEVs in the same segment in India do not hit parity until after 2030, due to very low average purchase prices in these segments. Larger batteries in US electric cars mean that upfront price parity in the country is one to three years later than for BEVs in Europe. Accelerating battery-pack price declines – using an 18% learning rate scenario – pushes upfront price parity of EVs forward by an average of one to two years. Delaying it using a 16% learning rate scenario would set the industry back by an average of two to three years. If prices remain elevated for longer, EV adoption will slow. Regardless of the scenario discussed, regional differences remain, and those will dictate the pace of electrification and the type of BEVs adopted in each region.

Figure 11: Impact of lithium-ion battery learning rate scenarios on year of price parity between EVs and combustion vehicles by region and segment



Source: BloombergNEF. Note: Dots represent year of up-front price parity without subsidies. Price parity year for base-case overlaps with the 16% learning rate scenario for large and SUV segments in Europe, SUV in US and SUV in Japan.

- Average EV ranges are rising quickly, adding pressure to the battery supply chain.** Globally, BEV models launched in 2022 had an average range of 337 kilometers, up from 230km in 2018. Average battery pack sizes have increased 10% annually over this period, going from 40kWh to 60kWh. Still, ranges remain below consumer expectations in most markets and segments, prompting automakers to launch longer-range models to ease range anxiety. Continued improvements in battery and powertrain technologies could quickly push range up to consumer expectations, while improved charger density and charging speed could reduce range requirements in the long term.

Increasing BEV ranges will further boost demand for lithium-ion batteries as EV adoption accelerates, putting more pressure on the battery materials supply. An annual BEV range increase of 5% in China, the US and Europe from 2023 to 2030 would add nearly 50% more demand for lithium, nickel and cobalt in those markets, compared to our base case scenario where BEV ranges remain flat. This would also push out the date for EV price parity. Wide adoption of advanced battery technologies and recycling could help mitigate materials supply constraints while enabling automakers to deliver long BEV ranges. Governments should direct investment toward supporting dense public charging networks as a cost-effective way to help avoid an EV range ‘arms race’

Figure 12: Lithium-ion battery demand for passenger BEVs in China, the US and Europe by battery pack size scenario

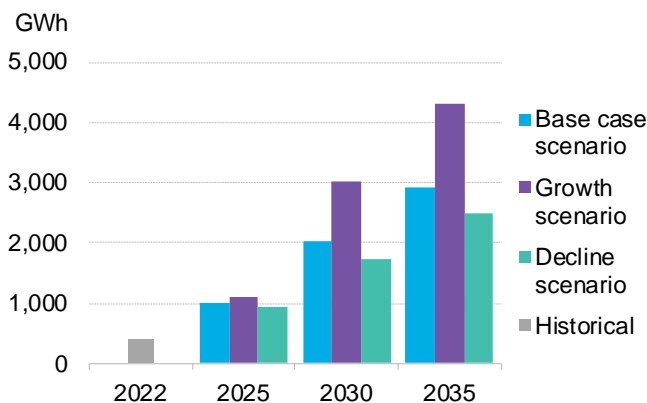
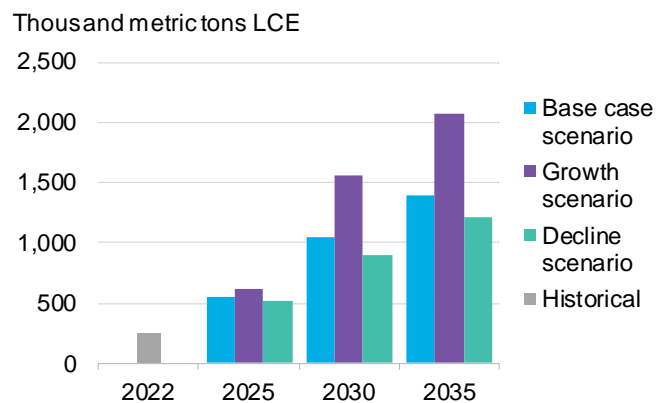


Figure 13: Lithium demand for passenger BEVs in China, the US and Europe by battery pack size scenario

