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EV Transition Check

Measuring progress towards zero-emission for passenger cars in the European Union

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INTRODUCTION

The current carbon dioxide (CO_2) emission standards for new passenger cars and light commercial vehicles (vans) in the European Union (EU) have been in place since 2023.[1] Key measures include a 55% fleet-wide CO_2 reduction target for new passenger cars by 2030 and a 100% reduction target by 2035. In May 2025, the standards were amended, and an averaging provision was added for the 2025–2027 period, meaning manufacturers can comply with targets by averaging their performance over the three years. The regulation is scheduled to be reviewed in 2026.[2] In preparation, the European Commission will submit a Progress Report to the European Parliament and Council in December 2025, and every two years thereafter.

This report distills key facts about the light-duty vehicle market in the European Union relevant to the upcoming Progress Report. Focusing on passenger cars, which represent 90% of light-duty vehicles in the European Union, this report draws upon a range of data and analysis to assess topics ranging from electric vehicle (EV) uptake to battery production and related supply chains. The chapters in the report are intended to answer five overarching questions:

1. Are manufacturers on track to meet the CO_2 targets?
2. What are the trends in vehicle technology affordability?
3. Which vehicle powertrain best supports climate and health goals?
4. Are Europe's EV charging infrastructure and electrical grid ready for the transition?
5. Can electrifying the automotive sector boost Europe's industrial competitiveness?

To address these questions, this report considers select key performance indicators related to each topic. These performance indicators encompass and go beyond the elements that the European Commission is required to consider in its Progress Report regarding passenger cars according to EU Regulation 2019/631. The table below lists these elements and indicates the chapter within this report where these elements are assessed. Throughout this paper, the term EVs refers to both battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs).

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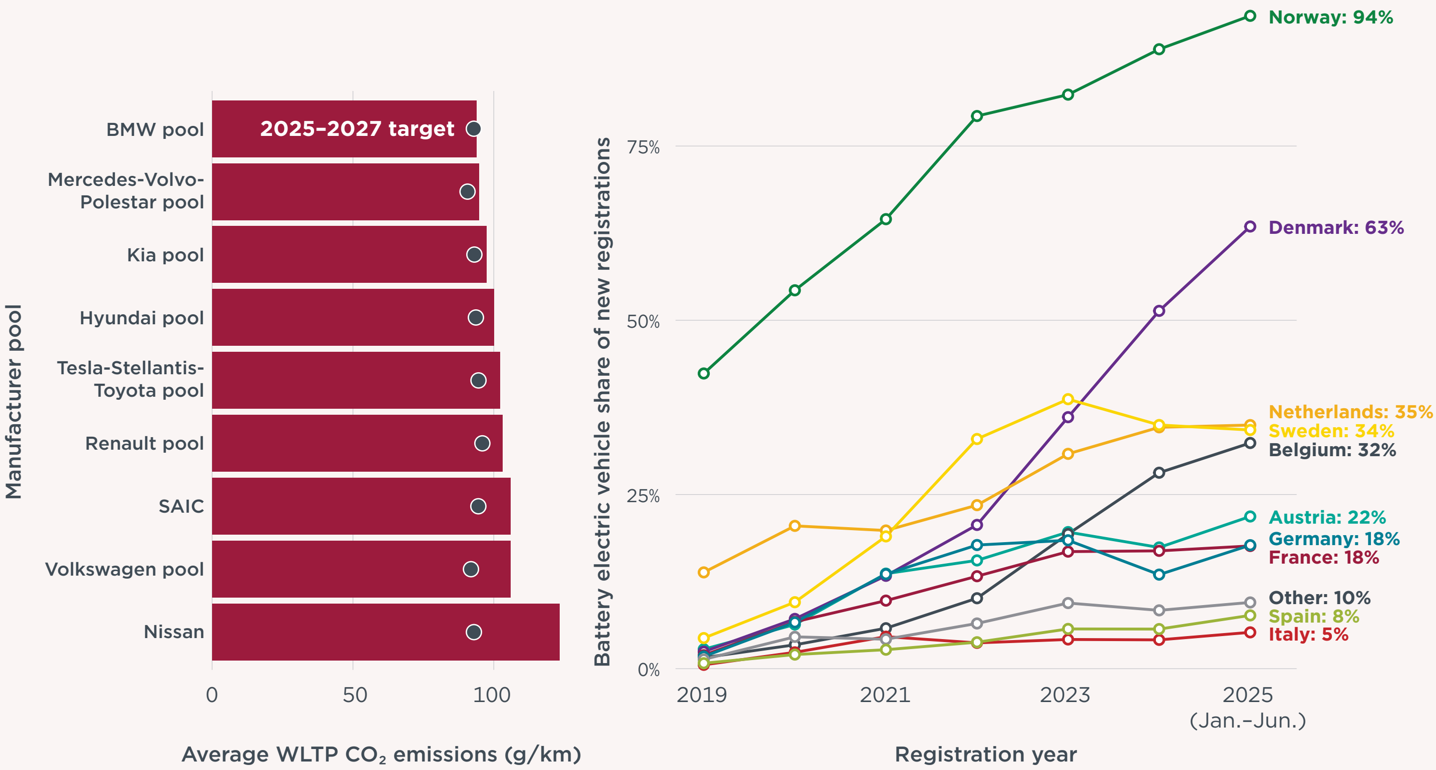
MANUFACTURER TARGETS AND ELECTRIC VEHICLE UPTAKE

Automakers are on track to meet the EU CO_2 performance targets for new vehicles, relying mostly on electric cars as a compliance option. Among the major markets, EV uptake has been strong in Germany and France and has recently increased in Italy and Spain. Several smaller markets show particularly high EV market shares.

FIGURE 1

January to June 2025 CO_2 performance and estimated 2025–2027 CO_2 emissions target by manufacturer pool (left) and BEV sales share by country and registration year (right)



Note: WLTP = Worldwide harmonised Light vehicles Test Procedure.

Data sources: Dataforce; "Monitoring of CO_2 Emissions from Passenger Cars: Regulation (EU) 2019/631," European Environment Agency, August 13 2025, https://www.eea.europa.eu/en/datahub/datahubitem-view/fa8b1229-3db6-495d-b18e-9c9b3267c02b.

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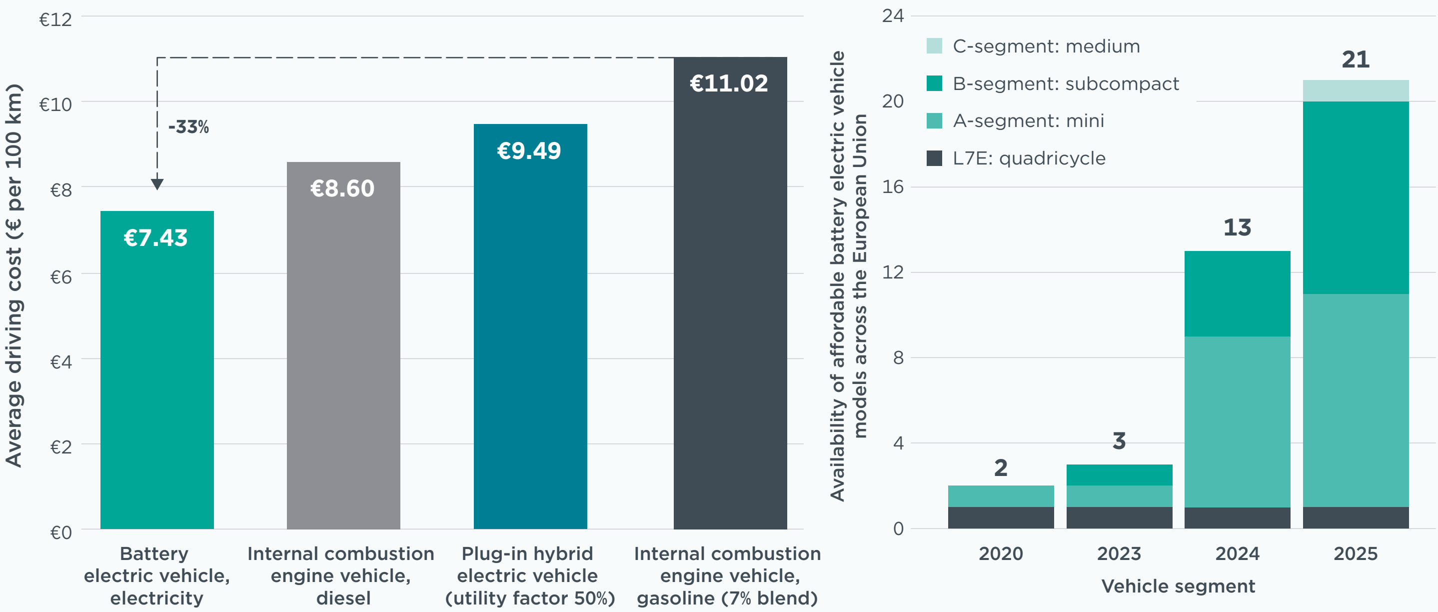
TECHNOLOGY AFFORDABILITY

Battery electric vehicles today have lower driving costs than other powertrains. With decreasing battery prices, the number of affordable electric cars is expected to continue to rise.

FIGURE 2

Comparison of refueling cost per 100 km for different fuels in the European Union for an average medium segment passenger car in 2025 (left) and evolution of BEV models priced below €30,000 available in the European Union by vehicle segment (right)



Notes: For battery electric vehicles, the proportional cost of a home charger is included and a mix of 80% private and 20% public charging is assumed.

Data sources: Eco-Movement, *EV Charging Price Data* [Dataset], https://www.eco-movement.com; Eurostat, *Weekly Oil Bulletin* [Dataset], June 2025, https://energy.ec.europa.eu/data-and-analysis/weekly-oil-bulletin_en; Marta Negri and Georg Bieker, *Life-Cycle Greenhouse Gas Emissions from Passenger Cars in the European Union: A 2025 Update and Key Factors to Consider* (International Council on Clean Transportation, 2025), https://theicct.org/publication/electric-cars-life-cycle-analysis-emissions-europe-jul25/; European Alternative Fuels Observatory, *Available Electric Vehicle Models*, accessed June 2025, https://alternative-fuels-observatory.ec.europa.eu; EV Database, June 2025, https://ev-database.org/.

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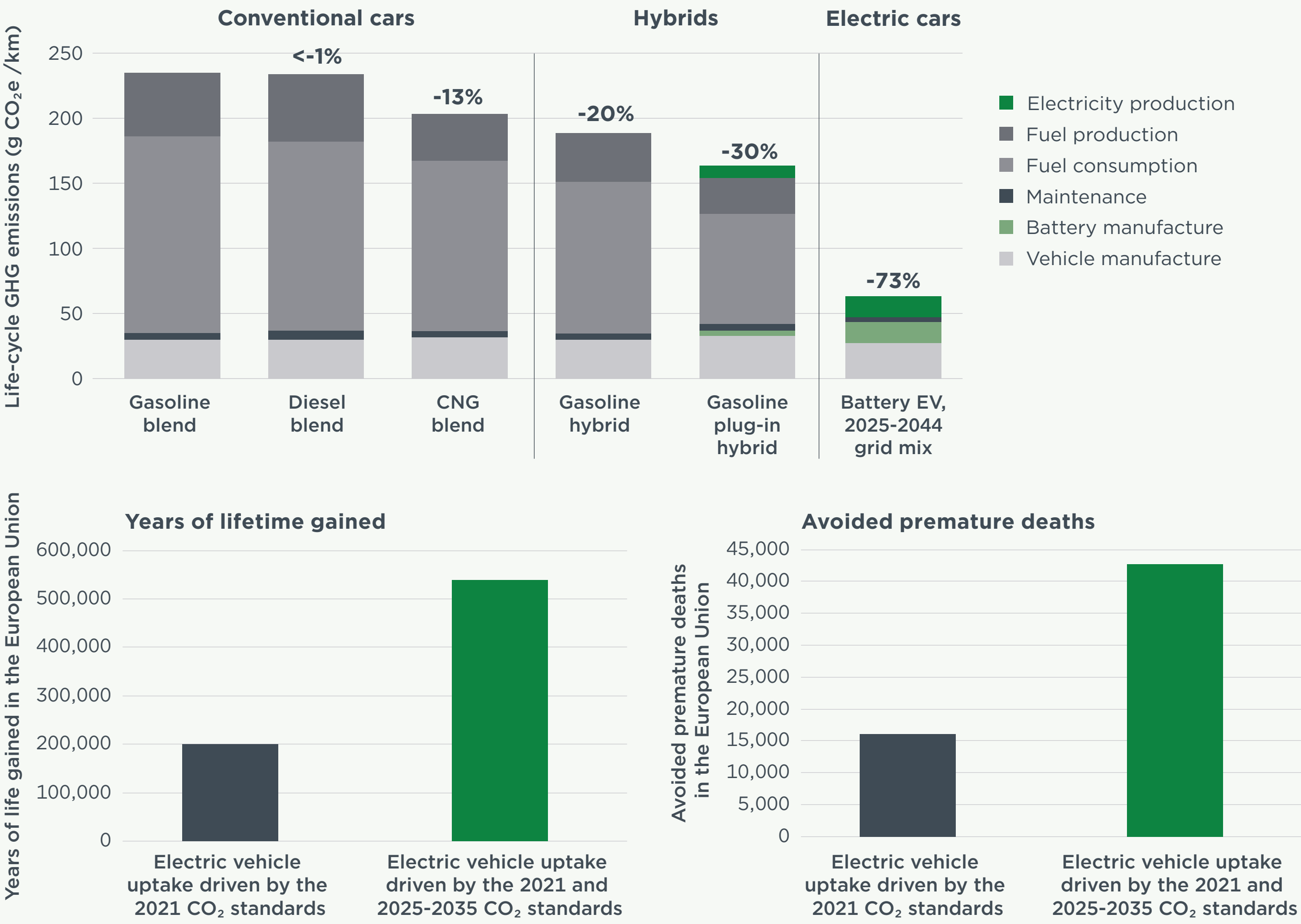
CLIMATE AND HEALTH IMPACT

Battery electric vehicles offer the greatest potential to reach climate targets on schedule while also reducing the air quality impact of road transport.

FIGURE 3

Life-cycle greenhouse gas emissions of medium segment passenger cars sold in the European Union in 2025 (top) and avoided premature deaths and years of lifetime gained (bottom) in the European Union between 2021 and 2050 from reduced tailpipe emissions, relative to a scenario with zero uptake of electric vehicles



Note: The average gasoline, diesel, and natural gas blends include 7vol% ethanol, 7vol% bio-based diesel, and 3% biomethane, respectively.
Data sources: Negri and Bieker, *Life-Cycle Greenhouse Gas Emissions;* International Council on Clean Transportation, *FATE v2.0 Documentation* (2024), https://theicct.github.io/FATE-doc/versions/v2.0/#vsl-calculation.

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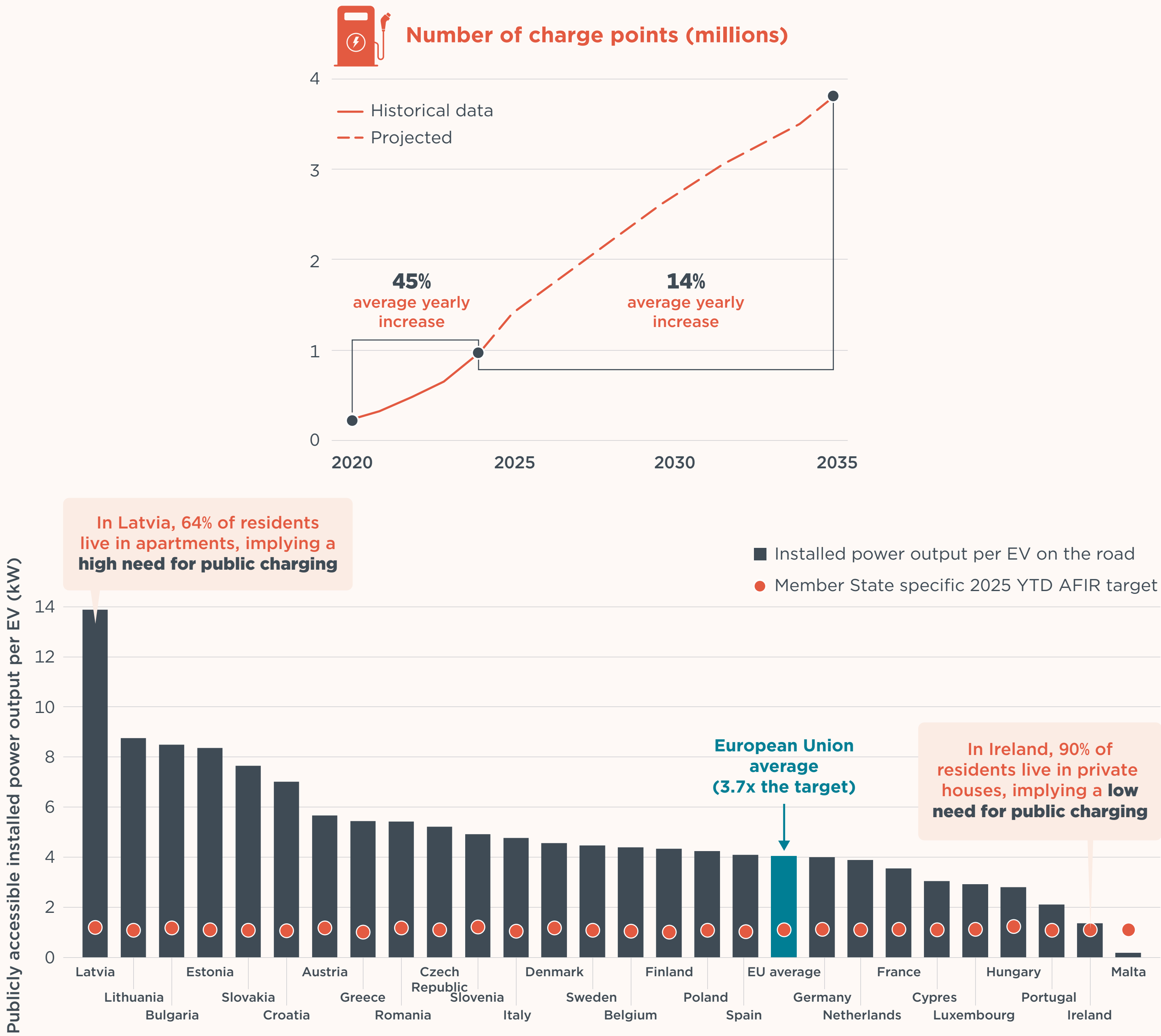
CHARGING INFRASTRUCTURE AND THE POWER GRID

With over 1 million public chargers, the European Union is equipped to support EVs currently on the road. Smart meter roll-out and time-varying tariff offers are increasing.

FIGURE 4

Public charging infrastructure deployment (solid line) and projected need (dashed line) in the European Union (top) and publicly accessible installed power output per EV by EU Member State compared with Alternative Fuel Infrastructure Regulation targets as of July 1, 2025 (bottom)



Data sources: Charging infrastructure historical data (since 2020) from Eco-Movement, *Public Charging Infrastructure Data* [Dataset], accessed in July 2025, https://www.eco-movement.com; projection of charging needs from International Council on Clean Transportation, *EV CHARGE Model Documentation*, accessed January 10, 2025, https://theicct.github.io/EVCHARGE-doc/; data on EVs on the road from European Alternative Fuel Observatory, "Vehicles and Fleet," accessed July, 2025, https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road/european-union-eu27/vehicles-and-fleet.