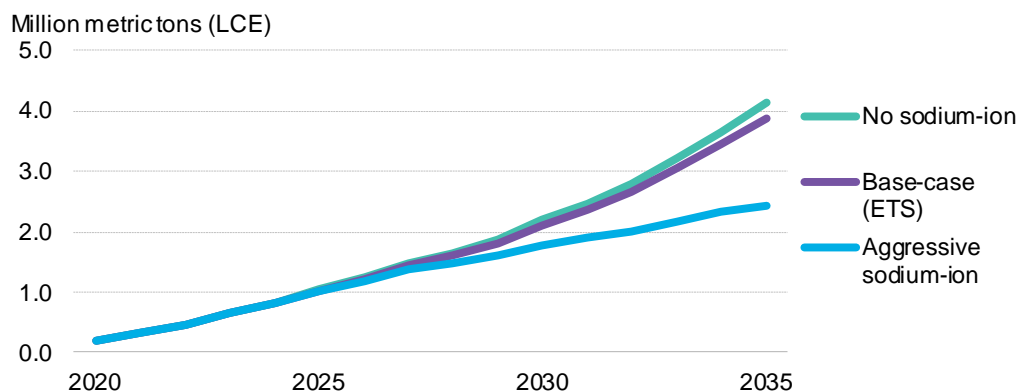


Source: BloombergNEF. Note: Growth scenario assumes 5% growth in average BEV range from 2023 to 2030. Decline scenario assumes 2% annual decline in average range from 2025 onwards. Includes lithium carbonate and lithium hydroxide.

- Several important next-generation battery technologies are entering the commercialization phase.** These will drive further performance and cost improvements. Improvements in battery energy density to date have been driven by advances in cathode materials, such as the move toward chemistries with higher nickel content. Next-generation technologies including silicon anodes, solid-state batteries and sodium-ion batteries will bring further improvements in performance and cost. They will also shift raw material supply chains. The next generation anode technologies in our base case displace 46% of graphite in 2035 compared with an all-graphite scenario. Similarly, in our base case sodium-ion cells displace 7% of lithium demand in 2035, compared to a no sodium-ion scenario. However, in the case of solid-state batteries, BNEF estimates that 45% to 130% more lithium would be needed on a battery-cell level if the solid-state electrolyte were to substitute both the liquid electrolyte and separator. Solid electrolytes contain more lithium due to slower diffusion of lithium ions through the solid electrolyte than a liquid one.

These newer technologies either involve new battery components or products, new manufacturing processes or establishing new raw material supply chains. Their success will be determined by how easily they can be scaled up and integrated into current manufacturing technology and processes.

Figure 14: Impact of sodium-ion battery uptake scenarios on lithium demand



Source: BloombergNEF. Note: LCE = lithium carbonate equivalent. ETS = Economic Transition Scenario.

- Charging is a challenge and opportunity for long-haul electric trucking.** The total ownership costs of electric heavy commercial vehicles are set to approach those of diesel equivalents around 2030, even for long-haul applications. Creating a sufficient charging network, however, brings challenges for vehicle owners, charging station developers, utilities and grid operators.

Truck charging stations will draw multi-megawatts of power and operators today are already developing stations exceeding 25 MW. Developing such stations can generate high returns, but this will be based on many locational factors, such as the availability of a grid connection, the cost to acquire a site and the structure of electricity tariffs.

There is currently a wide variability in pricing for peak-time electricity consumption that changes the business model. The internal rate of return of such projects varies widely. It can exceed 40% with moderate upfront investment and electricity tariffs but can also quickly become negative when trucks attempt to charge at peak times and demand charges hit.

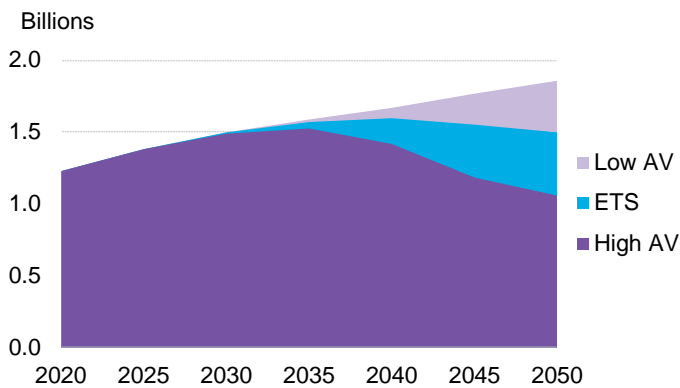
To smooth the roll-out of charging for trucks, grid operators should focus on electricity tariffs that are suitable for high power consumption and regulators should assess how 'least regret' investments in grid infrastructure can be made ahead of time to limit roll-out delays. Such investments can be large and, depending on whether they are done on the distribution or the transmission level, can range from \$100,000 to \$800,000 per kilometer.

- Autonomous vehicles are still a wildcard for the global vehicle market.** Steady progress is still being made on autonomous vehicle (AV) technology. AV fleets covered over 80 million kilometers in 2022 and operators are expanding services to new cities. The rollout of AVs could have big impacts on the size and distribution of the passenger vehicle fleet. Due to the uncertainty around autonomous vehicle deployment, we have laid out two scenarios in which the timeline of AV adoption varies significantly from our Economic Transition Scenario (ETS). Depending on the region in which they operate, robotaxis can cover three to five times the annual distance compared to private passenger vehicles, meaning that in a high AV adoption scenario, fewer vehicles are required to offer the same level of mobility to consumers. Our

high-AV scenario results in a 2050 fleet that is 29% smaller than in our ETS. Our low-AV scenario results in the passenger vehicle fleet continuing to grow out to 2050, ending up at over 1.8 billion vehicles, over 29% greater than in the ETS.

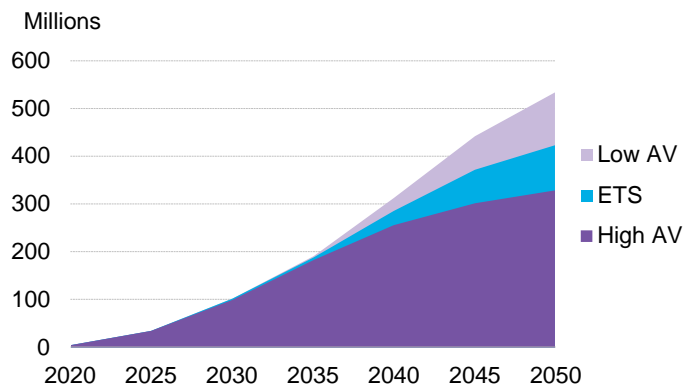
This will have an impact on investment decisions across all transport infrastructure. In particular, charging infrastructure companies will need to make strategic choices on the number, type and location of chargers based on different AV uptake scenarios. The high-AV scenario requires 40% fewer EV chargers than the low-AV scenario by 2050. Approximately 200 million low-speed chargers can be eliminated from the outlook through the addition of less than 1 million high-speed chargers that are optimized for a large robotaxi fleet.

Figure 15: Global passenger vehicle fleet outlook under varying autonomous vehicle adoption scenarios



Source: BloombergNEF. Note: ETS is BNEF's Economic Transition Scenario. High and Low AV scenarios reflect varying AV adoption.

Figure 16: Outlook for number of charging connectors under varying autonomous vehicle adoption scenarios



Source: BloombergNEF. ETS is BNEF's Economic Transition Scenario. High and Low AV scenarios reflect varying AV adoption.

List of figures in the report

- Figure 1: Global near-term passenger EV sales and share of new passenger vehicle sales by market*
- Figure 2: Global passenger vehicle sales by drivetrain – Economic Transition Scenario*
- Figure 3: Global passenger vehicle fleet by drivetrain – Economic Transition Scenario*
- Figure 4: Total cost of ownership of heavy-duty truck in long-haul duty cycle in 2030*
- Figure 5: Cumulative global EV market opportunity by region – Economic Transition Scenario*
- Figure 6: Annual battery factory investment by scenario*
- Figure 7: Annual metals demand from lithium-ion batteries under the Net Zero Scenario*
- Figure 8: Global oil demand – Economic Transition Scenario*
- Figure 9: Oil demand from road transport by scenario*
- Figure 10: Electricity demand outlook for selected regions by scenario*
- Figure 11: Impact of lithium-ion battery learning rate scenarios on year of price parity between EVs and combustion vehicles by region and segment*
- Figure 12: Lithium-ion battery demand for passenger BEVs in China, the US and Europe by battery pack size scenario*
- Figure 13: Lithium demand for passenger BEVs in China, the US and Europe by battery pack size scenario*
- Figure 14: Impact of sodium-ion battery uptake scenarios on lithium demand*
- Figure 15: Global passenger vehicle fleet outlook under varying autonomous vehicle adoption scenarios*
- Figure 16: Outlook for number of charging connectors under varying autonomous vehicle adoption scenarios*
- Figure 17: Markets by status of net-zero emissions targets*
- Figure 18: Total global CO2 emissions from road transportation by energy source – Economic Transition Scenario*
- Figure 19: Road transport emissions avoided by the penetration of electric and fuel cell vehicles – Economic Transition Scenario*
- Figure 20: Change in road transport emissions between 2022 and 2050*
- Figure 21: Global CO2 emissions from road transport by region – Economic Transition Scenario*
- Figure 22: Global CO2 emissions from road transport by segment – Economic Transition Scenario*
- Figure 23: CO2 emissions intensity of electricity generation*
- Figure 24: Share of global power generation from zero-emission sources and share of passenger kilometers travelled in zero-emission vehicles – Economic Transition Scenario.*
- Figure 25: EV charging emissions CO2 intensity – 2023*
- Figure 26: EV charging emissions CO2 intensity – 2030*
- Figure 27: CO2 tailpipe emissions from road transport – Economic Transition Scenario and Net Zero Scenario*
- Figure 28: Zero-emission vehicle fleet share outlooks – ETS versus NZS*
- Figure 29: Zero-emission vehicle sales share outlooks – ETS versus NZS*
- Figure 30: EV share of passenger vehicle sales, selected countries*
- Figure 31: Southeast Asia EV share of passenger vehicle sales scenario comparison, EVO 2023 and EVO 2022*
- Figure 32: Cumulative global EV market opportunity by segment – Economic Transition Scenario*
- Figure 33: Cumulative global EV market opportunity by region – Economic Transition Scenario*