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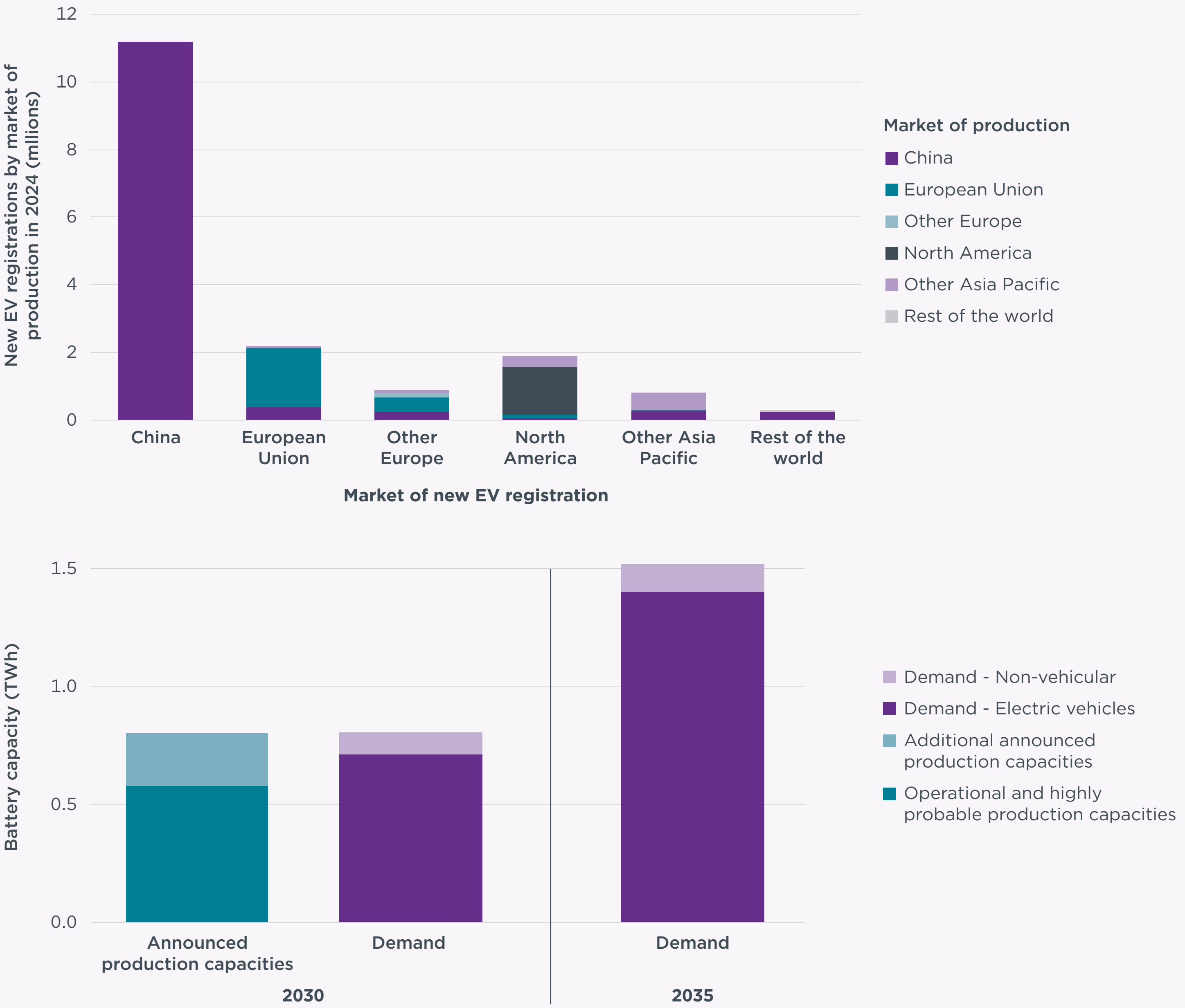
SUPPLY CHAINS AND INDUSTRIAL COMPETITIVENESS

Building up battery production and supply chains in Europe will require concerted efforts by governments and industry as well as market confidence. Further delays in the EV transition would risk losing battery and vehicle production market shares to global competitors.

FIGURE 5

EV registrations worldwide in 2024 by market (top) and announced battery production capacity and projected demand in the European Union (bottom)



Data sources: EV Volumes, *EV Data Center* [Dataset], Retrieved March 1, 2025, from https://www. ev-volumes.com/; International Energy Agency (IEA), *Global EV Outlook 2025: Trends in Electric Car Affordability* (2025), https://www.iea.org/reports/global-ev-outlook-2025/trends-in-electric-car-affordability [License: relevant CC license e.g. CC BY 4.0], and Eyal Li et al., *Electrifying Road Transport with Less Mining: A Global and Regional Battery Material Outlook* (International Council on Clean Transportation, 2024), https://theicct.org/publication/ev-battery-materials-demand-supply-dec24/.

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1

MANUFACTURER TARGETS AND ELECTRIC VEHICLE UPTAKE

Automakers are on track to meet CO_2 emissions targets for new vehicles, relying mostly on electric cars as a compliance option. Among major markets, EV uptake has been strong in Germany and France and recently increased in Italy and Spain. Several smaller markets show particularly high market shares of EVs.

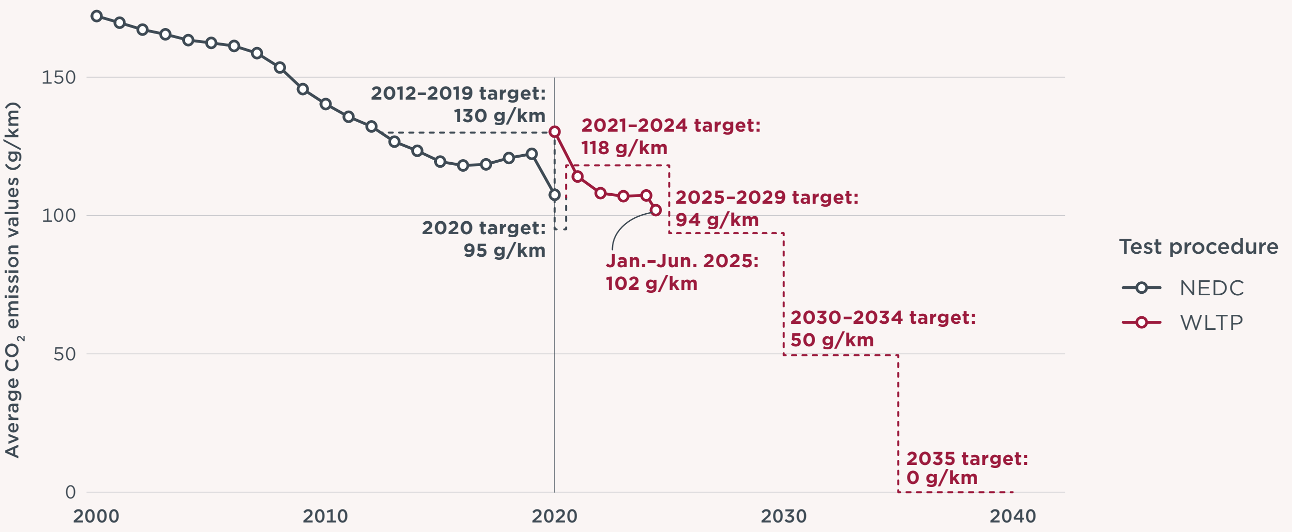
Road transport emissions account for more than two thirds of total greenhouse gas (GHG) emissions from the transport sector. To be in line with the EU Climate Law, these emissions need to decrease by about 90% by 2050 compared with 1990 levels. The EU CO_2 performance standards for new vehicles constitute a key policy instrument for achieving the necessary emission reductions. This section provides information on the progress of manufacturers in meeting their respective CO_2 targets, as well as the related uptake of zero-emission vehicles.

EU STANDARDS HELP TO REDUCE CO_2 EMISSIONS AND ENCOURAGE TECHNOLOGICAL INNOVATION

The EU CO_2 performance standards for new vehicles have proven effective in reducing emissions. Since their introduction in 2009, official type-approval emissions of new passenger cars decreased by about 42%, or about 4.7 g/km per year on average.[3] However, due to the stepwise nature of the targets, this progress has not been steady: instead, **manufacturers have tended to accelerate CO_2 reductions in target years, while slowing down their efforts in intermediate years**. In 2020/21, the last time the standards were tightened, emissions fell at a rate of 17 g/km per year. A similar trend was observed at the beginning of target year 2025, when the year-to-date CO_2 level decreased by 8 g/km compared with the first half of 2024. Figure 1.1 shows historical average CO_2 emission values and targets for new passenger cars, expressed in New European Drive Cycle (NEDC) values until 2020 and in Worldwide harmonised Light vehicles Test Procedure (WLTP) values from this point forward.[4]

FIGURE 1.1

Historical average CO_2 emission values and targets for new passenger cars



Notes: Data cover the European Economic Area excluding Liechtenstein, where the CO_2 standards do not apply, and are expressed in NEDC or WLTP values without accounting for flexible compliance mechanisms.

Data sources: European Environment Agency, "Monitoring"; Dataforce.

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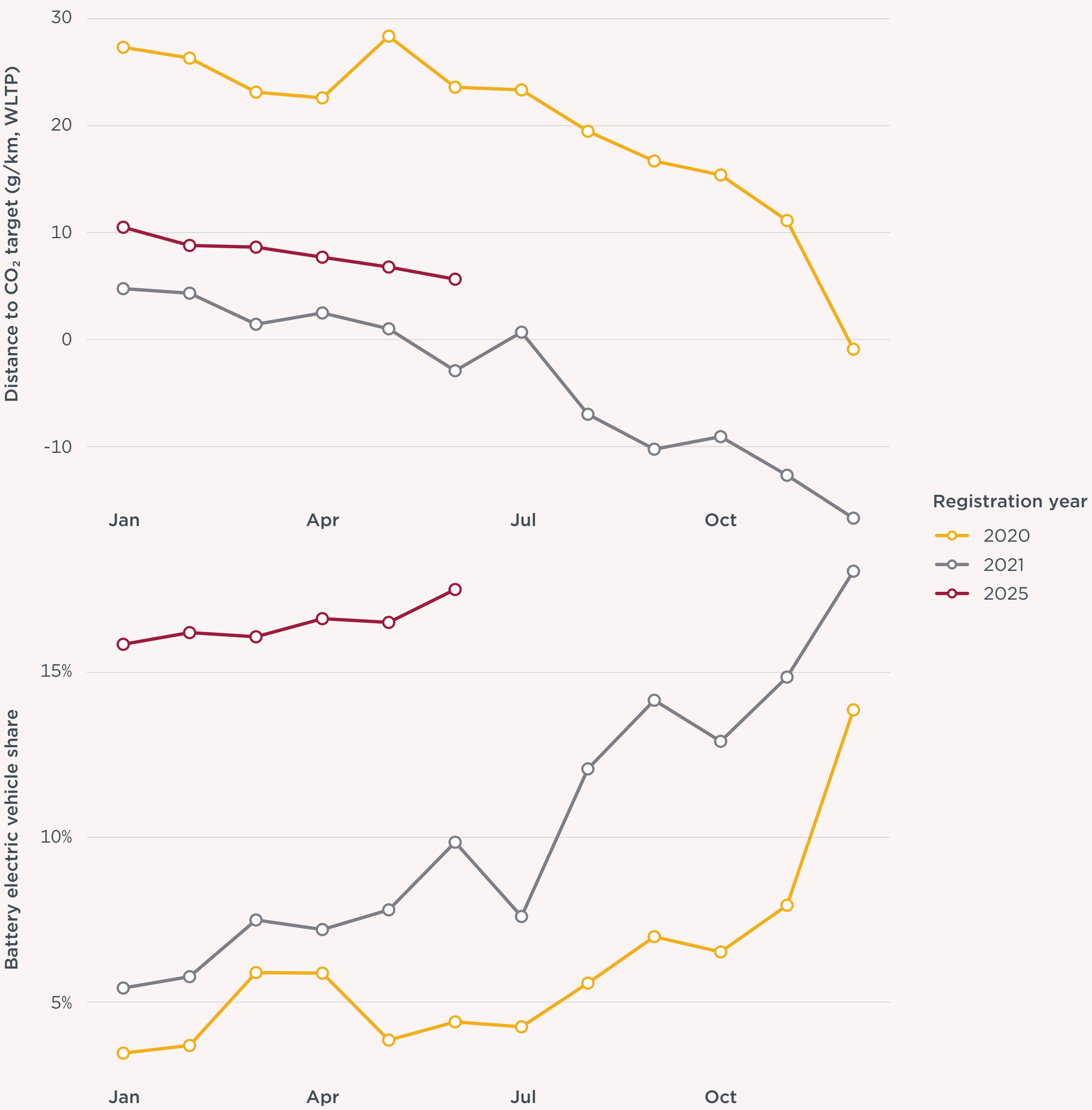
In target years 2020/21, **manufacturers strongly increased EV sales towards the end of the year,** pushing CO_2 emission levels down (Figure 1.2). With the European Union allowing manufacturers to balance out higher emissions in 2025 in later years via the 2025–2027 averaging provision introduced in May 2025, it remains to be seen if EV sales shares will increase at the end of 2025.[5] In the first half of 2025, BEVs made up 17% of new car and van sales in Europe, the highest level recorded to date.[6]

FIGURE 1.2

Distance between new car fleet-average monthly CO_2 performance and manufacturer target in 2020, 2021, and 2025 (top) and related BEV new sales share (bottom)



Note: CO_2 performance values exclude flexible compliance mechanisms, which were used by manufacturers to close the gap between CO_2 performance and associated targets at the end of 2020.
Data source: Dataforce.

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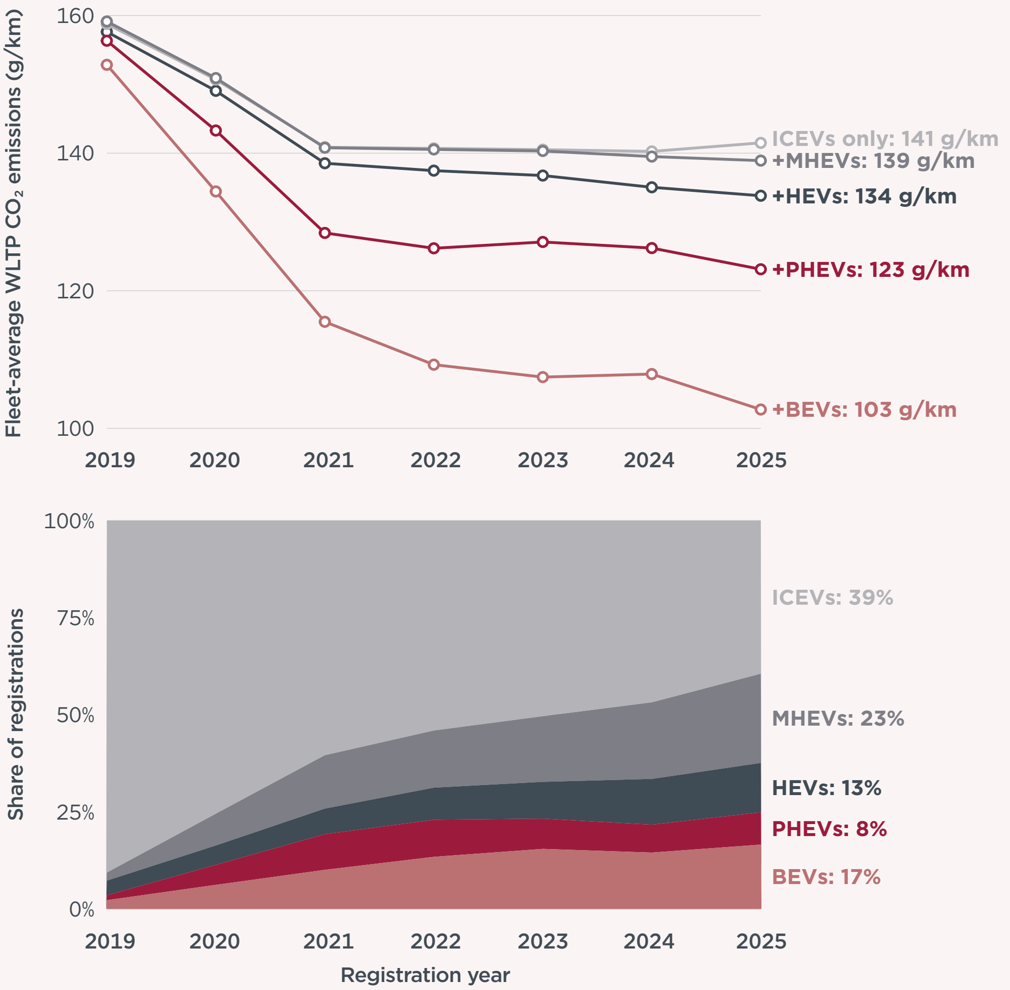
As shown in Figure 1.3, **fleet-average CO_2 reductions of newly registered cars since 2019 have primarily been achieved by increasing the share of BEVs and PHEVs**. Without including EVs, fleet-average CO_2 emissions today would be at about 134 g/km instead of 103 g/km. Average internal combustion engine vehicle (ICEV) emissions have stagnated at around 141 g/km since 2021; however, an increasing share of ICEVs are being replaced by mild hybrid electric vehicles (MHEVs) and full hybrid electric vehicles (HEVs). Fuel-cell EVs do not play a notable role in the EU passenger car market.

FIGURE 1.3.

Average CO_2 emissions of ICEVs and fleet-average emission reductions associated with including sales of electrified powertrains (top) and market shares of different powertrain technologies in the European Union (bottom)



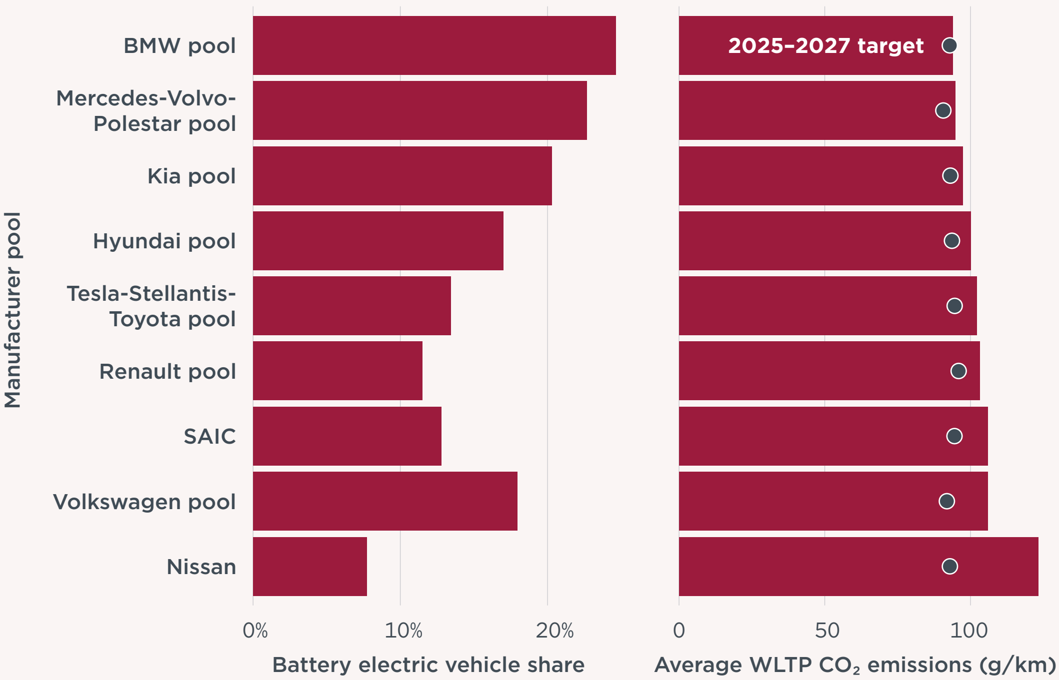
Data sources: European Environment Agency, "Monitoring"; Dataforce.

VEHICLE MANUFACTURERS ARE MAKING SUFFICIENT PROGRESS TOWARD MEETING THEIR CO_2 TARGETS

Three manufacturer pools, accounting for 19% of all new car sales in the first half of 2025, are already below or close to their respective 2025–2027 CO_2 targets as of June 2025: the BMW pool (compliant), Kia pool (3 g/km from target), and Mercedes-Volvo-Polestar pool (4 g/km from target).[7] These three pools also have the highest share of BEVs in 2025 (Figure 1.4). Among large manufacturers, the Volkswagen pool currently is the furthest away from its 2025 target (by 13 g/km), although its performance improved in the first half of the year, falling by 4 g/km. On average, manufacturers are currently 9 g/km (about 9%) away from the fleet-average CO_2 target for the 2025–2027 period.

FIGURE 1.4

Battery electric vehicle share by manufacturer pool (left) and CO_2 performance from January to June 2025 and estimated 2025-2027 target by manufacturer pool (right)



Data source: Dataforce.