- Figure 34: Estimated global EV market opportunity by 2050 – Economic Transition Scenario vs. Net Zero Scenario
- Figure 35: Global electric vehicle fleet in the Economic Transition Scenario and the gap to meet Net Zero Scenario
- Figure 36: Global electric road vehicle sales in the Economic Transition Scenario and the gap to Net Zero Scenario
- Figure 37: Global kilometers traveled by selected vehicle segments, 2022
- Figure 38: Global passenger vehicle fleet, 2022
- Figure 39: Global passenger vehicle sales, 2022
- Figure 40: Global two-wheeler sales, 2022
- Figure 41: Global commercial vehicle sales, 2022
- Figure 42: Global passenger EV sales by market
- Figure 43: Global passenger EV sales by drivetrain
- Figure 44: Passenger BEV and PHEV share of total car sales in selected markets, 2022
- Figure 45: Annual growth rate for passenger vehicle sales, 2021 to 2022
- Figure 46: Global EV fleet sizes by segment and market
- Figure 47: Cumulative lithium-ion battery cell manufacturing capacity
- Figure 48: Annual lithium-ion battery demand by application
- Figure 49: Volume-weighted average lithium-ion pack price
- Figure 50: Cumulative global public charging connectors
- Figure 51: Annual public charging installations by country
- Figure 52: Density of public charging per electric vehicle across selected countries
- Figure 53: Ultra-fast charging share of public charging roll-out in 2022
- Figure 54: Average public charging price for selected countries in 2022
- Figure 55: Value per unit of electricity from carbon credit programs (October 2022)
- Figure 56: Share of passenger vehicles sold by automakers with an ICE phase-out announcement
- Figure 57: Automakers' drivetrain development targets
- Figure 58: Simplified passenger EV outlook methodology
- Figure 59: Breakdown of vehicle kilometers traveled by segment and market, 2022
- Figure 60: Outlook for annual kilometers traveled by the global passenger vehicle fleet by market
- Figure 61: Outlook for annual kilometers traveled by the global passenger vehicle fleet by type
- Figure 62: Global passenger vehicle fleet outlook by market
- Figure 63: Global passenger vehicle fleet outlook by type
- Figure 64: Global annual passenger vehicle sales outlook by market
- Figure 65: Global annual passenger vehicle sales outlook by type
- Figure 66: Global near-term passenger EV sales and EV share of new passenger vehicle sales by market
- Figure 67: Global passenger vehicle sales by country
- Figure 68: Global passenger vehicle sales by drivetrain
- Figure 69: Global near-term passenger EV fleet by market
- Figure 70: Global near-term EV share of passenger vehicle fleet by market
- Figure 71: Comparison of gasoline, residential electricity, and average public charging prices
- Figure 72: Global passenger vehicle sales by drivetrain – Economic Transition Scenario
- Figure 73: Global passenger vehicle share of sales by drivetrain – Economic Transition Scenario
- Figure 74: China passenger PHEV sales by segment
- Figure 75: China passenger PHEV sales by price range
- Figure 76: Global long-term passenger EV sales by market – Economic Transition Scenario

- Figure 77: Global long-term EV share of new passenger vehicle sales by market – Economic Transition Scenario
- Figure 78: Global EV share of new passenger vehicle sales – Economic Transition Scenario
- Figure 79: EV share of new passenger vehicle sales in selected European countries – Economic Transition Scenario
- Figure 80: US EV share of new passenger vehicle sales – Economic Transition Scenario
- Figure 81: Passenger EV sales in the US – Economic Transition Scenario
- Figure 82: EV share of new passenger vehicle sales in the US – Economic Transition Scenario
- Figure 83: Global passenger EV sales by market – Economic Transition Scenario
- Figure 84: Global passenger vehicle fleet by drivetrain – Economic Transition Scenario
- Figure 85: Global passenger vehicle share of fleet by drivetrain – Economic Transition Scenario
- Figure 86: Global long-term passenger EV fleet by market – Economic Transition Scenario
- Figure 87: Global long-term EV share of passenger vehicle fleet by market – Economic Transition Scenario
- Figure 88: Passenger vehicle fleet split outlooks by drivetrain – Economic Transition Scenario and Net Zero Scenario
- Figure 89: Passenger vehicle fleet outlook by drivetrain – Economic Transition Scenario
- Figure 90: Passenger vehicle fleet outlook by drivetrain – Net Zero Scenario
- Figure 91: Zero-emission vehicle share of total passenger vehicle sales – Economic Transition Scenario and Net Zero Scenario
- Figure 92: Passenger EV sales and fleet in the Economic Transition Scenario and Net Zero Scenario
- Figure 93: National targets to phase out internal combustion vehicle sales
- Figure 94: Country-level EV share of sales – Economic Transition Scenario and Net Zero Scenario
- Figure 95: Passenger fuel-cell vehicle sales
- Figure 96: Battery pack prices scenarios
- Figure 97: Europe medium BEV pre-tax price breakdown, ICE pre-tax price and share of battery costs
- Figure 98: Base-case battery pack price scenario
- Figure 99: Price parity under the base-case scenario by region and segment
- Figure 100: Implications for battery pack price parity point
- Figure 101: Learning rate battery pack price scenarios
- Figure 102: Volume-weighted average regional and global battery pack prices in 2022
- Figure 103: Regional battery pack price scenarios
- Figure 104: Impact of lithium-ion battery learning rate scenarios on year of upfront price parity between EVs and combustion vehicles by region and vehicle segment
- Figure 105: Impact of learning rate scenarios on year of upfront price parity by pack region, vehicle segment, pack size and market share
- Figure 106: Impact of regional scenarios on year of upfront price parity by region and vehicle segment
- Figure 107: Impact of PTC scenarios on year of upfront price parity in the US
- Figure 108: US BEV pre-tax price under select scenarios and US ICE, pre-tax price
- Figure 109: Global average BEV range by segment
- Figure 110: BEV sales by market and segment
- Figure 111: Average BEV range by market and segment
- Figure 112: EVs per public charging connector by market
- Figure 113: Global average BEV pack size by segment
- Figure 114: Average BEV battery pack size by market and segment

- Figure 115: Global average BEV efficiency
- Figure 116: Average BEV efficiency by market and segment
- Figure 117: Consumers' main concerns over BEVs by market, 2022
- Figure 118: Consumers' expected BEV driving range by market, 2023
- Figure 119: Europe BEV sales by range
- Figure 120: China BEV sales by range
- Figure 121: Number of BEV models available with ranges of more than 400km
- Figure 122: BEV model range for selected car manufacturers
- Figure 123: Lithium-ion battery demand for passenger BEVs by market and scenario
- Figure 124: Lithium carbonate demand for passenger BEV batteries by market and scenario
- Figure 125: Lithium hydroxide demand for passenger BEV batteries by market and scenario
- Figure 126: Cobalt sulfate demand for passenger BEV batteries by market and scenario
- Figure 127: Nickel sulfate demand for passenger BEV batteries by market and scenario
- Figure 128: Commercial van and truck sales outlook by class - Economic Transition Scenario
- Figure 129: Commercial van and truck fleet outlook by class - Economic Transition Scenario
- Figure 130: Global electric and fuel cell commercial van, truck, and buses near-term sales outlook
- Figure 131: Historical and short-term forecast of combined electric and fuel cell commercial van, truck, and bus sales share by country
- Figure 132: Low- and zero-emission commercial van and truck model availability
- Figure 133: Low- and zero-emission commercial van and truck range in zero-emission mode
- Figure 134: Technology and supply chain strategies for zero-emission truck manufacturers
- Figure 135: Electric and fuel cell van and light-duty truck sales in China
- Figure 136: Electric and fuel cell medium- and heavy-duty truck sales in China
- Figure 137: Electric van and light-truck sales and share in South Korea
- Figure 138: Total cost of ownership of heavy-duty truck in long-haul duty cycle in 2030
- Figure 139: Historical and forecast battery prices for electric commercial vehicles
- Figure 140: Fuel cell stack cost
- Figure 141: Hydrogen pump cost
- Figure 142: Efficiency and weight of available battery electric truck models
- Figure 143: Electric and fuel cell commercial van, truck, and bus sales global outlook
- Figure 144: Electric and fuel cell commercial van, truck, and bus fleet global outlook
- Figure 145: Medium- and heavy-duty fuel cell truck fleet by duty cycle
- Figure 146: Hydrogen demand – Economic Transition Scenario
- Figure 147: Hydrogen demand – Net Zero Scenario
- Figure 148: Electric and fuel cell commercial van and truck adoption outlook in California and comparison with the Advanced Clean Truck targets
- Figure 149: Light commercial van and truck fleet share outlooks by drivetrain – Economic Transition and Net Zero Scenario
- Figure 150: Medium/heavy commercial van and truck fleet share outlooks by drivetrain – Economic Transition and Net Zero Scenario
- Figure 151: Light commercial van and truck sales share outlooks by drivetrain – Economic Transition and Net Zero Scenario
- Figure 152: Medium/heavy commercial van and truck sales share outlooks by drivetrain – Economic Transition and Net Zero Scenario
- Figure 153: Zero-emission bus share of total bus sales – Net Zero Scenario and Economic Transition Scenario
- Figure 154: Zero-emission bus share of total bus fleet – Net Zero Scenario and Economic Transition Scenario
- Figure 155: Commercial vehicle fleet sizes in the US

Figure 156: Distribution of the 300 largest commercial vehicle fleets (excluding heavy-duty trucks) in the US

Figure 157: Distribution of the 200 largest heavy-duty commercial vehicle fleets in the US