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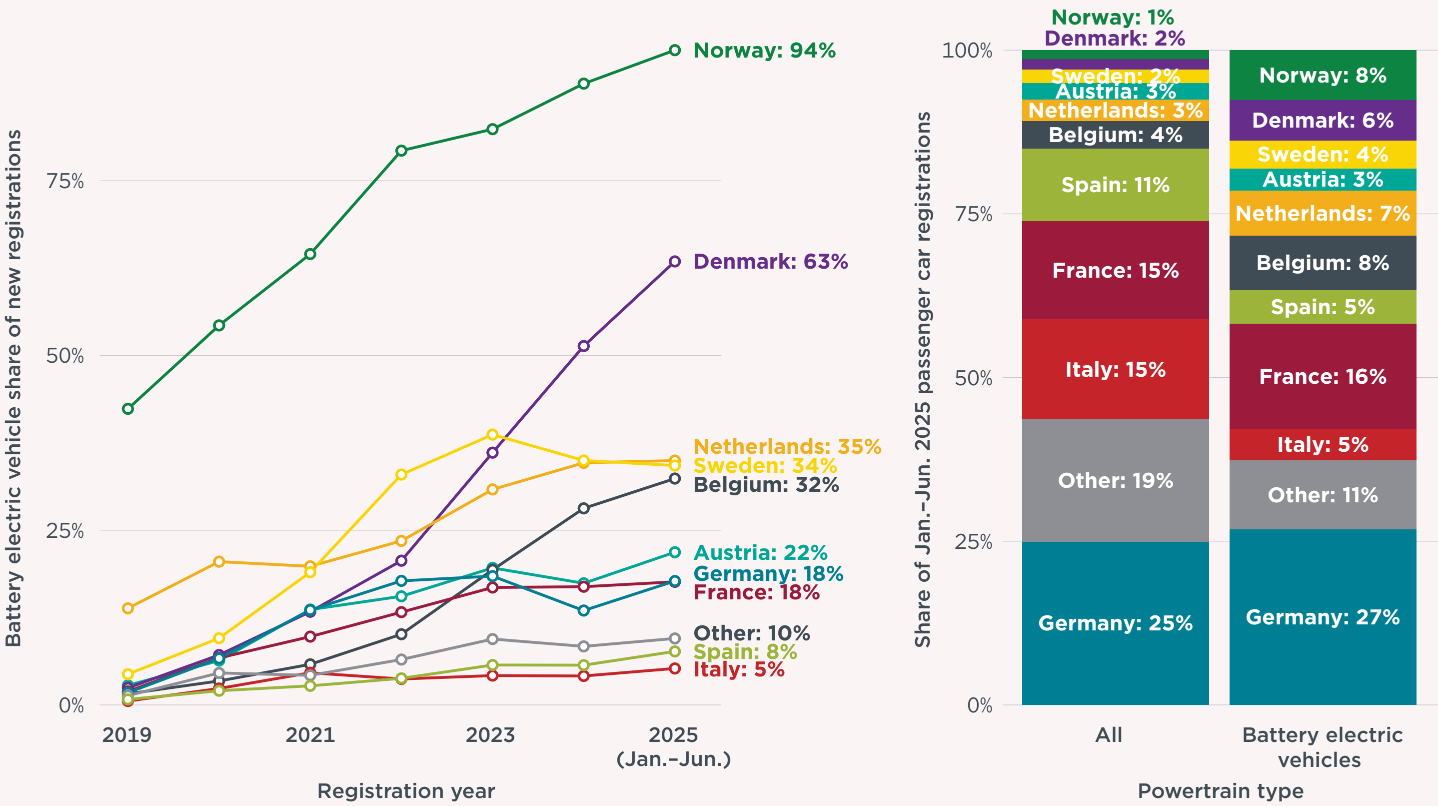
ELECTRIC VEHICLE MARKET SHARES ARE PICKING UP ACROSS EUROPE

New passenger car registrations in the European Union are dominated by four markets: Germany, France, Italy, and Spain. Together, these markets accounted for two thirds of all new passenger car registrations in the European Union from January to June 2025 (Figure 1.5). Germany and France accounted for 27% and 16% of the EU BEV market, respectively, roughly equal to their respective shares of the overall passenger car market (25% and 15%). Meanwhile, **Italy and Spain each accounted for 5% of the BEV market in the same period, significantly lower than their respective shares of the full passenger car market (15% and 11%)**. Smaller markets such as Belgium, the Netherlands, Sweden, Denmark, and Norway—the latter of which is not an EU Member State but counts towards manufacturers' compliance with the EU CO_2 standards—account for a disproportionate share of EV registrations.

BEV shares of new vehicle registrations have increased across virtually all markets in recent months. **In Spain, BEV registrations were 83% higher in the first half of 2025 than in the first half of 2024; in Italy, they were up 29% relative to the same period**. In many cases, high EV uptake rates are observed in markets that leverage the regulatory push from the EU CO_2 performance standards with incentives for consumers at the national level, such as tax deductions and benefit-in-kind provisions for electric company cars in Belgium.[8]

FIGURE 1.5

Market share of battery electric vehicles in new passenger car registrations in Europe (left) and shares of passenger car and battery electric vehicle registrations in January–June 2025 by country (right)



Data sources: Dataforce.

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TABLE 1

Manufacturer targets and electric vehicle uptake

Key performance indicator	Status	
Technology progress	EU standards are helping to reduce CO_2 emissions and foster technology innovation	
Average CO_2 emission levels of new vehicles	**+9 g/km** Distance to target	On average, manufacturers are 9 g/km (about 9%) from their 2025–2027 fleet-average CO_2 target.
Speed of CO_2 reduction per year	**-8 g/km** CO_2 reduction within the first half of 2025	Since the introduction of EU CO_2 performance standards in 2009, official type-approval emissions of new passenger cars decreased by about 4.7 g/km per year on average. In the first half of 2025, the CO_2 level decreased by 8 g/km.
Market uptake of BEVs	**17%** Market share of BEVs	Between January and June 2025, the share of BEVs in new passenger car registrations in Europe was 17%, the highest level recorded to date.
Manufacturer progress	Vehicle manufacturers are on a path to meeting their CO_2 targets	
Manufacturer-specific compliance with CO_2 targets	**3** Manufacturer pools are within 5% compliance of the 2025–2027 targets	As of June 2025, three manufacturer pools were below or close to their respective 2025 CO_2 target: BMW (compliant), Kia (3 g/km from target), and Mercedes-Volvo-Polestar (4 g/km from target).
Manufacturer-specific uptake of BEVs	**25%** Highest BEV share among the largest manufacturer pools	In the first half of 2025, BMW (25%) had the highest share of BEVs, followed by Mercedes-Volvo-Polestar (23%) and Kia (20%).
Use of additional compliance options	**8%** Average PHEV share of manufacturer sales	On average, in the first half of 2025, PHEVs made up 8% of manufacturer sales in the European Union, HEVs 13%, and MHEVs 23%.
Member State progress	Electric vehicle market shares are picking up across Europe	
BEV shares in the largest EU Member States	**18%** BEV market share in Germany and France	BEVs made up 18% of all new car registrations in Germany and France in the first half of 2025. Shares in Spain (8%) and Italy (5%) were lower, but increased markedly relative to the same period in 2024 (Italy by 29% and Spain by 83%).
BEV market share in first-mover markets	**64%** BEV market share in Denmark	As of June 2025, 12 countries were above the European average for BEV share in new passenger car registrations in the first half of 2025 (17%), led by Norway (94%), Denmark (63%), the Netherlands (35%), and Sweden (34%).

2

VEHICLE AFFORDABILITY

Battery electric vehicles today have lower driving costs than other vehicle types. With decreasing battery prices, the number of affordable electric cars continue to rise.

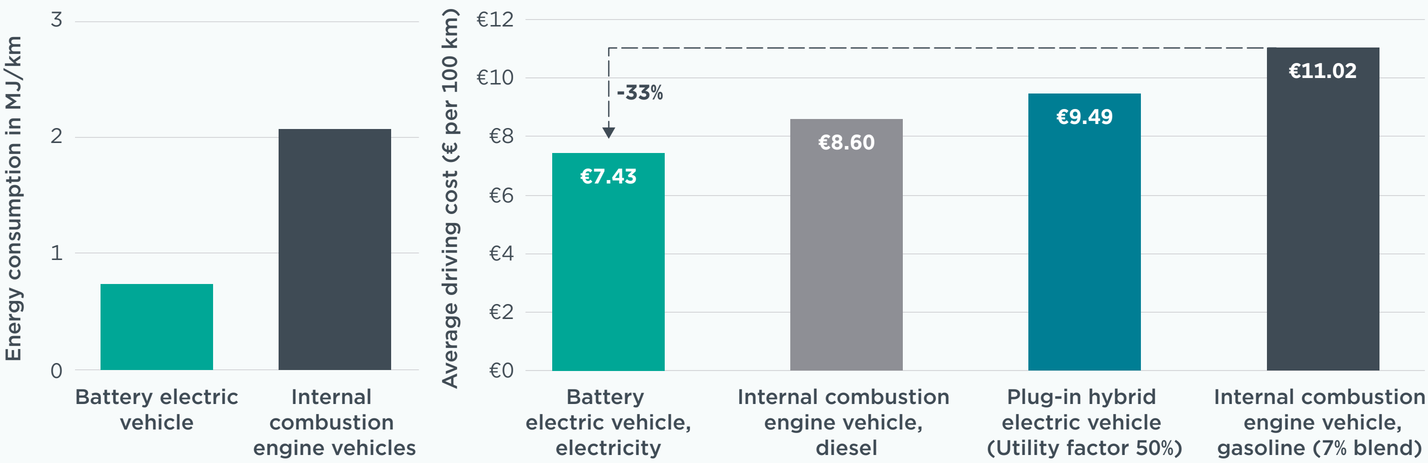
Advancements in battery technology and the implementation of binding regulations such as the EU CO_2 standards have spurred the development of new electric car models, technological innovation, and increased production capacities. This has decreased the costs of EVs for consumers in recent years. This chapter compares the costs of charging BEVs with those of fueling other vehicle types and illustrates how falling battery prices have contributed to an expanding selection of affordable EVs. It concludes with data on the market for used BEVs.

BATTERY ELECTRIC VEHICLES ARE CHEAPER TO DRIVE THAN OTHER VEHICLE TYPES, BUT PUBLIC CHARGING COSTS FOR ELECTRICITY VARY SIGNIFICANTLY ACROSS EUROPE

BEVs are the most efficient powertrain type, with an energy consumption of 0.73 MJ/km or 20.2 kWh per 100 kilometers driven for an average medium segment vehicle (Figure 2.1).[9] **ICEVs, whether fueled with conventional gasoline or alternative liquid fuels, consume almost 3 times more energy per kilometer on a tank/battery-to-wheel basis (2.07 MJ/km).** These differences in energy efficiency directly influence the operating costs.

BEVs are the cheapest powertrain to operate in the European Union, with an estimated average electricity cost of €7.43 per 100 kilometers driven. This charging cost accounts for the purchase of a home charger and assumes 80% home charging (at €0.28/kWh) and 20% public charging, the latter comprising 15% alternating current (AC) charging and 5% direct current (DC) fast charging (prices discussed below).[10] **ICEVs are more expensive to operate, with costs ranging from €8.60 per 100 km driven for diesel (at the EU average price of €1.48/L), and €11.02 per 100 km for gasoline (€1.59/L).** PHEVs, which run partially on electricity and partially on fuel, are €2.06 more expensive to drive than BEVs on a 100 km basis assuming a utility factor (share of driving on electric power) of 50%. Figure 2.1 does not include e-fuels, which are not yet available on a commercial scale in Europe and are projected to be too costly (€9.65–€22.68 per 100 km)[11] to be a viable alternative to BEVs; it also does not consider fuel-cell EVs, which currently do not play a notable role in the European passenger market.

FIGURE 2.1
Comparison of energy consumption (left) and estimated refueling and recharging costs (right) by passenger car type



Note: For BEVs, the proportional cost of a home charger is included and a mix of 80% private and 20% public charging is assumed.
Data sources: Eco-Movement, *EV Charging Price Data*; Eurostat, *Weekly Oil Bulletin*; and Negri and Bieker, *Life-Cycle Greenhouse Gas Emissions*.

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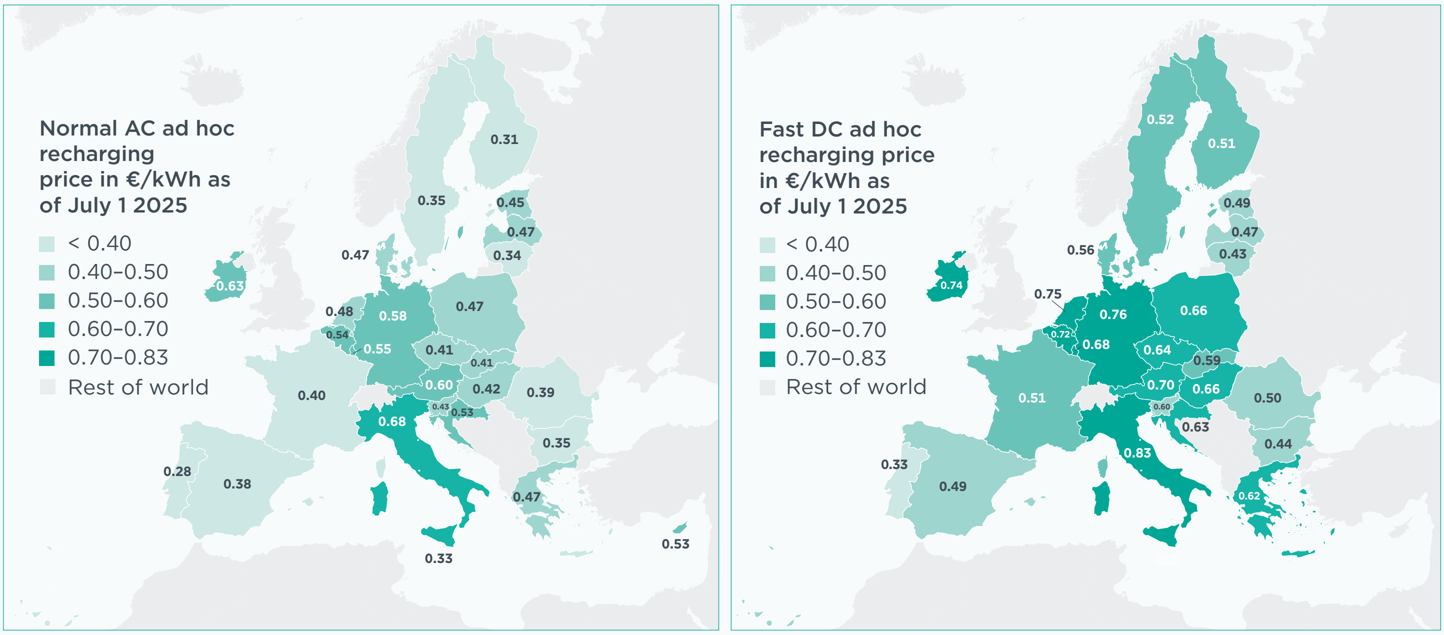
Although BEVs are the most energy efficient and cost-effective vehicle type to fuel, electricity prices—in particular, ad hoc (without subscription) prices at public charging points—can vary significantly across the European Union. On average, in July 2025, ad hoc energy rates across the European Union were €0.49/kWh for AC charging and €0.63/kWh for DC charging, including value added tax (VAT). As shown in Figure 2.2, prices for AC charging are significantly lower in some EU Member States, such as Finland (€0.31/kWh) and Portugal (€0.28/kWh), and higher in others, such as Italy (€0.68/kWh), where taxes are higher for electricity than for fossil fuel.[12] Prices for DC charging also vary significantly across the region partly due to differences in average DC charger speed in each country.

FIGURE 2.2
Average AC (left) and DC (right) ad hoc public charging prices as of July 1, 2025, by EU Member State



Notes: Figure reflects average national ad hoc charging costs; costs when charging within one's own network (i.e., without roaming) would be lower.
Data source: Eco-Movement, *EV Charging Price Data*.

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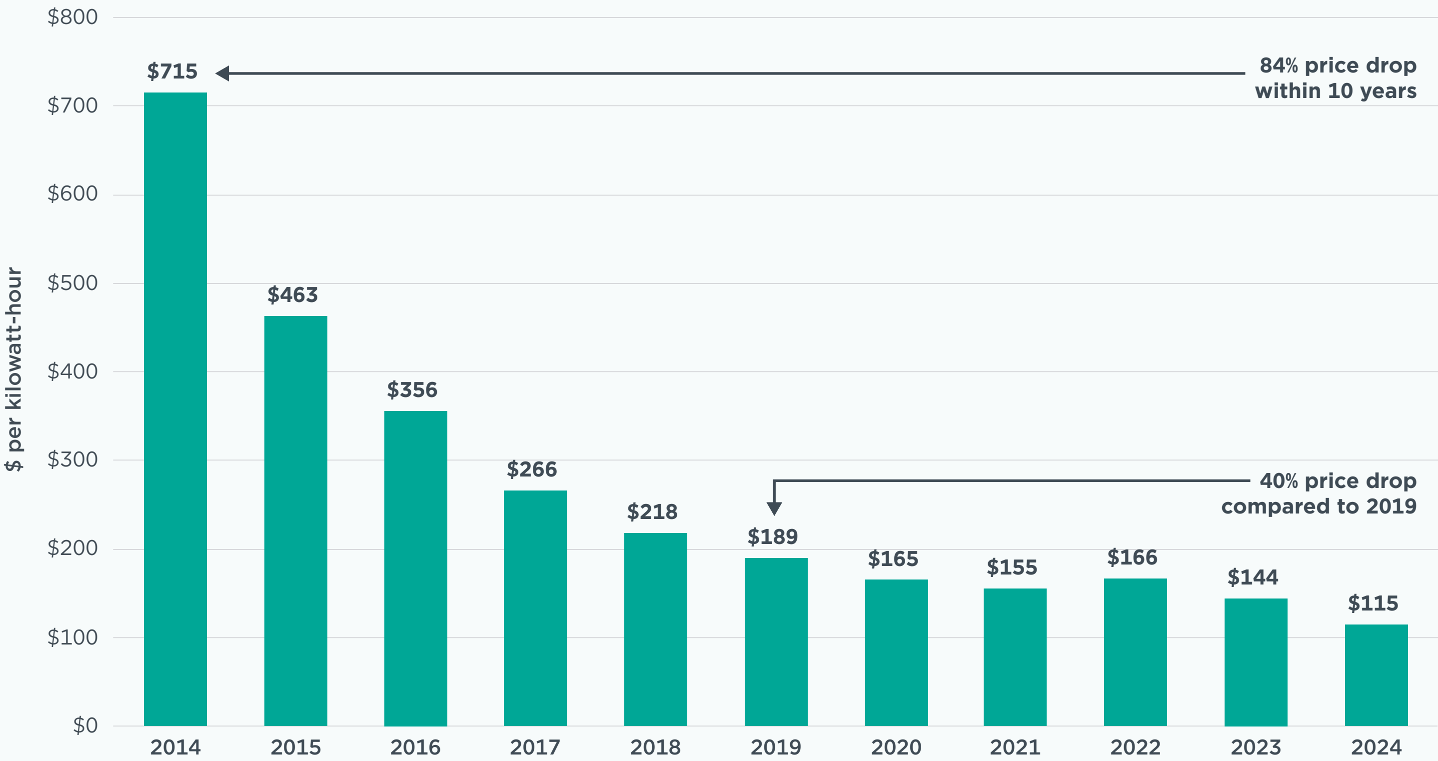
THE NUMBER OF AFFORDABLE EV MODELS IS LOW BUT INCREASING ACROSS A RANGE OF SEGMENTS, DRIVEN BY FALLING BATTERY PRICES

Prices of lithium-ion battery packs declined by about 84% within the past 10 years and about 40% within the past 5 years, to a global average of $115 (€99) per kilowatt-hour in 2024 (Figure 2.3). This trend is due to increased production capacities as well as technological improvements in terms of higher energy density. **Battery prices in Europe tend to exceed those of other regions.** In China, for example, average pack prices in 2024 were $94 (€82) per kilowatt-hour, compared with $139 (€122) in Europe.[13] Continued reductions in battery pack prices, which currently account for 30%–40% of total average EV acquisition costs, can further enhance affordability for a broader range of consumers in Europe.[14]

FIGURE 2.3
Global average pack price for lithium-ion batteries, 2014–2024



Data source: BloombergNEF, "Lithium-ion Battery Pack Prices See Largest Drop Since 2017, Falling to $115 per Kilowatt-Hour," press release, December 10, 2024, https://about.bnef.com/insights/commodities/lithium-ion-battery-pack-prices-see-largest-drop-since-2017-falling-to-115-per-kilowatt-hour-bloombergnef/.