Figure 158: Daily distance distribution for tractors and delivery trucks in the US

Figure 159: Van and truck utilization in Germany in 2021

Figure 160: Annual average traffic flow in Germany in 2021

Figure 161: Share of electricity consumption occurring in the peak demand period (4pm – 9pm) by scenario

Figure 162: Capital and energy cost over 10 years for diesel and electric trucks in California

Figure 163: Charging station IRR based on the fee to truck drivers, the utility tariff and site costs (non-peak scenario)

Figure 164: Monthly demand charges and energy costs depending on tariff – peak scenario

Figure 165: Typical peak demand of various power users

Figure 166: Grid voltages of European distribution networks and suitability to accommodate 20MW truck stop

Figure 167: Global two-wheeler sales by market

Figure 168: Global two-wheeler sales outlook by market

Figure 169: Global two-wheeler fleet outlook by market

Figure 170: Two-wheeler sales outlook by segment in China, Indonesia, Vietnam and India

Figure 171: Electric two-wheeler sales outlook by market

Figure 172: Electric share of two-wheeler sales outlook by market

Figure 173: Long-term electric two-wheeler sales outlook by market – Economic Transition Scenario

Figure 174: Long-term electric two-wheeler fleet outlook by market – Economic Transition Scenario

Figure 175: Global electric share of two-wheeler sales outlook by segment – Economic Transition Scenario

Figure 176: Global long-term two-wheeler sales outlook by drivetrain – Economic Transition Scenario

Figure 177: Global share of two-wheeler sales by drivetrain – Economic Transition Scenario

Figure 178: Global share of two-wheeler fleet by drivetrain – Economic Transition Scenario

Figure 179: Two-wheeler fleet split by drivetrain – Economic Transition Scenario and Net Zero Scenario

Figure 180: Two-wheeler fleet outlook by drivetrain – Net Zero Scenario

Figure 181: Two-wheeler fleet outlook by drivetrain and market – Net Zero Scenario

Figure 182: Global three-wheeler sales by market

Figure 183: Global three-wheeler sales outlook by market

Figure 184: Global three-wheeler fleet outlook by market

Figure 185: Long-term electric three-wheeler sales outlook by market – Economic Transition Scenario

Figure 186: Long-term electric three-wheeler fleet outlook by market – Economic Transition Scenario

Figure 187: Global three-wheeler sales outlook by drivetrain – Economic Transition Scenario

Figure 188: Global share of three-wheeler sales by drivetrain

Figure 189: Global share of three-wheeler fleet by drivetrain

Figure 190: Three-wheeler fleet split by drivetrain – Economic Transition Scenario and Net Zero Scenario

Figure 191: Three-wheeler fleet outlook by drivetrain – Net Zero Scenario

Figure 192: Three-wheeler fleet outlook by drivetrain and market – Net Zero Scenario

- Figure 193: Lithium-ion battery demand outlook – Economic Transition Scenario
- Figure 194: Lithium-ion battery pack price outlook
- Figure 195: Log-log lithium-ion battery pack experience curve
- Figure 196: Volume-weighted average lithium-ion battery price in 2022
- Figure 197: Publicly announced lithium-ion cell prices
- Figure 198: Publicly announced lithium-ion pack prices
- Figure 199: Annual lithium-ion battery cell manufacturing capacity
- Figure 200: Lithium cell and component manufacturing capacity by region of plant location
- Figure 201: Historical and estimated changes to battery-pack energy density
- Figure 202: Evolution of cathode chemistry across all passenger electric vehicle segments
- Figure 203: Metal content of selected lithium-ion battery cathode materials
- Figure 204: Evolution of cathode chemistry across all commercial electric vehicle segments
- Figure 205: Evolution of cathode chemistry for e-buses
- Figure 206: Evolution of electric two-wheeler battery mix by share of battery demand
- Figure 207: Evolution of cathode chemistry for two- and three-wheeled electric vehicles
- Figure 208: Lithium- and sodium-ion electric vehicle battery anode chemistry outlook
- Figure 209: Lithium carbonate supply and demand balance
- Figure 210: Lithium hydroxide supply and demand balance
- Figure 211: Cobalt sulfate supply and demand balance
- Figure 212: Refined battery-grade nickel supply and demand balance
- Figure 213: Manganese sulfate supply and demand balance
- Figure 214: Annual battery demand outlook under BNEF's Economic Transition Scenario and Net Zero Scenario
- Figure 215: Battery factory investment by scenario
- Figure 216: Annual metals demand from lithium-ion batteries under the Net Zero Scenario
- Figure 217: Cumulative lithium demand and reserves
- Figure 218: Cumulative cobalt demand and reserves
- Figure 219: Cumulative class 1 nickel demand and reserve
- Figure 220: Cumulative manganese demand and reserve
- Figure 221: Status of battery performance metrics in 2022
- Figure 222: Outlook for battery performance metrics in 2035
- Figure 223: Selected cell energy density targets from 2010-2035
- Figure 224: Specific capacity by anode material, benchmarks and selected company announcements
- Figure 225: Anode chemistry mix scenarios, based on gigawatt-hours
- Figure 226: Impact of anode chemistry mix scenarios on raw material demand
- Figure 227: Companies' announced plans on solid-state electrolytes for lithium-ion batteries
- Figure 228: Sodium-ion battery demand in electric vehicles – Economic Transition Scenario
- Figure 229: Timeline of companies' announcements on sodium-ion EV technology
- Figure 230: Sodium-ion battery uptake scenarios considered in resource footprint analysis
- Figure 231: Impact of sodium-ion battery uptake scenarios on lithium demand
- Figure 232: Road demand and fuel displaced by electric and fuel cell vehicles – Economic Transition Scenario
- Figure 233: Evolution of oil demand from road transport – Economic Transition Scenario
- Figure 234: Oil demand avoided by electric and fuel cell drivetrains across segments – Economic Transition Scenario
- Figure 235: China road fuel demand – Economic Transition Scenario
- Figure 236: Oil demand growth by region – Economic Transition Scenario
- Figure 237: Oil demand by fuel – Economic Transition Scenario