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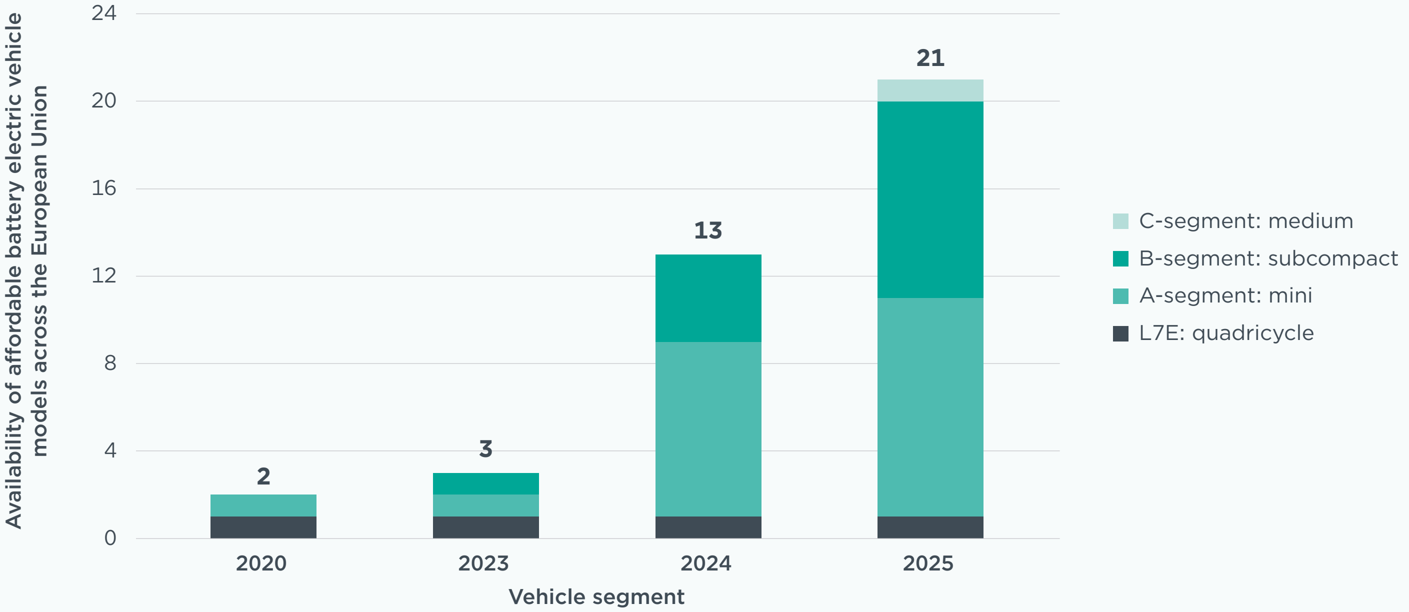
As battery prices are likely to continue to fall, the availability of affordable EV models is expected to increase. This is important, as the prices of new vehicles in Europe have continued to rise, limiting options for those with lower incomes.[15] In this study, we consider an affordable EV model to have a list price below €30,000, as studies on EV adoption reference the need for models at or lower than this price point to trigger broader market acceptance.[16] **In 2024, only 5% of BEV models were priced below €30,000, compared with 25% of ICEV models**.[17] **The number of affordable BEV models in the European Union has risen from two across two segments in 2020 to 21 across four segments in 2025** (Figure 2.4).

FIGURE 2.4

BEV models priced below €30,000 available in the European Union by vehicle segment



Data sources: European Alternative Fuels Observatory, *Available Electric Vehicle Models*; EV Database.

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The most common segments for affordable BEV models are the city car and subcompact segments, while only two of the 21 affordable models are in the quadricycle and compact car segments. **Affordable BEV options within the mid-sized car segment could be an important mobility option for families and allow a broader group of customers to participate in the transition to electromobility.** Other models have been announced for future years, such as the subcompact Volkswagen ID.2, priced at less than €25,000 and set to be released in 2026. These announcements suggest affordable model availability will continue to grow in Europe.

Policies are also being implemented to promote access to EVs for a broader portion of the population. In 2023, France launched a social leasing scheme offering new EVs for a maximum of €150 per month, with eligibility based on income and commuting needs.[18] The program received over 90,000 applications within weeks, above its initial target of 25,000. A second round of the social leasing program is set to start in September 2025. The *Industrial Action Plan for the European Automotive Sector*, issued by the European Commission in March 2025, suggests implementing similar programs that support vulnerable groups and could be financially supported by the EU Social Climate Fund.[19]

EU CO_2 STANDARDS CAN ALSO HELP TO GROW THE MARKET FOR USED BEVS

In addition to the development of new affordable BEV models, a secondhand market for electric cars can offer more affordable options to consumers who do not typically purchase new vehicles. The used electric car market is indirectly supported by the European CO_2 standards, as the new vehicles on the road will eventually be sold to second users at a reduced price.

BEVs have the largest depreciation rates among all vehicle types, with vehicles aged 36 months with approximately 60,000 kilometers retaining only 37.6% of their original list price. This is significantly lower than gasoline (49.3%), diesel (48.5%), and plug-in hybrid vehicles (43.6%).[20] This could be in part due to consumer concerns about secondhand battery capacity and rapidly advancing EV battery technology in newer models.

Despite these challenges, **the secondhand BEV market has grown steadily in recent years.** As an example, in France, close to 40,000 secondhand EVs were sold in the first four months of 2025, a 40% increase from the first four months of 2024.[21] Most of these vehicles (84%) were sold to private individuals as opposed to fleets and automotive professionals. The growth of the secondhand EV market in France can partly be attributed to the Orientation Mobility Law.[22] This fleet mandate requires companies managing a fleet of more than 100 light-duty vehicles to include an increasing minimum proportion of "very-low emission vehicles" in fleet renewals annually, which include either battery electric or hydrogen vehicles, causing an influx in supply to the secondhand market. Beginning in 2022, at least 10% of annual vehicle purchases had to be very-low emission, rising to 20% from 2024, 40% from 2027, and 70% from 2030.[23]

TABLE 2
Vehicle affordability

Key performance indicator	Status	
Charging and fueling costs	BEVs are cheaper to charge per 100 km due to higher energy efficiency	
Cost of BEV charging	**€7.43** Per 100 km driven	On average, driving BEVs costs €7.43 per 100 km, compared with €8.60 for diesel and €11.02 for gasoline. PHEVs with a 50% utility factor cost €9.49 per 100 km.
Energy consumption	**0.73** MJ/km	BEVs are the most efficient powertrain, at 0.73 MJ/km (real-world), compared with more than 2.07 MJ/km for ICEVs.
Public charging prices	**€0.49/kWh** Average AC charging price (including VAT)	Considering energy costs alone, public charging prices average €0.49/kWh for AC and €0.63/kWh for DC, including VAT.
Fixed costs	Affordable EV models remain limited but are increasing across market segments, driven by falling battery prices	
Lithium-ion battery pack prices	**84%** Drop in global average battery pack price in the past 10 years	The global average battery pack price fell from $715/kWh in 2014 to $115/kWh in 2024.
Affordable (<€30,000) BEV models	**21+** Affordable BEV models	The number of affordable BEV models in the European Union rose more than tenfold in 5 years, from two models in 2020 to 21 in 2025. Additional affordable models have been announced beyond 2025.
Secondhand market	The secondhand battery electric car market continues to develop but some constraints exist	
Depreciation rates	**37.6%** Of the original list price	Battery electric vehicles saw the lowest residual value after 60,000 kilometers at 37.6% off the original list price, compared with 49.3% for gasoline, 48.5% for diesel, and 43.6% for plug-in hybrids.
Growth of the secondhand market	**40,000** Secondhand BEVs sold in France in the first trimester of 2024	In France, 40,000 secondhand BEVs were sold in the first quarter of 2025, up 40% year-on-year. This is partly due to the Orientation Mobility Law, which requires companies to purchase a minimum share of "very low emission vehicles," including hydrogen and battery electric cars, as part of their fleet renewals.

3

CLIMATE AND HEALTH IMPACTS

BEVs offer the greatest potential to reach climate targets on schedule while also reducing the air pollution impact of road transport.

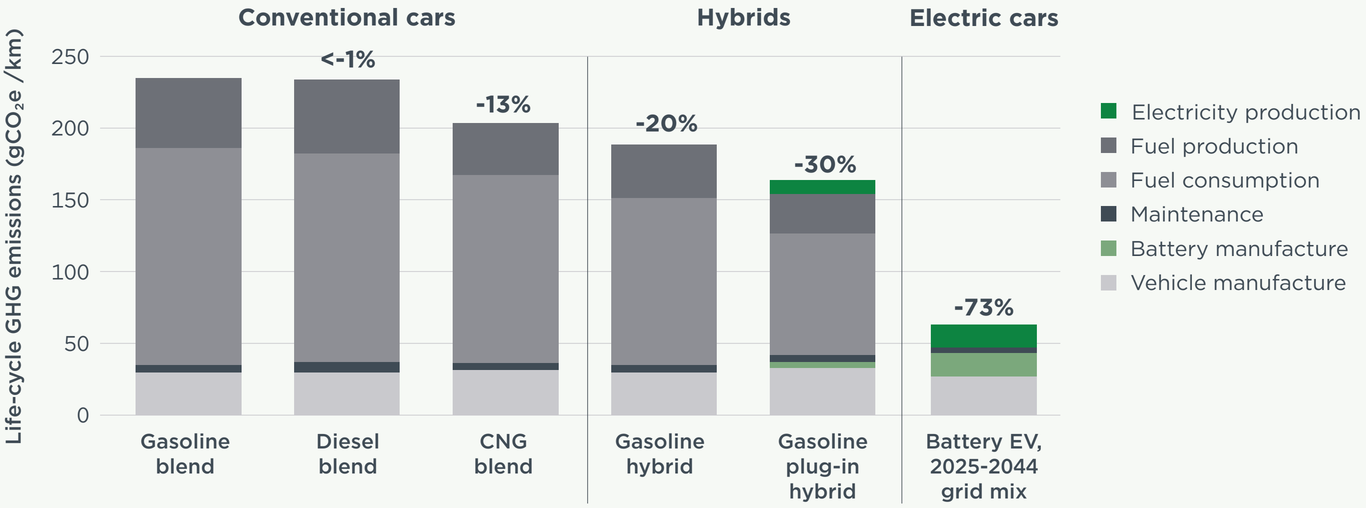
To achieve the European Union's objective of climate neutrality by 2050, GHG emissions from the transportation sector must be reduced by 90% from 1990 levels.[24] In addition to contributing to climate change, vehicle emissions also have a negative impact on health, with more than 83% of Europe's urban population exposed to pollutant levels above those recommended by the World Health Organization.[25] This chapter compares life-cycle GHG emissions of BEVs to those of other powertrains and quantifies the health and air quality impacts of different vehicle types. It concludes with an outlook on the health and environmental impacts associated with the supply chain for vehicle batteries.

BEVS SOLD TODAY HAVE A LOWER GHG INTENSITY THAN COMBUSTION ENGINE OR HYBRID VEHICLES

BEVs are estimated to have 73% lower life-cycle GHG emissions than conventional gasoline ICEVs, with emissions of 63 g CO_2e/km compared with 235 g CO_2e/km. This estimate considers a vehicle registered in 2025 running on the average EU electricity grid mix and accounts for projected changes in the electricity mix over the vehicles' lifetime (Figure 3.1).[26] Although the battery causes BEVs to have about 40% higher emissions than an ICEV during vehicle production, these emissions are more than offset by lower emissions during vehicle use (90%–96% lower than gasoline ICEVs) after about 17,000 km of driving in the first 1 to 2 years.

FIGURE 3.1

Life-cycle GHG emissions of medium segment passenger cars sold in the European Union in 2025



Notes: The average gasoline, diesel, and natural gas blends include 7vol% ethanol, 7vol% bio-based diesel, and 3% biomethane, respectively.
Source: Negri and Bieker, *Life-Cycle Greenhouse Gas Emissions*.

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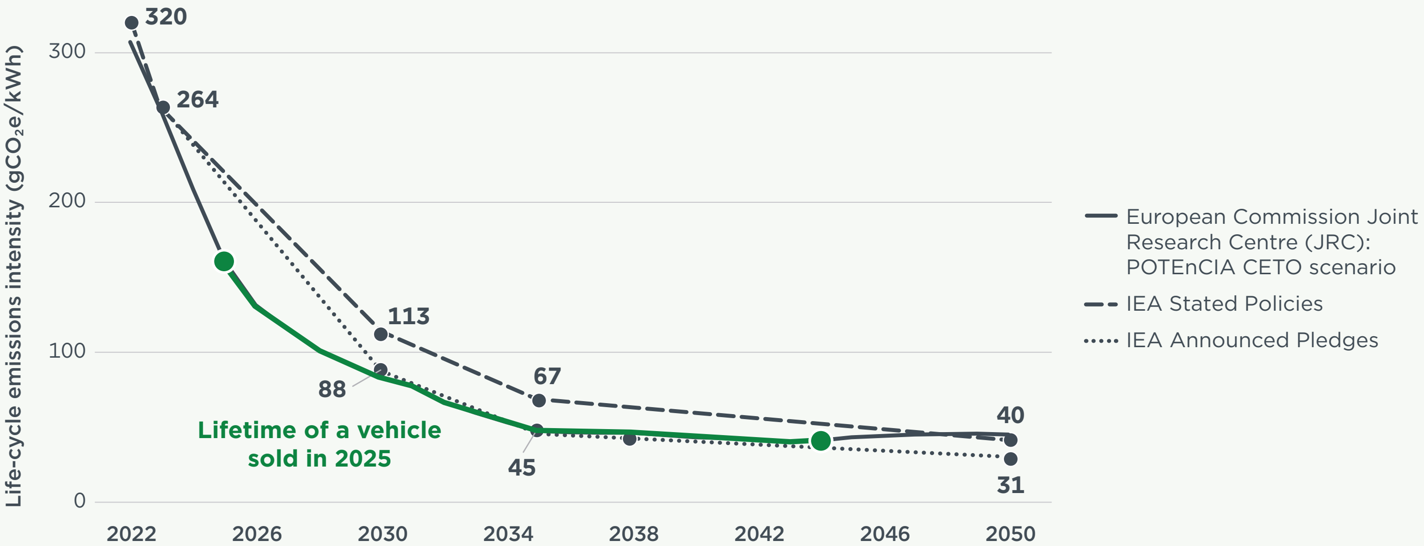
With an observed average vehicle lifetime of about 20 years, BEVs sold in 2025 will be used until 2044 and will rely on an increasingly decarbonized electricity mix over that period. The electricity mix has seen a substantial increase in renewable energy sources and is projected to decarbonize even further with reductions in the cost of wind- and solar-powered electricity generation (Figure 3.2). The EU Joint Research Centre (JRC) expects the share of renewables in the EU electricity mix to increase from 56% in 2025 to 71% in 2030 and 85% in 2040.[27] This contributes to a projected reduction in the average life-cycle GHG emissions of BEVs sold today by 24% compared with those sold in 2021.[28] Home charging, when coupled with rooftop solar photovoltaic systems, can also result in use-phase GHG emissions below the average CO_2 intensity of the grids. Dynamic pricing schemes are also likely to further increase the carbon savings advantage of home charging.[29]

FIGURE 3.2

Projected life-cycle GHG emissions of electricity generation in the European Union based on JRC and IEA modeling



Data sources: United Nations Economic Commission for Europe (UNECE), *Life Cycle Assessment of Electricity Generation Options* (2021), https://unece.org/sed/documents/2021/10/reports/life-cycle-assessment-electricity-generation-options; IEA, *Global EV Outlook 2024: Moving Towards Increased Affordability* (2024), https://www.iea.org/reports/global-ev-outlook-2024; Joint Research Centre, "POTEnCIA CETO 2024 Scenario" (2024), https://joint-research-centre.ec.europa.eu/scientific-tools-and-databases-0/potencia-policy-oriented-tool-energy-and-climate-change-impact-assessment/potencia-scenarios_en.

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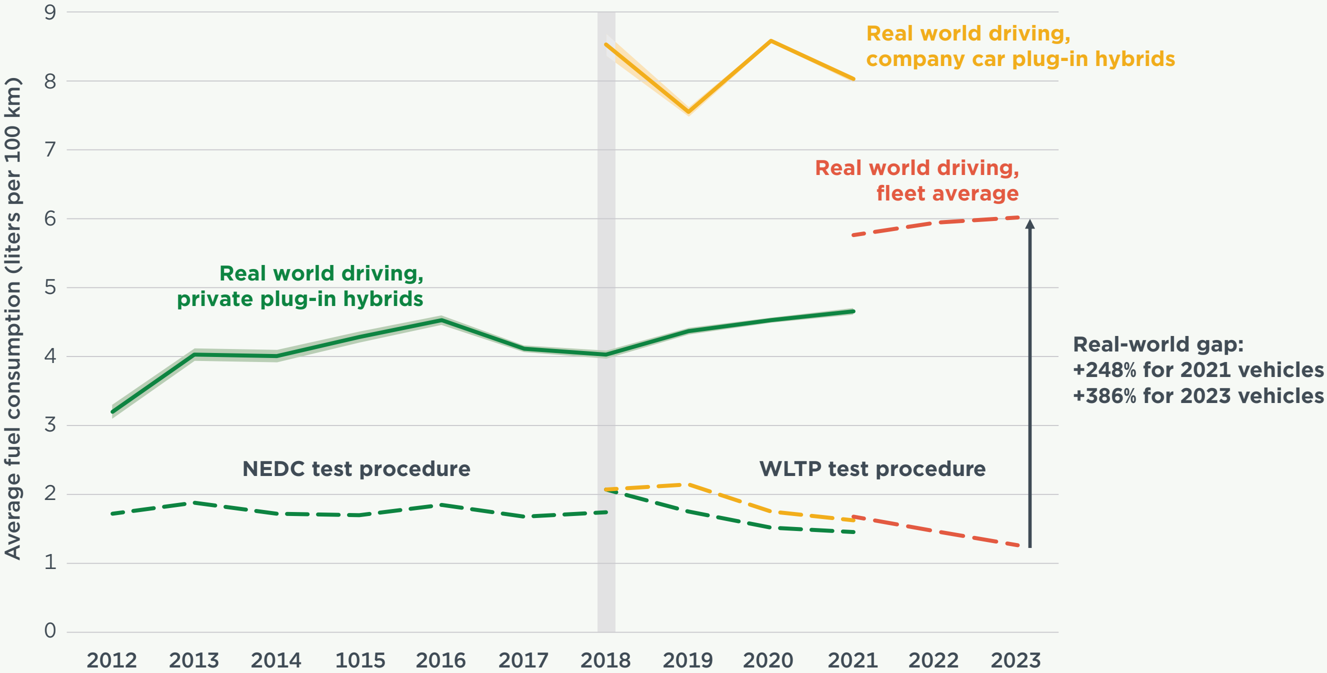
Hybrid and plug-in hybrid electric cars have life-cycle emissions about 3 times higher than those of BEVs sold today. Compared with a conventional ICEV, HEVs and PHEVs can achieve 20% and 30% lower emissions, with emissions of 188 g CO_2e/km and 163 g CO_2e/km, respectively. These numbers reflect the real-world average consumption of fuel and, in the case of PHEVs, electricity.[30] For PHEVs, the average real-world fuel consumption reported by the European Energy Agency is more than 3 times higher than official test values for 2021 vehicles and 5 times higher for 2023 vehicles (Figure 3.3).

FIGURE 3.3

Development of the average real-world and type-approval fuel consumption of PHEVs in Europe by vehicle build year



Data sources: Data on 2021–2023 vehicles are from "Real-World CO_2 Emissions from New Cars and Vans," European Environment Agency, accessed June, 2025, https://climate-energy.eea.europa.eu/topics/transport/real-world-emissions/data; data on 2012–2021 vehicles are from Patrick Plötz et al., *Real-world Usage of Plug-In Hybrid Vehicles in Europe: A 2022 Update on Fuel Consumption, Electric Driving, and CO_2 Emissions* (International Council on Clean Transportation, 2022), https://theicct.org/wp-content/uploads/2022/06/real-world-phev-use-jun22-1.pdf.

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In a scenario in which the blend share of biofuels doubles, the life-cycle emissions of ICEVs are still estimated to be 4 times higher than those of BEVs. Biofuels offer limited decarbonization potential for several reasons. Food and feed biofuels, the most common biofuels available today, are associated with substantial land-use change emissions from feedstock cultivation and fuel production, while low-GHG biofuels produced from waste and residue materials have low availability.[31] In addition, some biofuels, like ethanol for gasoline and biodiesel for diesel, face blending constraints. A recent ICCT study assessed the impact of a scenario in which the bio-based diesel blend would increase to levels twice as high as today and the ethanol share in gasoline reaches the maximum technically feasible blending rate with current EU gasoline cars.[32] The study found that the life-cycle emissions of gasoline and diesel cars would only be 0.5% to 3% lower than in the baseline scenario assuming constant biofuel shares. **Furthermore, the combustion of biofuels generates air pollutants, and blending biodiesel into diesel fuel increases nitrogen oxide (NO_x) emissions from the vehicle.**[33]

E-fuels require 6 times more energy to produce than is needed to power a BEV, which is reflected in the costs and climate impact. Vehicles operating exclusively on e-fuels could theoretically reach emissions of 63 g CO_2/km. However, e-fuels are not available at a commercial scale in Europe and are projected to be too costly to be a viable option for passenger cars.[34] For vehicles operating on e-fuels, the CO_2 from fuel combustion is balanced by the CO_2 emissions during fuel production. Further, the emissions of the construction of the solar and wind power plants needed to produce the electricity for these fuels make up around 40% of the total life-cycle GHG emissions of medium vehicles running on 100% e-fuels, due to the high energy losses during fuel production and combustion.

Fuel-cell EVs allow for low life-cycle emissions only when using renewable electricity-based hydrogen. However, renewable hydrogen is not widely available in Europe.[35] When driving on natural gas-based hydrogen, which corresponds to almost all hydrogen consumed in Europe today, fuel-cell EVs have emissions of about 175 g CO_2e/km, which is 26% lower than conventional gasoline ICEVs. Only when operating on renewable hydrogen do fuel-cell EVs reach emissions of 50 g CO_2e/km.

Efficiency improvements and increasing electrification for new cars required to comply with the EU CO_2 standards are projected to provide the largest reductions in GHG emissions from passenger cars up to 2030. However, these standards alone are insufficient to align passenger car GHG emissions with the European Union's 2030 economy-wide reduction target of 55% from 1990 levels without requiring additional reductions in other sectors. Different options exist to bridge the gap.[36] Accelerating the adoption of BEVs and fully phasing them in before the 2035 target would hasten the decarbonization of the vehicle stock and significantly lower the costs of decarbonizing the fleet later. A vehicle scrappage program could also help to close the gap. In Germany, for example, it is estimated that a scrappage program could close roughly one third (11 Mt CO_2e) of the gap with the country's non-binding 2030 climate target for the transport sector.[37]

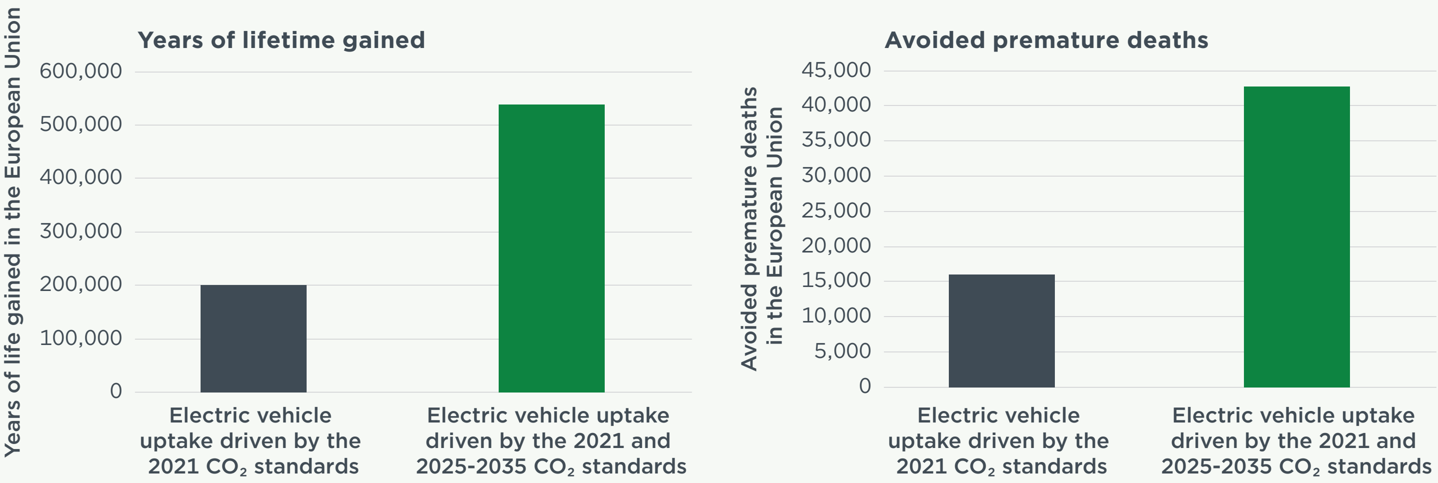
BEV ADOPTION REDUCES AIR POLLUTION, PREVENTING THOUSANDS OF PREMATURE DEATHS

Road transport is linked to significant levels of air pollution due to the emission of NO_x, particulate matter (PM), carbon monoxide, volatile organic compounds, ammonia, and sulfur oxides.[38] In Europe, transport was the largest source of NO_x emissions in 2022 and was responsible for almost 30% of $PM_{2.5}$ and PM_{10} emissions.[39] Air pollution is the most significant environmental health risk in Europe,[40] causing cardiovascular and respiratory diseases, diabetes, cancer, and other diseases that impact health, reduce quality of life, and cause preventable deaths.[41] Across Europe, residents are exposed to air pollutant concentrations that are considerably above the levels recommended by the World Health Organization.[42] Reducing air pollution to recommended levels would prevent hundreds of thousands of premature deaths each year in EU Member States.[43]

By requiring improved vehicle efficiency and EV adoption, CO_2 standards have the co-benefit of reducing criterion air pollutants and improving human health.[44] It is projected that the EU passenger car CO_2 standards that took effect in 2021 will prevent over 16,000 premature deaths in the European Union, representing over 201,000 years of lifetime gained between 2021 and 2050 (Figure 3.4). The next stage of the standards, limiting emissions to 0 g CO_2/km—meaning 100% ZEV sales—by 2035, will **nearly triple the health benefits of the EU light-duty CO_2 standards**, bringing the cumulative benefits of both policies to approximately 42,600 avoided premature deaths in the European Union, or 540,000 years of lifetime gained.

FIGURE 3.4

Years of lifetime gained (left) and avoided premature deaths (right) in the European Union between 2021 and 2050 from reduced tailpipe emissions, relative to a scenario with zero uptake of electric vehicles



Data source: International Council on Clean Transportation, *FATE v2.0 Documentation*.

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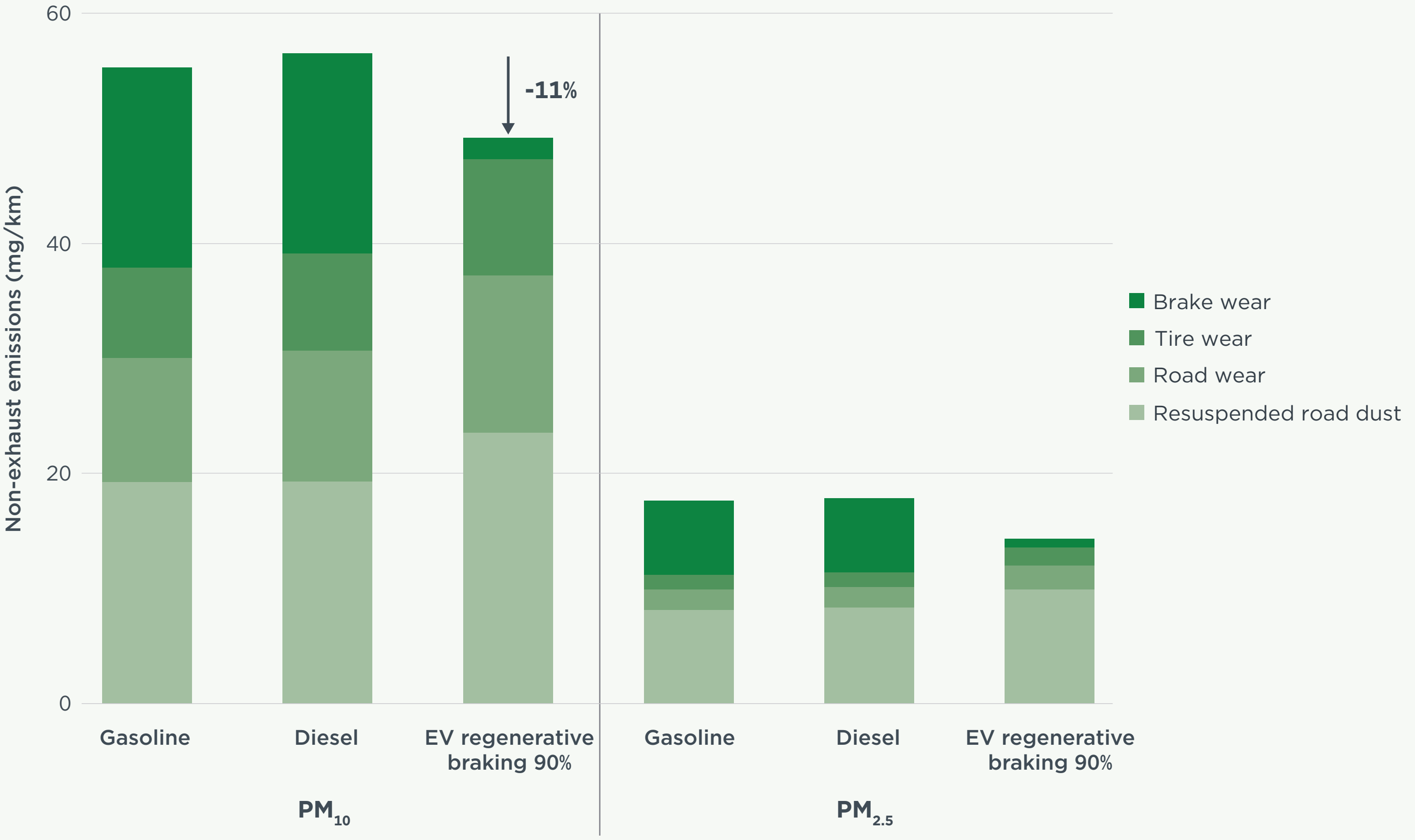
The monetary value of the health benefit of the 2025–2035 CO_2 targets is estimated to be €217 billion over 2021–2050 when applying the value of a statistical life as estimated by the ICCT FATE model.[45] The value of statistical life quantifies the economic value that countries place on reducing the risk of premature death.

When considering a broader geographical scope, **the total health benefits of the EU CO_2 standards translate to nearly 950,000 years of lifetime gained and 75,500 premature deaths avoided worldwide.** This is because air pollution does not stop at borders and has been shown to travel large distances, having impacts far beyond Europe.

In addition to zero tailpipe emissions, BEVs also have lower non-exhaust PM emissions. Although studies show that BEVs tend to produce more tire, road wear, and dust resuspension PM emissions due to their heavier weight, this increase is more than offset by the reduction in brake emissions due to the use of regenerative braking.[46] This is also reflected by BEVs having to comply with lower brake PM emissions levels than hybrids and conventional cars in Euro 7.[47] **Overall, the non-exhaust emissions of BEVs are lower than those of ICEVs by about 10% for PM_{10} and 20% for $PM_{2.5}$** (Figure 3.5). Moreover, the PM emissions from brakes have been estimated to have worse health impacts than equivalent amounts of tire wear emissions.[48]

FIGURE 3.5
Non-exhaust PM emissions



Notes: Values in the figure are based on analyses on a Hyundai Kona, which can be equipped with either a gasoline, diesel, or electric powertrain.
Data source: Sang-Hee Woo et al., "Comparison of Total PM Emissions Emitted from Electric and Internal Combustion Engine Vehicles: An Experimental Analysis," *Science of The Total Environment 842* (2022), https://www.sciencedirect.com/science/article/pii/S004896972204058X.

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THE DUE DILIGENCE PROVISION IN THE EU BATTERY REGULATION CAN HELP TO MITIGATE SOCIAL AND ENVIRONMENTAL RISKS IN THE BATTERY SUPPLY CHAIN

The mining of battery materials can stimulate the economy and support infrastructure development, thereby improving the livelihoods of the communities involved. At the same time, the extraction of raw materials for batteries can contribute to the displacement of local communities, health impacts, and human rights abuses, among other issues. These social risks are accompanied by environmental risks, such as a high water consumption, air pollution, and insufficient waste treatment associated with mining operations.

The EU Battery Regulation requires companies that sell BEV batteries in the European Union to identify and assess social and environmental risks along the entire supply chain of lithium, nickel, cobalt, and natural graphite, and to prevent, mitigate or otherwise address adverse impacts.[49] Companies are also required to adopt due diligence policies consistent with internationally recognized schemes, such as the OECD's Due Diligence Guidances for Responsible Business Conduct and for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas. Such policies need to be incorporated in contracts with suppliers and include a system of controls and transparency, risk management measures, and grievance and remediation mechanisms.

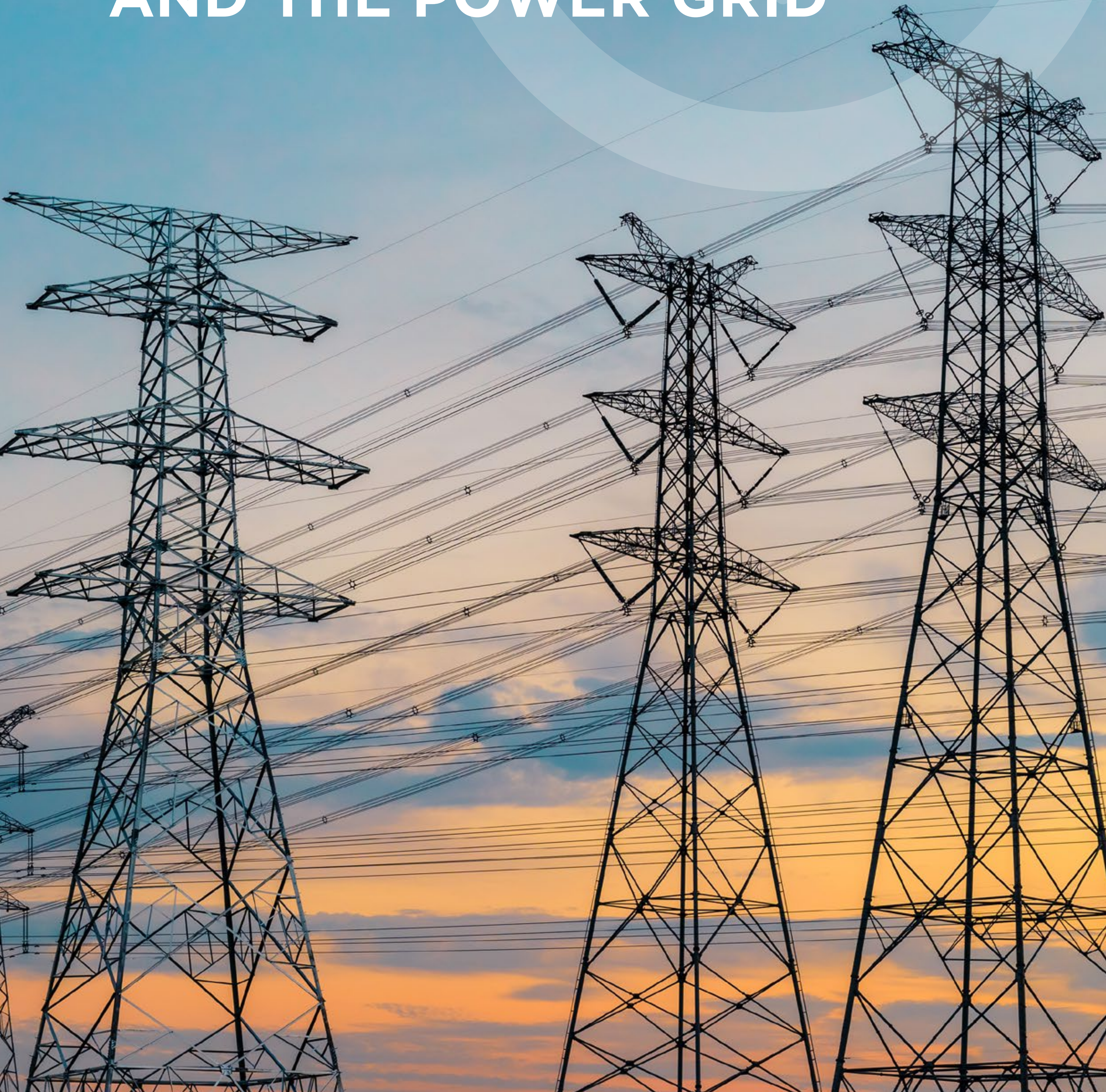
TABLE 3

Climate and health impacts

Key performance indicator	Status	
Climate impact	BEVs today offer lower GHG intensity than combustion engine or hybrid vehicles	
Life-cycle emissions of BEVs compared with those of ICEVs, HEVs, and PHEVs	**-73%** Life-cycle GHG emissions of BEVs compared with gasoline ICEVs	BEVs are powered by an increasingly decarbonized electric grid and achieve reductions in life-cycle GHG emissions of 73% compared with gasoline ICEVs for vehicles sold in 2025. This reduction is projected to increase for future vehicles. In comparison, HEVs and PHEVs, which rely on fossil fuels, offer life-cycle GHG emissions reductions of 20% and 30%, respectively, compared with ICEVs.
Decarbonization of the electricity grid	**71%** Projected renewable electricity generation by 2030	The GHG emissions intensity of the EU electricity grid is decreasing, with renewable energies projected to account for 71% of electricity generation by 2030.
Health impact	BEV adoption cuts air pollution and has positive health impacts	
Lifetime gained and premature deaths avoided within the European Union	**42,600** Avoided premature deaths	The EU passenger car CO_2 standards that took effect in 2021 are projected to result in health benefits that correspond to about 200,000 years of lifetime gained in the European Union. The next stage of standards from 2025 onwards is expected to deliver health benefits worth about 540,000 years of lifetime gained, equivalent to about 42,600 avoided premature deaths between 2021 and 2050.
Lifetime gained and premature deaths avoided worldwide	**75,500** Avoided premature deaths	The health impact of the European Union's 2025–2035 passenger car CO_2 standards is estimated to translate into 950,000 years of lifetime gained worldwide and 75,500 premature deaths avoided between 2021 and 2050.
$PM_{2.5}$ for BEVs compared with ICEVs	**20%** Lower $PM_{2.5}$ non-exhaust emissions	BEVs are estimated to have about 20% lower non-exhaust $PM_{2.5}$ emissions compared with ICEVs.
PM_{10} for BEVs compared with ICEVs	**10%** Lower PM_{10} non-exhaust emissions	BEVs are estimated to have about 10% lower non-exhaust PM_{10} emissions compared with ICEVs.
Other social impacts	Due diligence provisions in the EU Battery Regulation can help to mitigate social and environmental risks in the battery supply chain	
Due diligence requirements	**Reporting and action** requirements	The EU Battery Regulation requires companies that sell BEV batteries in the European Union to identify and assess social and environmental risks along the entire supply chain of lithium, nickel, cobalt, and natural graphite, and prevent, mitigate, or otherwise address adverse impacts.

4

CHARGING INFRASTRUCTURE AND THE POWER GRID



With over 1 million public chargers, the European Union is equipped to support EVs currently on the roads. Smart meter roll-out and time-varying tariff offers are increasing.