- Figure 238: Oil demand from road transport by scenario
- Figure 239: Oil demand growth from road transport by scenario
- Figure 240: Oil demand from road transport by scenario and segment
- Figure 241: Global oil demand – Economic Transition Scenario
- Figure 242: Global electric vehicle electricity demand by scenario to 2050
- Figure 243: Global electric vehicle electricity demand split by vehicle segment
- Figure 244: Assumed efficiency of passenger electric vehicles by country and vehicle segment
- Figure 245: Assumed efficiency of commercial trucks by vehicle class
- Figure 246: Electricity demand outlook for selected regions by scenario
- Figure 247: Peak electricity demand by market and EV share of peak demand
- Figure 248: Peak demand per electric vehicle shifted due to smart charging
- Figure 249: Public fast charging demand by hour for Fastned
- Figure 250: Annual grid expenditure on electric vehicle integration
- Figure 251: Outlook for annual kilometers traveled by the global passenger vehicle fleet by type – Economic Transition Scenario
- Figure 252: Global passenger vehicle fleet outlook by type – Economic Transition Scenario
- Figure 253: Global passenger vehicle fleet outlook under varying autonomous vehicle adoption scenarios
- Figure 254: Outlook for number of charging connectors under varying autonomous vehicle adoption scenarios
- Figure 255: Venture capital and private equity investments in autonomous vehicle and related technologies
- Figure 256: Notable policies on autonomous vehicle deployment
- Figure 257: Cumulative autonomous kilometers tested on public roads
- Figure 258: Disclosed driverless kilometers completed, by company
- Figure 259: Share of autonomous kilometers tested in California, by drivetrain
- Figure 260: Share of vehicle kilometers traveled by road type, California
- Figure 261: Robotaxi share of passenger vehicle kilometers in a high AV adoption scenario
- Figure 262: Robotaxi share of passenger vehicle kilometers in a low AV adoption scenario
- Figure 263: Global passenger vehicle fleet outlook under varying autonomous vehicle adoption scenarios
- Figure 264: Electric kilometers as a share of total
- Figure 265: Passenger vehicle electricity demand by scenario
- Figure 266: Electric vehicle charging infrastructure rollout in the high AV uptake scenario
- Figure 267: Electric vehicle charging infrastructure rollout in the low AV uptake scenario
- Figure 268: Global electric vehicle demand for electricity, charging infrastructure and investment
- Figure 269: Average annual electric vehicle charger sales by region and charger type – Economic Transition Scenario
- Figure 270: Global electric vehicle demand for electricity, charging infrastructure and investment to 2050
- Figure 271: Regional overview of passenger electric vehicle demand for charging infrastructure – Economic Transition Scenario
- Figure 272: Share of commercial electric vehicles with a depot charger – Economic Transition Scenario
- Figure 273: Assumed average daily travel distance and electricity demand of commercial electric vehicles – Economic Transition Scenario
- Figure 274: Heavy-duty truck share of total kilometers by duty cycle
- Figure 275: Annual charger investment by region – Economic Transition Scenario
- Figure 276: Annual charger investment by category – Economic Transition Scenario