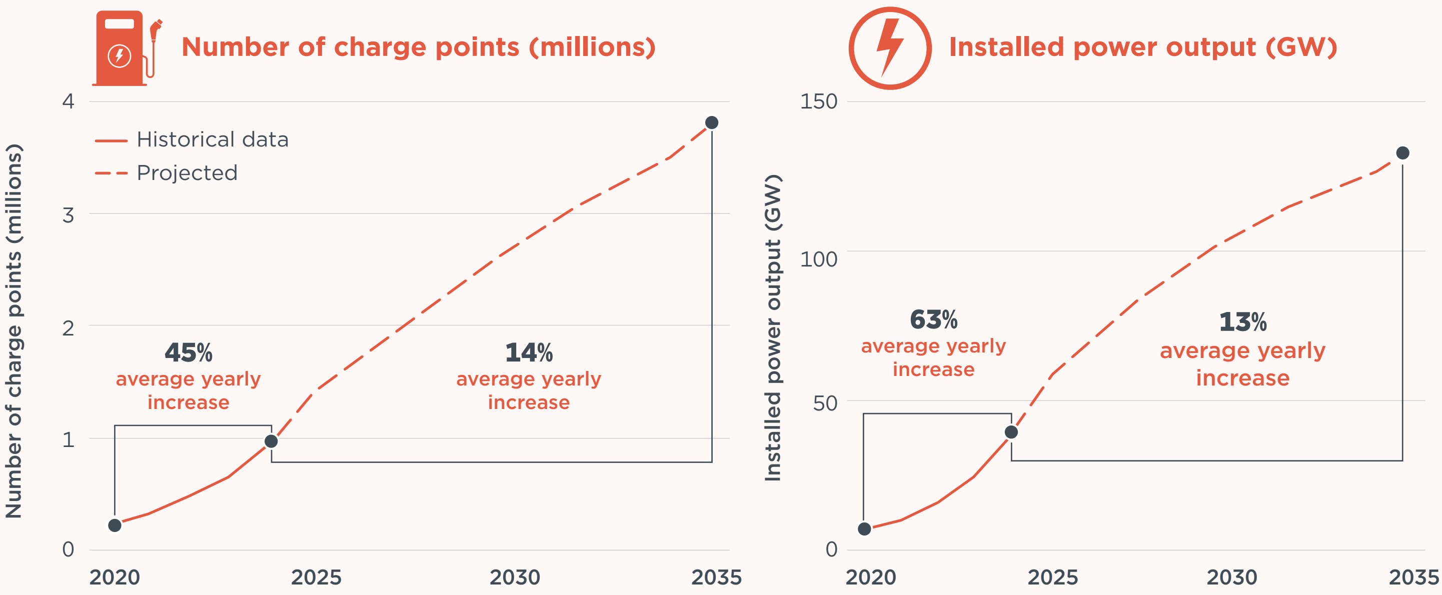
The deployment of sufficient charging infrastructure is a key factor in the widespread adoption of EVs. Proper planning can allow for EV charging to be well integrated into the grid and ensure efficient use of renewable energy. This section outlines the status of and implied outlook for charging infrastructure in the European Union, evaluating public and private charging infrastructure buildout and assessing integration of EV charging into the power grid.

OVERALL, PUBLIC CHARGING IS BEING DEPLOYED AT A SUFFICIENT PACE, WITH DIFFERENCES BETWEEN COUNTRIES MIRRORING DIFFERENCES IN EV ADOPTION

Over 1 million public chargers, representing **44 GW of installed power output,** were available across Europe as of July 1, 2025.[50] **The number of public chargers has increased by more than 45%, and installed power output by over 63%, each year** on average since 2020. This growth rate is above the 14% annual increase in public chargers and 13% annual increase in installed power projected to be needed until 2035 (Figure 4.1).

FIGURE 4.1

Historical and projected required public charging infrastructure deployment across the European Union in terms of absolute number of chargers (left) and installed power output (right)



Data sources: Historical data from Eco-Movement, *Public Charging Infrastructure Data;* forecast data from International Council on Clean Transportation, EV CHARGE Model Documentation.

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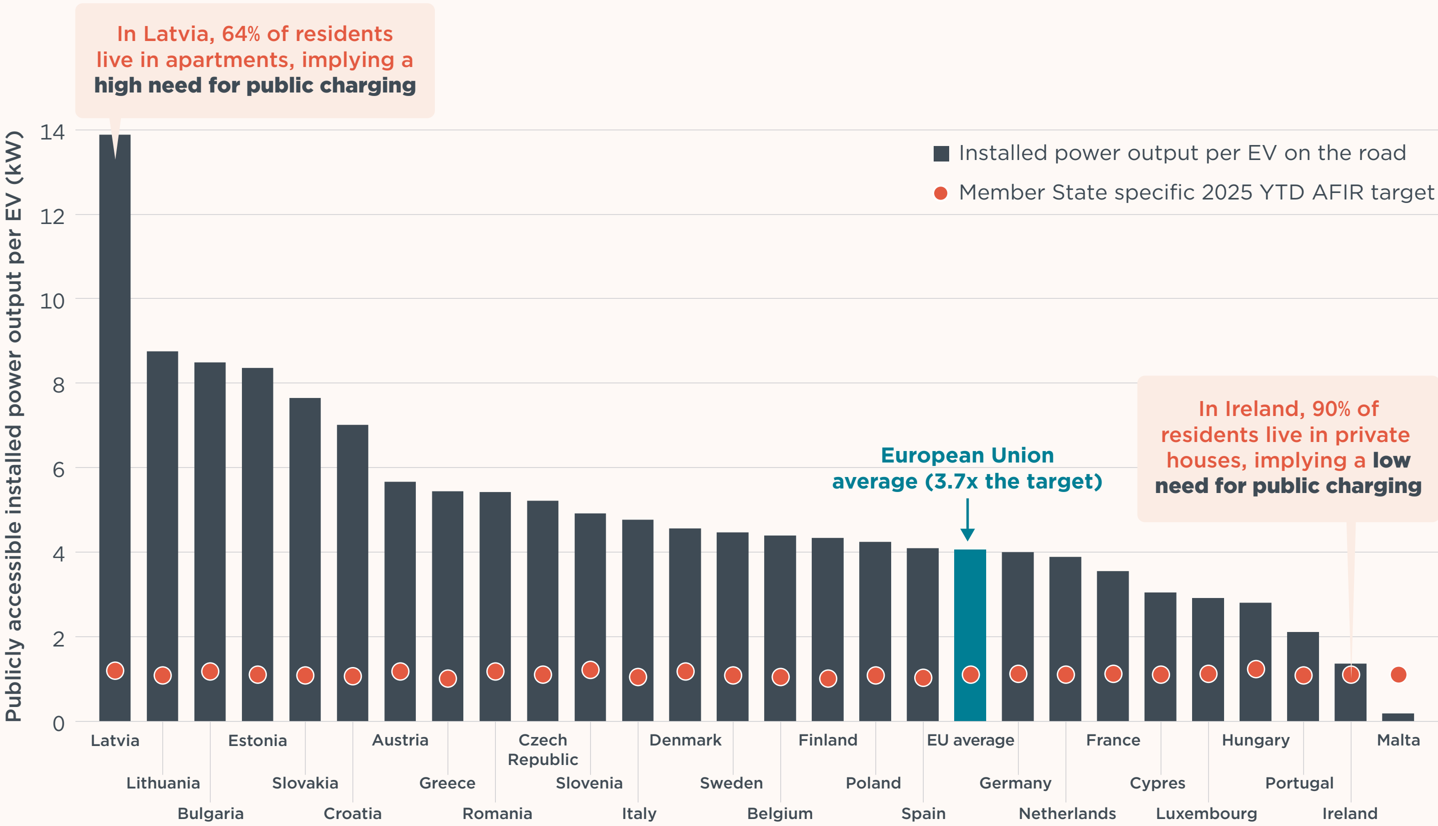
The Alternative Fuels Infrastructure Regulation (AFIR) ensures minimum installed power output, but **requirements for average power output per EV on the road differ between EU Member States.** All but one Member State, Malta, are above their current AFIR target, with Latvia and Lithuania currently leading (Figure 4.2). Differences in public charging uptake between Member States are partly connected to differences in housing stock. Generally, the more houses there are compared with apartments, the greater the number of drivers that have the possibility to use home charging, lowering the dependence on public charging infrastructure. **On average, EU Member States over-complied with their July 1, 2025 AFIR targets by a factor of 3.7**.

FIGURE 4.2

Publicly accessible installed power output per EV as of July 1, 2025, compared with AFIR Member State targets



Data sources: Charging infrastructure data from Eco-Movement, *Public Charging Infrastructure Data;* number of EVs on the road from European Alternative Fuel Observatory, Road.

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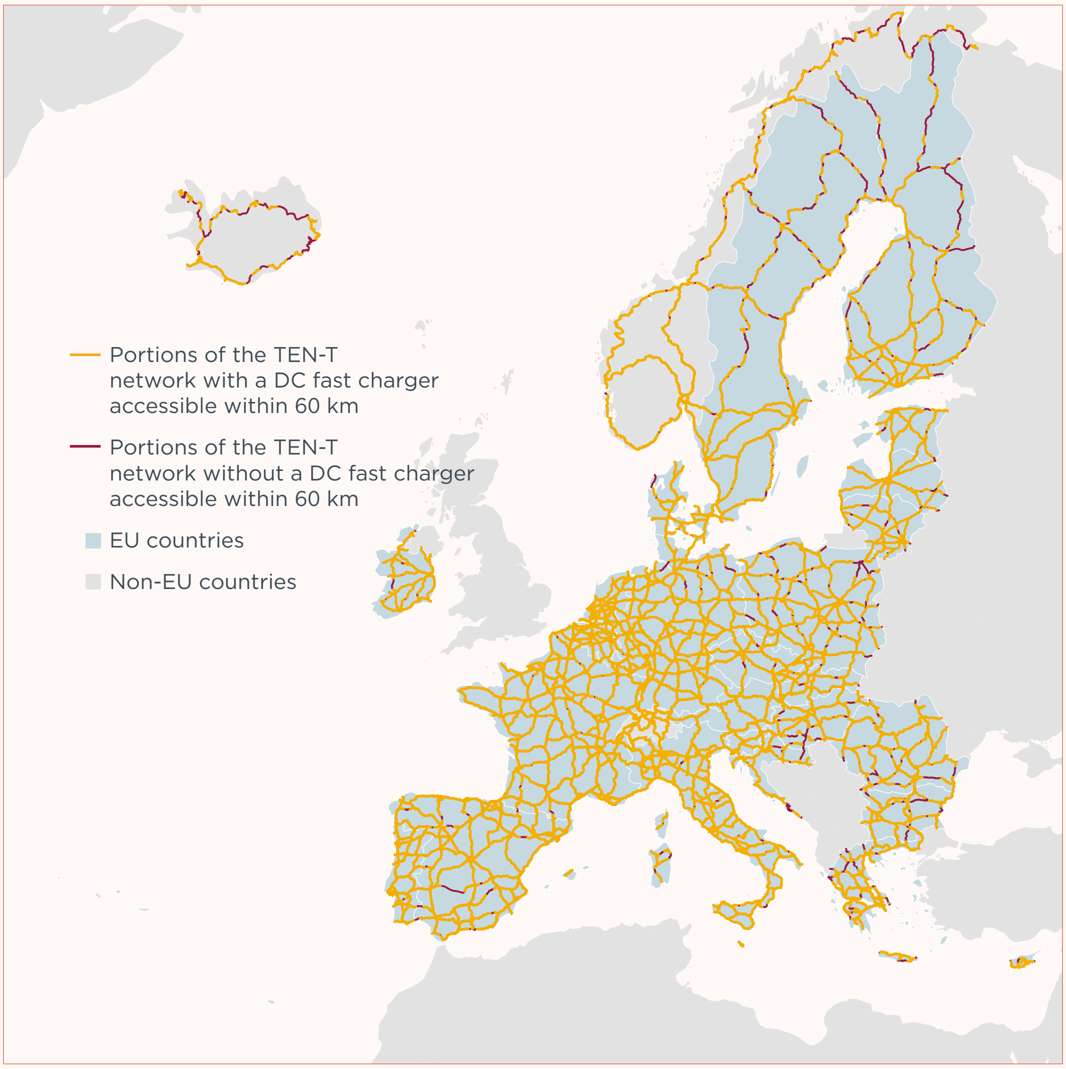
There has been progress in deploying DC fast chargers along the Trans-European Transport (TEN-T) network in Northern and Western Europe. Additional manageable work is needed in countries with lower EV adoption, especially in Southern and Eastern Europe. Figure 4.3 shows the segments of the TEN-T network that have a DC fast charger accessible (yellow) and those that do not (red) as of July 2025. A portion of the TEN-T has a DC fast charger accessible if there are DC charging stations every 60km and the DC chargers maximum 1km away from the network. Efforts to deploy chargers are supported by EU and Member State funding schemes such as the Alternative Fuel Infrastructure Facility, which awarded €422 million for charging infrastructure deployment in February 2025 and will award a total of €780 million over 2024 and 2025.[51]

FIGURE 4.3

Areas with a combined charging system DC fast charger installed every 60 km along the EU TEN-T corridors as of July 1, 2025



Data sources: Charging infrastructure information from Eco-Movement, *Public Charging Infrastructure Data;* accessible charge identification from an ICCT internal isochrone tool with the support of Mapbox, accessed August 14, 2025 https://www.mapbox.com.

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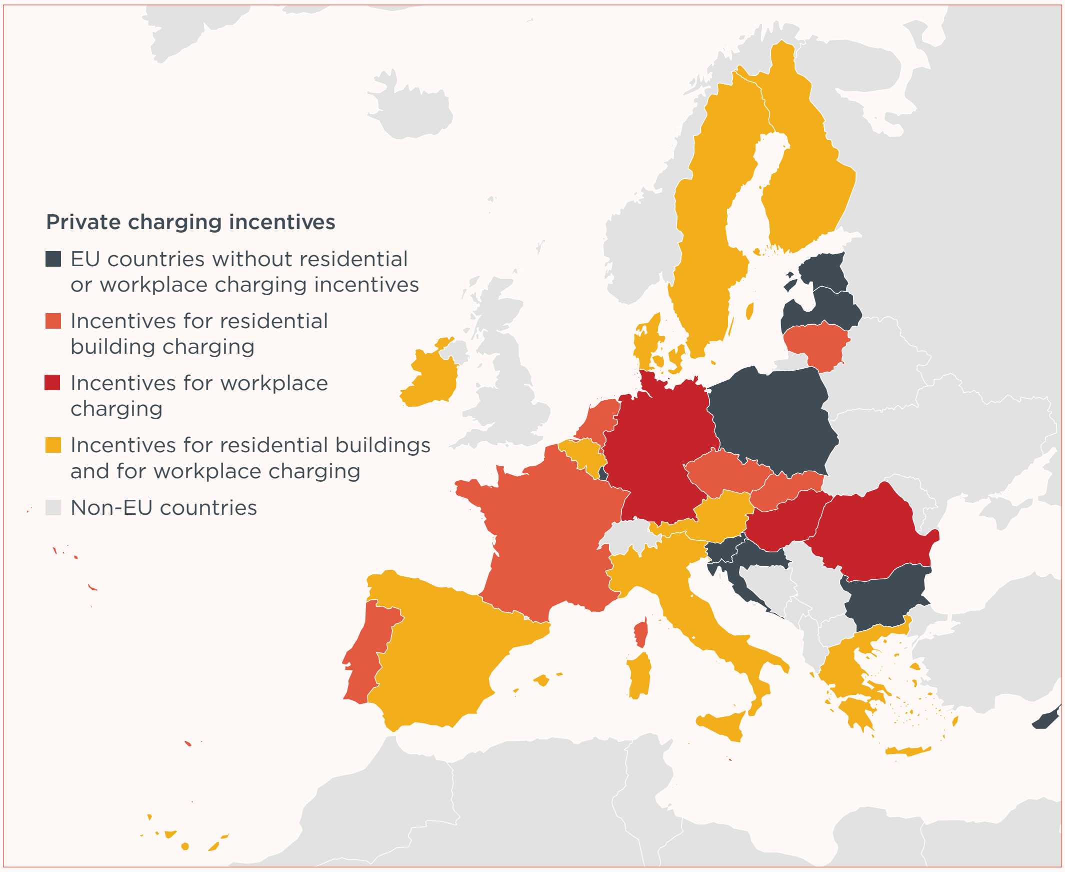
PRIVATE CHARGING IS FOSTERED BY MULTIPLE NATIONAL PROGRAMS, MORE EFFORTS WOULD HELP PROVIDE ACCESS TO PRIVATE CHARGING FOR PEOPLE LIVING IN RESIDENTIAL BUILDINGS

The EU-wide Energy Performance Building Directive (EPBD) enables basic private charging for residents of new apartment buildings, and some Member States have established additional programs.[52] In France, for example, 5.5% of all buildings and 4.0% of residential buildings had a collective charging infrastructure solution installed by the end of 2024.[53] This amounts to about 28,700 charging points already installed in residential buildings, **a 110% increase since the end of 2023**. In addition, 16% of all buildings and 13% of residential buildings had approved the deployment of a collective charging solution. This equals a total of 33,900 buildings, or 2.2 million households, equipped or soon to be equipped with charging infrastructure. This deployment occurred primarily due to two national programs: one led by France's largest electricity distribution system operator, Enedis, and the other entailing a public-private partnership with a French public financial institution.[54] These estimates do not account for chargers installed outside of these collective infrastructure programs; the total number and share of buildings is therefore higher. While EPBD enables basic private charging in new apartment buildings, additional efforts would be needed for existing residential buildings.

In addition to private residential charging, access to convenient and affordable charging at workplaces can be important for encouraging drivers without a dedicated place for charging to opt for an EV. As shown in Figure 4.4, **about half of EU Member States have programs in place to incentivize charging infrastructure deployment in apartment buildings, and a third of Member States incentivize workplace charging deployment.** Some Member States also have local and regional programs not accounted for in this figure.

FIGURE 4.4
EU Member States with private workplace and residential charging programs in place as of April 2025



Data source: "Incentives and Legislations," European Alternative Fuels Observatory, accessed May 16, 2025, https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road/austria/incentives-legislations.

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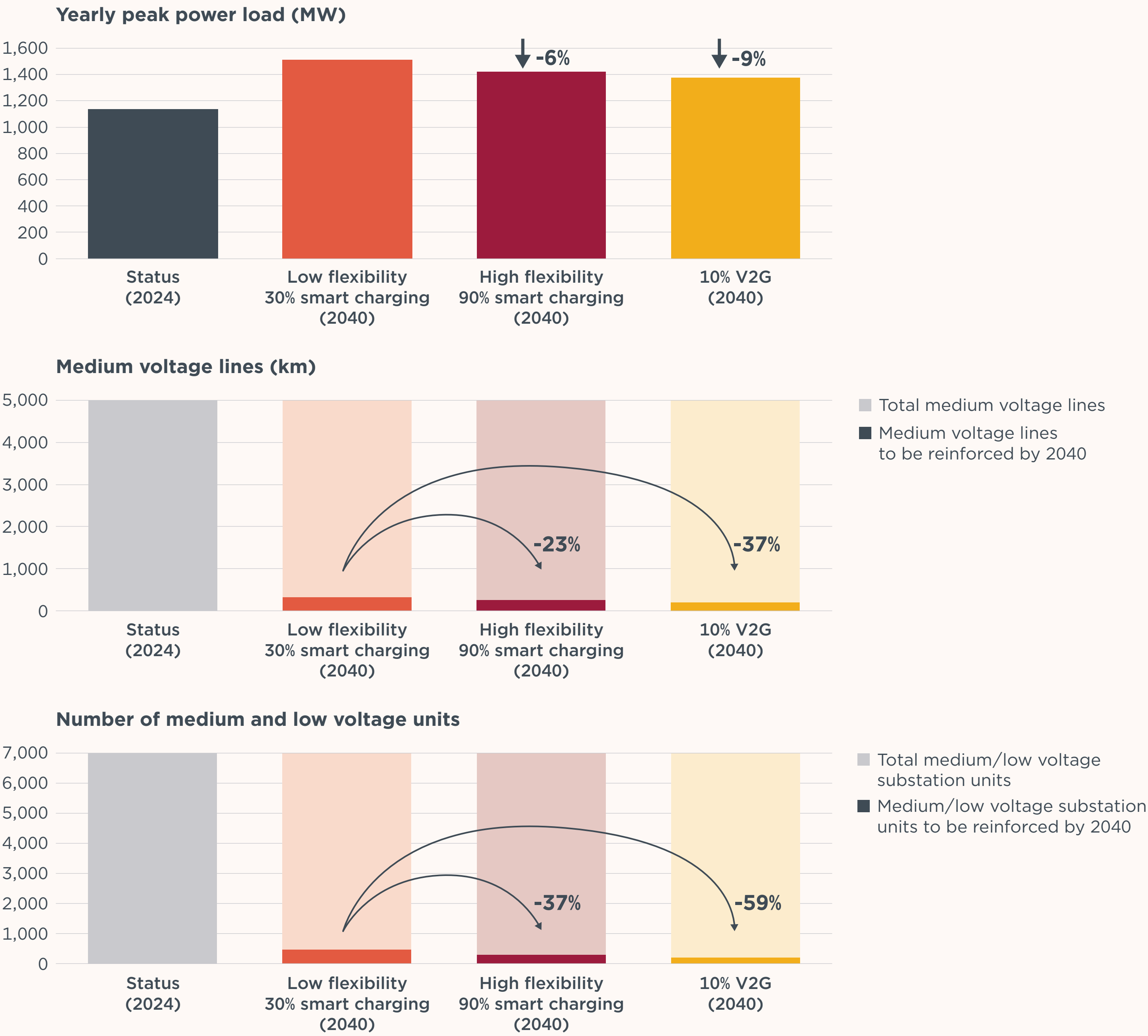
EVS CAN BE AN ASSET TO THE GRID. PLANNING FOR GRID EXPANSION AND GRID CONNECTION COULD BE UPDATED.

Electric vehicles bring a flexible load to the electricity grid that can be managed with smart charging, allowing for the integration of renewable energy that would otherwise be lost. **Peak power from charging can be shifted to time periods when sufficient renewable energy is available. In addition, with updated planning and smart charging in place, demand peaks can be minimized, reducing the need for grid reinforcement**.

For example, a 10% vehicle-to-grid managed charging scenario developed for the Essonne department in France resulted in a **9% decrease in peak power load, a 37% decrease in medium voltage line reinforcement, and a 59% decrease in medium and low voltage station unit reinforcement** compared with a low flexibility charging scenario (Figure 4.5).[55] **These benefits are likely to be even higher for other EU Member States**, given that the French electricity grid has relatively high spare capacity compared with other European grids.

FIGURE 4.5

Differences in grid reinforcement needs between low flexibility, high flexibility, and vehicle-to-grid (V2G) scenarios in Essonne, France, by 2040



Data source: Julia Hildermeier et al., *Savings from Smart Charging Electric Cars and Trucks in Europe: A Case Study for France in 2040* (Regulatory Assistance Project, 2025), https://theicct.org/publication/smart-charging-cars-trucks-europe-mar25/.

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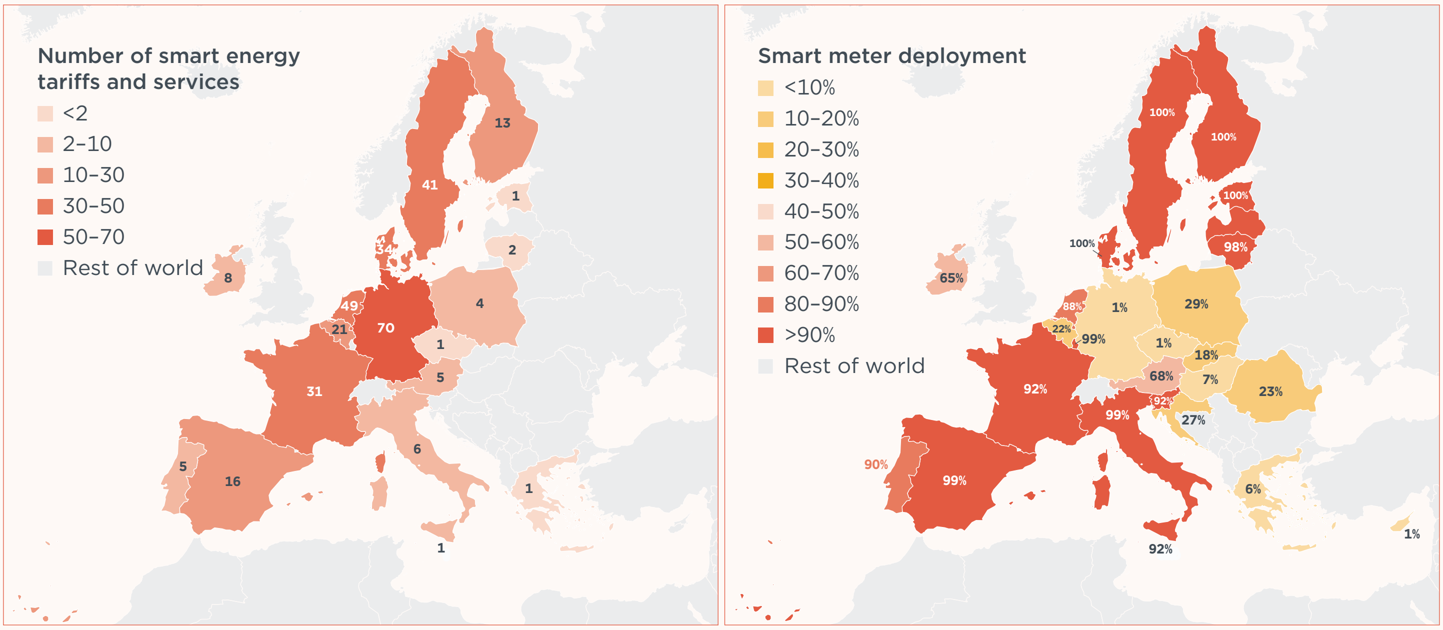
Time-varying energy and grid tariffs, which can make smart charging attractive for customers, have seen a sharp increase in past years. As of March 2025, there were 480 tariffs and services that allowed EU residents to adapt their charging based on static or dynamic time-varying energy and grid tariffs and 390 EV-related tariffs and services across the European Union, a **181% increase** from 139 in 2021 (Figure 4.6).[56]

The deployment of smart meters in the European Union reached 63% at the end of 2024.[57] Member States are at different stages of smart meter deployment, with several planning to increase smart meter distribution in the coming years. For example, while Germany currently has a very low penetration (1% in 2024) of smart meters, it is targeting full smart meter deployment by 2032 for households and companies.[58]

FIGURE 4.6

Number of time-varying energy and grid tariffs as of mid-2025 (left) and share of smart meters as of 2024 (right)



Data sources: Number of tariffs from Jaap Burger, *Imagine all the People* (Regulatory Assistance Project, 2025), https://www.raponline.org/toolkit/strong-growth-in-tariffs-and-services-for-demand-side-flexibility-in-europe/; share of smart meters from DSO Entity, *DSOs United in Diversity, Enablers of the Energy Transition* (2024), https://eudsoentity.eu/wp-content/uploads/2025/01/2024_EU-DSO-map_web.pdf.

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Lastly, **grid connection times for charging infrastructure can vary by Member State and have been cited by charge point operators as hindering charging infrastructure deployment**.[59] There are best-practice examples, such as the City of Stockholm, where it takes 1 to 3 months to install an AC charger and about 3 months to obtain approval for a DC charger.[60] The European Union is working on accelerating grid connection processes through various actions such as the EU Grid Action Plan.[61] Overall, decreasing the time needed to get a grid connection could be done through updated grid planning procedures.

TABLE 4

Charging Infrastructure and the power grid

Key performance indicator	Status	
Public charging	Overall deployed at a sufficient pace; Eastern European countries are leading in power output per EV	
Deployment	**> 1 million** Public chargers	As of July 1, 2025, there were over 1 million public chargers installed in the European Union, representing 44 GW of public power output.
Growth rate	**63%** Power output growth rate	The average annual growth rate since 2020 is 45% for the number of installed public chargers and 63% for the installed power output. In comparison, between 2025 and 2035, annual growth rates of 14% and 13%, respectively, will be needed.
AFIR targets	**3.7** Times more power output than AFIR target	As of July 1, 2025, all EU countries except for Malta had met their respective AFIR power output target, over-complying by a factor of 3.7 on average. Additional efforts will be needed to meet TEN-T network targets.
Reliability	**85.5%** Public charging reliability in France	Public charging reliability is increasing; for example, in France, 85.5% of charging sessions were successfully completed in the second half of 2023, compared with 74.7% in second half of 2020.[62] However, more efforts are needed to continue improving public chargers' reliability.
Pricing	**€0.49/kWh and €0.63/kWh** EU average AC normal and DC fast charging fee (including VAT)	AFIR is to ensure that ad hoc charging be made available everywhere, but price transparency could be improved.[63]
Investments	Dynamic market	European auto manufacturers, electric utilities, and oil and gas companies are operating, investing in, and acquiring public charging infrastructure companies.[64]
Private charging	Targets and programs in place to encourage private charging deployment, more efforts would help provide access to private charging for people living in residential buildings	
Residential	**13%** Residential buildings in France approved a common charging solution	Half of EU Member States have a program in place to foster residential charging in apartment buildings. For example, 13% of residential buildings in France covering 2.2 million households have approved a common charging solution to be installed in their building. Member States can set more stringent targets than EPBD.
Workplace	**One in three** EU Member States have a workplace charging program	One third of EU Member States have a program in place to foster workplace charging.
Grid	Smart tariffs and smart meter deployment is increasing, but more action needed to prepare the grid	
Smart charging	**AFIR and EPBD** Regulations in place to boost smart charging	Smart charging can encourage renewable energy integration and help to manage loads on the electricity grid. Legislation is in place to mandate the deployment of public and private chargers capable of smart charging.[65]
Dynamic tariffs	**390** EV-related smart tariffs and services	As of March 2025, there were 480 tariffs and services that allowed EU residents to adapt their EV recharging based on static or dynamic time-varying energy and grid tariffs, and 390 EV-related tariffs and services across the European Union, a 181% increase from 139 in 2021.
Smart meter deployment	**63%** EU smart meter deployment	EU Member States are at different stages of smart meter deployment (1%–100%), with several planning to increase smart meter rollout in the coming years.
Grid connection	**EU Grid Action Plan** Aims to modernize the EU electricity grid	Grid connection times for charging infrastructure can vary by Member States and are often cited by charge point operators as hindering charging infrastructure deployment. More cooperation between stakeholders and transparency regarding grid capacity and connection processes could assist with connection timelines.

5

SUPPLY CHAINS AND INDUSTRIAL COMPETITIVENESS

Building up battery production and supply chains in Europe requires concerted efforts by governments and industry as well as market confidence, and further delays in the EV transition risk losing battery and vehicle production market shares to global competitors.

As one of Europe's most important economic sectors, it is critical that the automotive industry remain resilient and internationally competitive. This section assesses the EV supply chain in the European Union, including global vehicle trade, access to raw materials, and battery manufacturing and recycling capacity. It also examines the workforce transition, estimates employment impacts, and takes stock of international best practices in support mechanisms for workforce retraining programs.

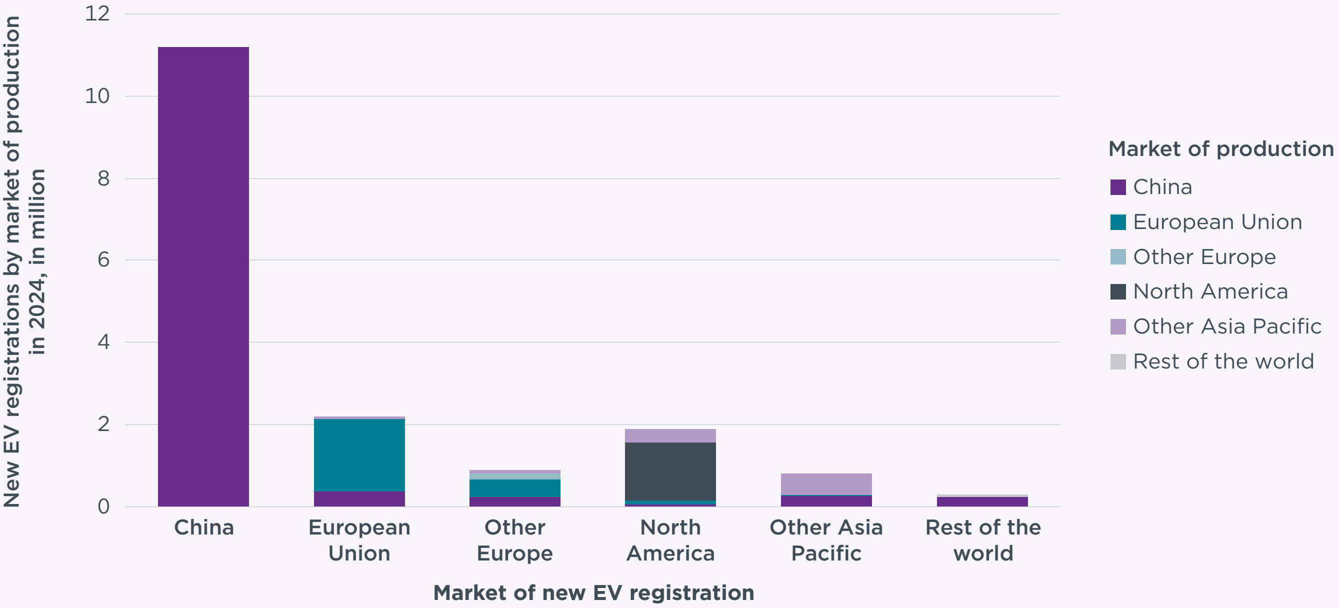
EUROPEAN AUTOMAKERS CAN CAPITALIZE ON THEIR EXPERTISE TO SECURE A STRONG POSITION IN THE EVOLVING GLOBAL EV MARKET

The top 5 European passenger car manufacturers (BMW, Mercedes, Renault, Stellantis, and Volkswagen) accumulated **€254 billion in profits globally from 2019 to 2024**; with about 140 million vehicles sold, this corresponds to an average of about €1,815 of profit per vehicle.[66]

The European Union is a net exporter of passenger cars. In 2024, the European Union sent 5.4 million cars abroad, representing about half of all passenger cars manufactured in the region. It imported 4.0 million cars (37% of vehicles sold in the region), resulting in a trade surplus of €89.3 billion.[67] Similar patterns are observed in the electric vehicle market, in which 35% of EVs produced in the European Union (830,000 units) were exported while 31% of EVs sold in the European Union (680,000 units) were imported, **making the European Union a net exporter of EVs** (Figure 5.1).[68] EV exports from the European Union mostly go to other non-EU European countries. Meanwhile, **70% of EVs sold in the European Union are produced by automaker groups with headquarters in the European Union**.[69]

FIGURE 5.1

New electric passenger car sales worldwide in 2024 by market of production



Data source: *EV Volumes*; IEA, *Global EV Outlook 2025*.

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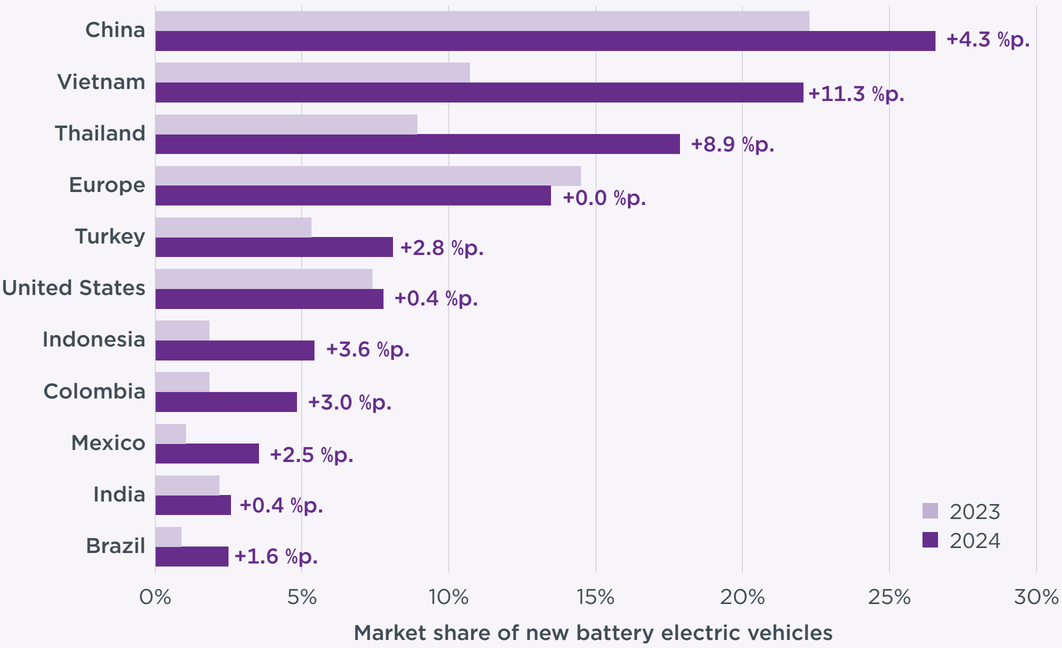
Global EV sales continue to grow, with an average growth rate of about 3% in 2024. This trend extends beyond China—the world's largest EV market, with close to a 30% BEV sales share—to smaller markets such as Vietnam (22%) and Thailand (18%; Figure 5.2). Today, nearly 14% of all EVs sold worldwide are manufactured in Europe. **In light of such rapid global EV uptake, manufacturers can take steps to secure market shares not only within their European home market but also in emerging EV markets worldwide.**

FIGURE 5.2

Market share of BEVs among new passenger car sales in 11 select markets in 2023 and 2024



Data sources: Ilma Fadhil and Chang Shen, *Global Electric Vehicle Market Monitor for Light-Duty Vehicles in Key Markets, 2024* (International Council on Clean Transportation, 2025), https://theicct.org/publication/global-ev-market-monitor-for-ldv-in-key-markets-2024-jun25/.

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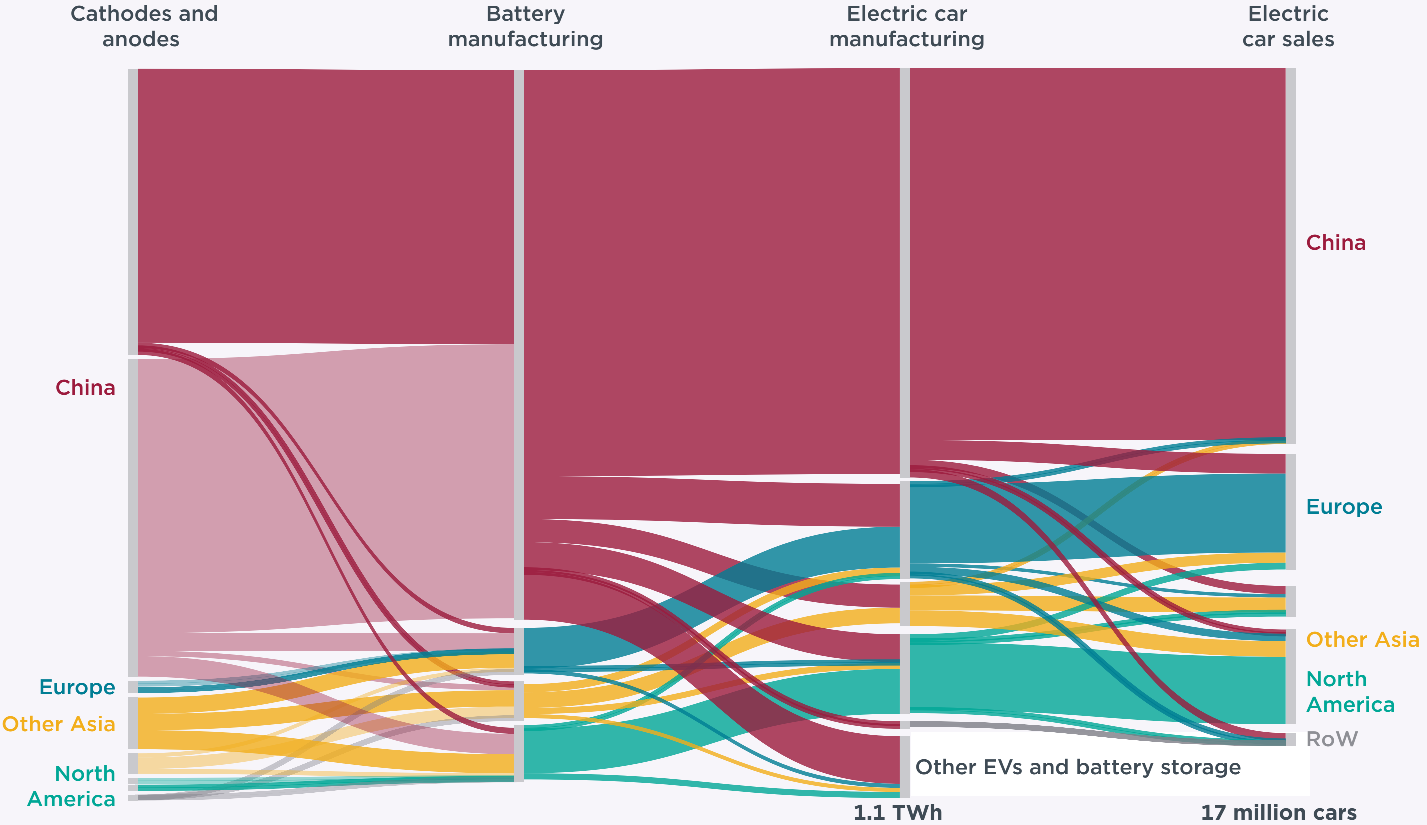
Today, the main economic value in producing vehicle components comes from core, non-powertrain related parts, such as interiors, electronics, wheels and tires, and axle systems.[70] However, with increasing EV sales shares, **the revenue pool of the non-powertrain related components market is forecast to decrease to 55% by 2030 from 69% in 2022**.[71]