- Figure 277: Share of total costs to deploy charging infrastructure including grid support costs
- Figure 278: Announced European public ultra-fast charging connectors compared with the Economic Transition Scenario
- Figure 279: Fastned's electricity demand and network utilization
- Figure 280: Electricity demand from Tesla vehicles by location in 2022
- Figure 281: Electricity demand from public chargers in China
- Figure 282: Comparison of China's charging investment and automotive sales revenue
- Figure 283: Share of China's passenger car sales by automaker category
- Figure 284: Example of public charging network growth curve and influences
- Figure 285: Europe's annual public charger sales by new and replacement chargers
- Figure 286: Electric vehicle charging infrastructure rollout in Europe to 2040 – Economic Transition Scenario
- Figure 287: Public charging electricity demand by country in Europe – Economic Transition Scenario
- Figure 288: Public charging network size by country in Europe – Economic Transition Scenario
- Figure 289: Electric vehicle charging infrastructure rollout in the US to 2040 – Economic Transition Scenario
- Figure 290: California's share of US electric vehicle electricity demand
- Figure 291: California's electric vehicle electricity demand – Economic Transition Scenario
- Figure 292: Comparison of BNEF and California's charger outlooks (excluding homes)
- Figure 293: Annual private charger installations in China
- Figure 294: Annual public charger installations in China
- Figure 295: Electric vehicle charging infrastructure rollout in China to 2040 – Economic Transition Scenario
- Figure 296: Comparison of weighted average battery pack sizes for EVO 2023 and EVO 2022
- Figure 297: Comparison of global passenger vehicle kilometers traveled, passenger vehicle fleet and annual sales in EVO 2023 and EVO 2022
- Figure 298: Comparison of Australia, Southeast Asia and India passenger EV sales outlook between EVO 2023 and EVO 2022
- Figure 299: Comparison of global EV sales outlook between EVO 2023 and EVO 2022
- Figure 300: Comparison of global EV share of sales between EVO 2023 and EVO 2022
- Figure 301: California annual EV sales outlook
- Figure 302: Nordics annual EV sales outlook
- Figure 303: Comparison of global commercial vehicle kilometers traveled, commercial vehicle fleet and annual sales in EVO 2023 and EVO 2022 – Economic Transition Scenario
- Figure 304: Comparison of electric bus shares of vehicle kilometers traveled, vehicles on road and sales in EVO 2023 and EVO 2022
- Figure 305: Comparison of global two-wheeler vehicle kilometers traveled, vehicles on road and annual sales in EVO 2023 and EVO 2022
- Figure 306: Comparison of electric three-wheeler shares of vehicle kilometers traveled, vehicles on road and sales in EVO 2023 and EVO 2022
- Figure 307: Comparison of critical battery metals demand in EVO 2023 and EVO 2022
- Figure 308: Simplified passenger EV outlook methodology
- Figure 309: Simplified outlook methodology for passenger vehicle demand, sales and fleet
- Figure 310: Historical annual distance traveled by passenger vehicles in the US divided by GDP per capita
- Figure 311: Annual distance traveled by the US passenger vehicle fleet
- Figure 312: Shared-mobility service and robotaxi share of annual distance traveled by the US passenger vehicle fleet

- Figure 313: Annual distance traveled by the US passenger vehicle fleet by type*
- Figure 314: US passenger vehicle fleet by type*
- Figure 315: US passenger vehicle sales by type*
- Figure 316: Near-term EV adoption forecast methodology*
- Figure 317: SUV segment BEV and ICE pre-tax prices and share of battery cost in Europe*
- Figure 318: Total cost of ownership of medium ICEs and BEVs in the US and China*
- Figure 319: Global private passenger EV sales outlook by segment – Economic Transition Scenario*
- Figure 320: The trucking market and current activity of alternative fuels, by truck segment*
- Figure 321: Freight demand, commercial vehicle sales and fleet simplified outlook methodology*
- Figure 322: Road freight demand outlook in the Economic Transition Scenario*
- Figure 323: Outlook for GDP and road freight demand indexed to 2022*
- Figure 324: Simplified two-wheeler outlook methodology*
- Figure 325: Simplified charging infrastructure forecast methodology*
- Figure 326: Distribution of population by housing type across Europe*
- Figure 327: Share of housing by type for select countries*
- Figure 328: Energy demand split for battery-electric passenger vehicles and vans by charger location for all countries except China, India and South Korea*
- Figure 329: Energy demand split for battery-electric passenger vehicles and vans by charger location for China, India and South Korea*
- Figure 330: Energy demand split for plug-in hybrid electric passenger vehicles and vans by charger location for all countries except China, India and South Korea*
- Figure 331: Energy demand split for battery-electric medium- and heavy-duty commercial EVs and e-buses by charger location*
- Figure 332: Share of electricity supplied to EVs from different chargers, by power rating and location*
- Figure 333: Usage assumptions for passenger vehicle and van chargers*
- Figure 334: Usage assumptions for e-bus and truck chargers at depots*
- Figure 335: Usage assumptions for e-bus and truck chargers in public*
- Figure 336: 7-22kW charger prices and installation cost assumptions, excluding China*
- Figure 337: 50-1,000kW charger prices and installation cost assumptions, excluding China*

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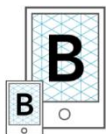
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