Almost half of all EVs manufactured in Europe are equipped with batteries also manufactured in Europe (Figure 5.3).[72] Today, Europe accounts for about 7% of global battery production; China has a market share of about 80%. In future years, as announced production capacities in the European Union and the United States increase, the share of battery cells manufactured in China is forecast to decrease to about two thirds of total announced battery production capacity in 2030.[73] At the same time, part of the growth in announced cell production capacities in the European Union is due to Chinese and South Korean manufacturers expanding their EU-based production capacities.[74]

As battery manufacturing capacities are increasing, the European Commission is aiming to build a domestic battery production ecosystem beyond battery cell production to include **battery material mining and processing capacities, the production of cell components such as cathodes, anodes, and electrolytes, and battery recycling.** This is reflected in particular in the Critical Raw Materials Act's domestic capacity targets for strategic raw materials mining, processing, and recycling in 2030.[75]

FIGURE 5.3
Shares of cathodes (darker shade), anodes (lighter shade), and battery cells by producing country and EV manufacturing and sales by market as of 2024



Data source: IEA, Global EV Outlook 2025

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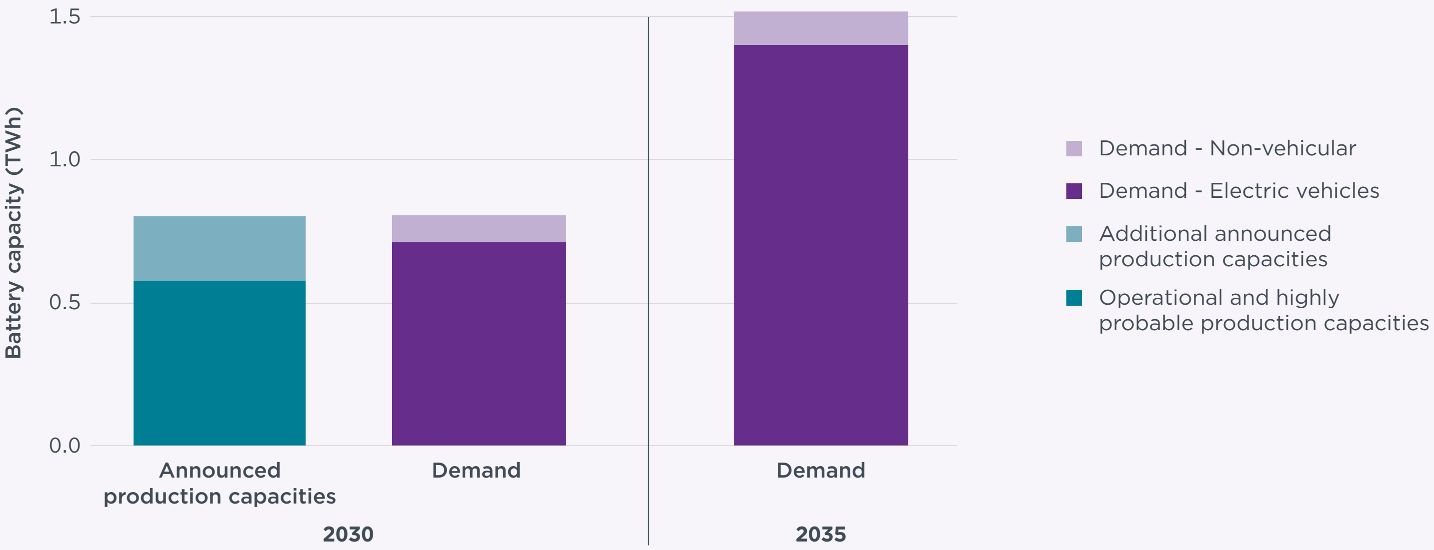
BUILDING UP BATTERY PRODUCTION AND SUPPLY CHAINS IN EUROPE REQUIRES CONCERTED EFFORTS AS WELL AS MARKET CERTAINTY

Announced battery production capacities in the European Union could meet projected domestic demand if a large share of announced projects can be realized. The ICCT's recent global and regional battery material outlook found that on a global level, total announced cell production capacity is nearly double the estimated 2030 demand, and the proportion of this capacity that is considered highly probable also exceeds projected demand.[76] In the European Union, total announced battery cell production capacities would be sufficient to cover up to 99% of road transport as well as non-vehicular battery capacity demand by 2030, if all announced projects are realized. The proportion of these facilities that are already operational or considered highly probable to reach planned output covers 72% of projected demand in 2030 (Figure 5.4). **Ensuring that a large share of this announced capacity will be realized on schedule and is cost competitive to support a high utilization rate will be critical.** Indeed, while the announced battery production capacities in the European Union would have been sufficient to meet most of the region's battery demand in 2024,[77] only about 30% of the batteries used in EVs sold in Europe were produced domestically.[78]

FIGURE 5.4
Projected battery demand in the European Union in 2030 and 2035 compared with announced cell production capacity for 2030



Notes: Battery manufacturing trade percentage is calculated in terms of GWh of battery capacity. Demand projection excludes lead-acid batteries; no supply assessed beyond 2030.
Data source: Li et al., *Electrifying Road Transport*.

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Maintaining the timeline and stringency of light-duty and heavy-duty CO_2 standards can send a clear signal to the private sector to invest in and build up battery production and mineral supply chains in the European Union. Beyond that, the European Union could prioritize domestic battery production and supply chain capacities by expanding public funding. The Commission has announced a €3 billion Battery Booster, including €1 billion made available in 2024, an additional €200 million through the InvestEU Programme, and €1.8 billion from the Innovation Fund.[79] In addition, accelerated permitting processes for projects selected under the Critical Raw Materials Act could help these projects catch up with production capacities in other markets.

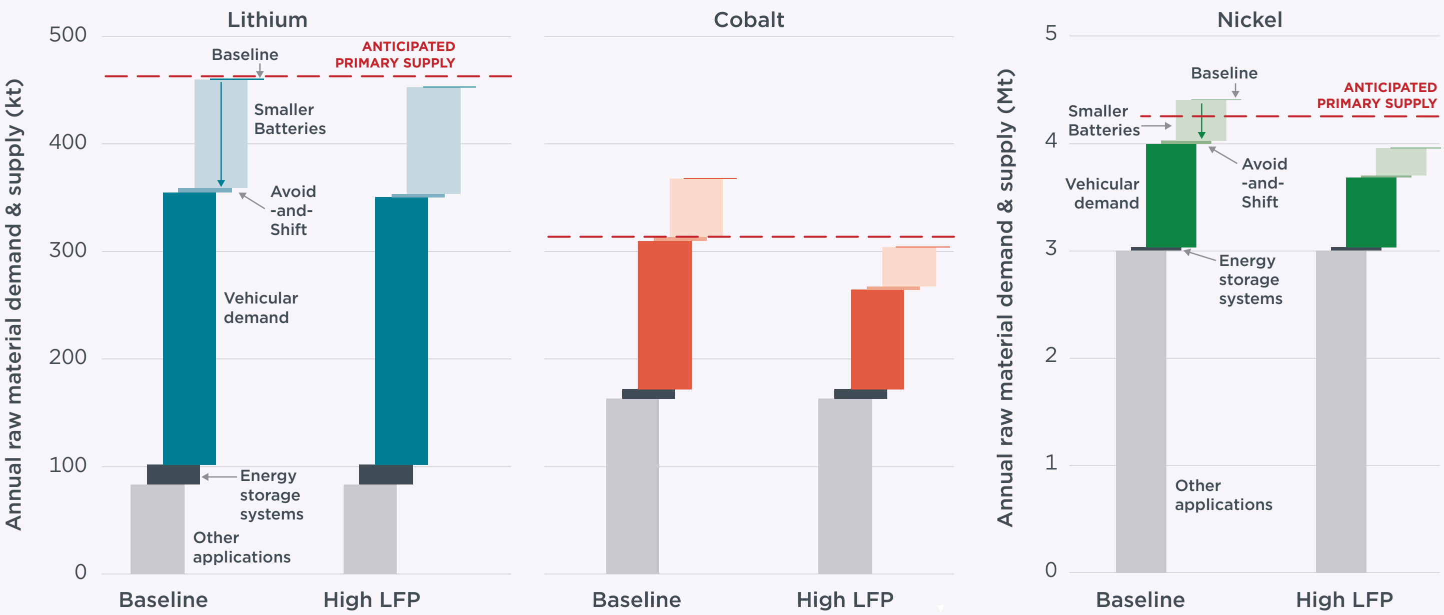
Depending on the outcome of the revision of the Clean Industrial Deal State Aid Framework, more Member States could be mobilized to support the European battery industry. **As observed in the case of the Inflation Reduction Act in the United States, production-linked incentives could be effective in bringing more investments to the European Union.**

Battery production emissions intensity and due diligence requirements in the EU Battery Regulation can also help to support the environmental and social standards of European producers. Building on these standards, environmental criteria for public procurement as foreseen in the Industrial Decarbonization Accelerator Act, as well as targeted EV purchase incentives on a national level such as in the French *bonus écologique*, can indirectly support European production. [80] More direct support could be achieved through domestic content requirements.

In parallel with the global scaling up of cell production capacities, **mineral supply is projected to keep pace with growing demand**.[81] The ICCT global and regional battery material outlook found that mining capacities anticipated for 2030 would meet 101% of the annual global demand for lithium, 97% of the demand for nickel, and 85% of the demand for cobalt, including the projected demand for these minerals in non-vehicle applications (Figure 5.5). When considering a scenario with higher market shares of lithium iron phosphate (LFP) batteries, the capacities would meet a slightly higher 102% of lithium demand, along with 108% of nickel demand and 103% of cobalt demand.[82] These scenarios highlight that the market can continue to react to high prices of individual materials by optimizing market shares of battery technologies. In addition, reversing the trend of increasing battery sizes for light-duty BEVs can significantly reduce battery and related raw mineral demand in the near term, as displayed in the figure. An efficient battery collection and recycling ecosystem, alongside reduced vehicle sales as a result of less vehicle-dependent transportation systems due to avoid-and-shift policies, can further reduce raw material demand in the longer term.

FIGURE 5.5

Annual global raw material demand for lithium, cobalt, and nickel in 2030 by battery demand reduction scenario



Data source: Li et al., *Electrifying Road Transport.*

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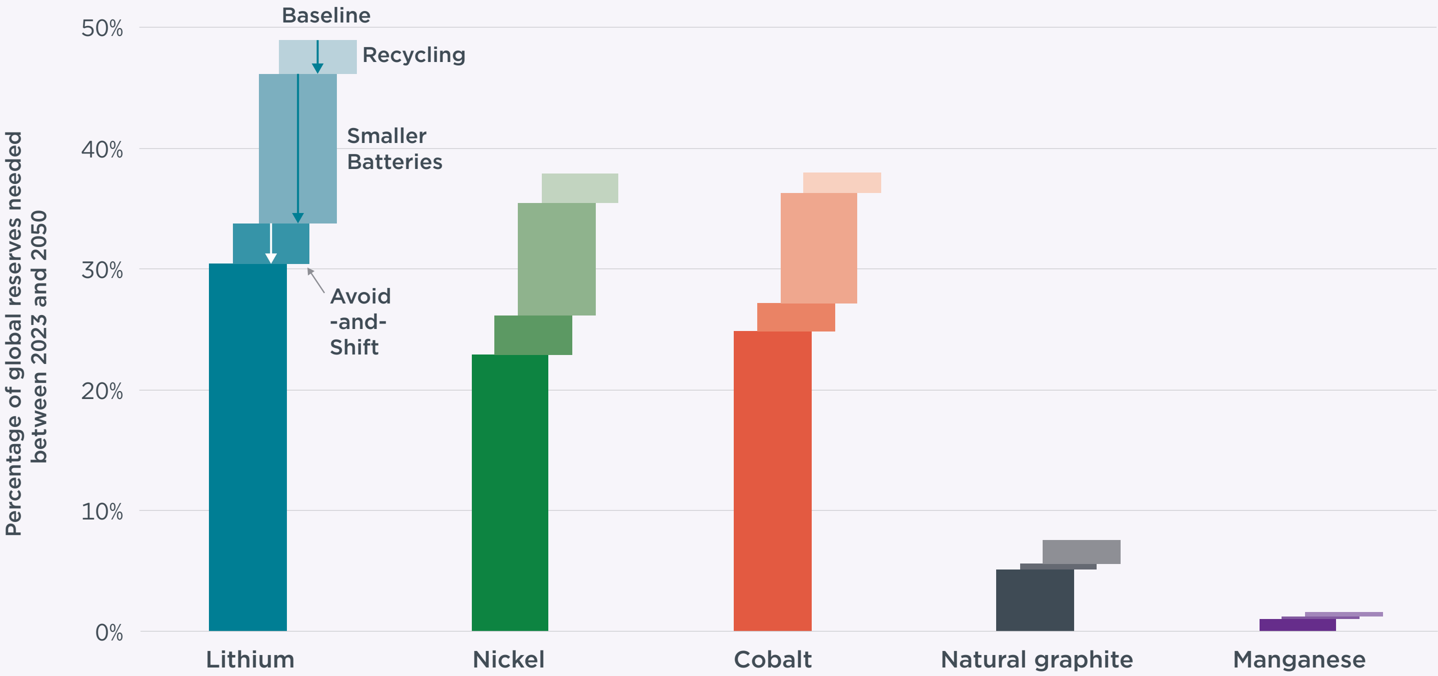
Analyses indicate that global mineral reserves are sufficient to meet future battery demand. Even in a baseline scenario in which battery demand through 2050 would be met solely by relying on lithium-ion battery technologies already commercialized in 2024—that is, without assuming any technology progress—cumulative material demand would correspond to less than half of global land-based lithium, cobalt, and nickel reserves (Figure 5.6). These projections are likely to be overestimates, for two reasons. First, given rapid improvements in battery technology in recent years, including in technologies with different mineral compositions such as sodium-ion batteries, it is likely that new battery technologies will be commercialized in the future that will reduce aggregate demand for these three minerals. Second, given advances in mineral exploration and mining technology, deposits classified as reserves keep increasing, exemplified by a doubling of lithium reserves in the past five years alone, and it is likely that they will continue to increase in the future.[83]

FIGURE 5.6

Cumulative global raw material demand between 2023 and 2050 as a share of global reserves identified as of 2024



Data source: Li et al., *Electrifying Road Transport.*

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Domestic reserves within the European Union can partially meet raw material demand for certain minerals. There are considerable nickel reserves in the French overseas territory of New Caledonia; Portugal has the largest lithium reserves of Europe, and there are significant additional lithium resources in Germany, Czech Republic, Spain, Finland, and Austria.[84] Outside the European Union, Norway has natural graphite reserves and Serbia has lithium resources.

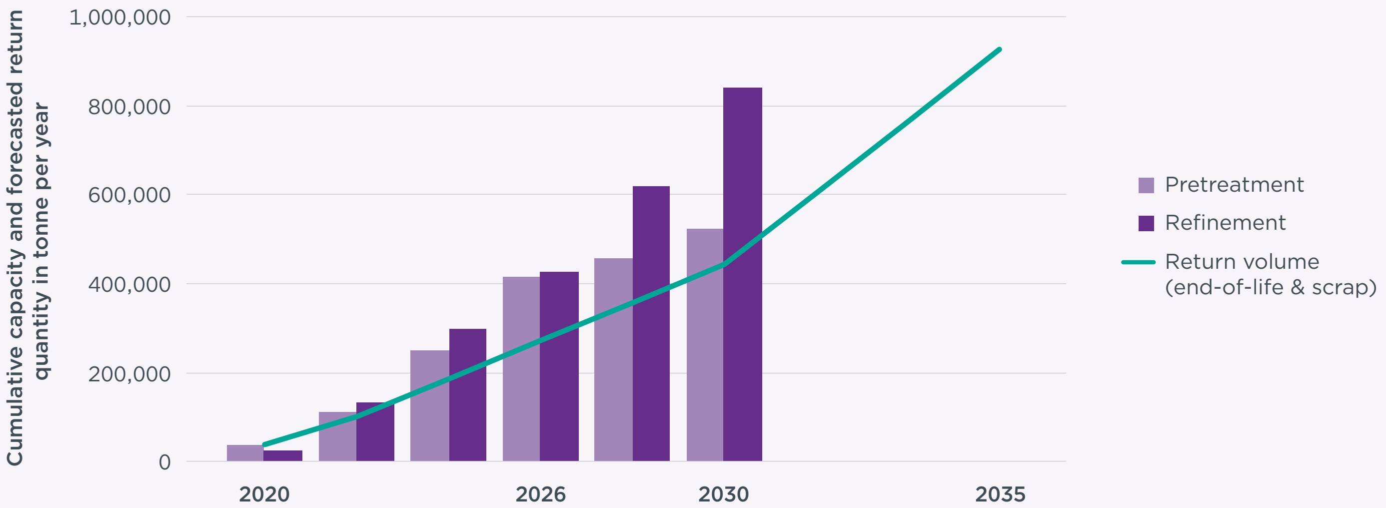
In addition to the measures to support domestic battery production and supply chain projects described above, **the European Union has secured trade partnerships with many large resource-rich countries to secure raw mineral supply** for demand not covered by domestic reserves. The European Union has free trade agreements that include raw materials with seven countries, including Australia, Chile, and India, and has signed strategic partnerships on raw materials with 13 countries, including Canada, Serbia, and Norway.

The collection and recycling of EV batteries at their end of life can help to reduce annual raw material demand in the European Union by about 1% in 2035 and up to

20%–30% in 2050.[85] This reflects the expectation that larger numbers of EVs will reach their end of life only in the late 2030s. Until then, recycling has a limited impact on raw material demand and most of the recycling of batteries is from production scrap. A comparison of planned recycling capacities, including pre-treatment and refinement, with the forecasted return volumes of end-of-life batteries and production scrap indicates that the **cumulative planned capacities for recycling are sufficient and even exceed recycling demand in the coming years** (Figure 5.7).

FIGURE 5.7

Recycling demand and announced capacities (dark and light purple) for lithium-ion battery recycling in Europe as of May 2025



Data source: Maximilian Stephan, "Recycling Capacities for Lithium-ion Batteries will Exceed Demand in Europe for the Time Being," *Fraunhofer ISI*, July 24, 2025, https://www.isi.fraunhofer.de/en/blog/themen/batterie-update/batterie-recycling_europa_kapazitaeten_bedarf_update_2025.html.

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In addition to the raw materials needed to produce EVs, electricity is required to power them. In contrast to fossil fuels, which are mostly imported, the electricity used by EVs is mostly produced in the European Union. In 2023, the most recent year for which official data are available, the **European Union was a net exporter of electricity and a net importer of fossil fuel,** with 98% of petroleum being imported.[86] Transitioning to an all-EV fleet would not only reduce energy dependency but also provide economic benefits; in 2024, the Euro area spent €291 billion on net energy imports.[87]

THE TRANSITION TO EVS CAN CREATE NEW JOBS THAT WILL REQUIRE WORKFORCE MANAGEMENT AND RE-SKILLING

Due to overlapping effects, forecasting the impact of the transition to EVs on employment is challenging. **Between 2020 and 2024, about 19,000 new automotive supplier jobs created in Europe were directly linked to EV technologies**, while 2,070 new jobs were related to ICEV technology.[88] Meanwhile, **the majority of job losses (57%, 48,500) that occurred over the same time period were not tied to powertrain technologies,** but rather to a decline in demand, higher production costs, automation in production processes, and other influencing factors. According to the European Association of Automotive Suppliers, about 26% of jobs lost in this period can be directly attributed to a decline in ICEV technologies.[89]

One growth area is battery production. A study by New Automotive estimated that **62,274 people are currently employed in the European battery supply chain**.[90] Looking forward, **between 202,800 and 312,000 jobs could be created in the battery supply chain by 2030**. EV charging is another sector that could see significant growth in jobs over the next few years.

In this context, studies estimate that by 2035, about 2.4 million workers will have to be re-trained in the European Union.[91] **The European Union has a range of workforce retraining programs in place that can equip workers with the skills needed for the shift to electromobility**. A notable example is the European Battery Academy, launched in 2022, which has upskilled over 100,000 workers throughout the European Union and aims to train 800,000 workers by 2030.[92] Another initiative is the Automotive Skills Alliance, with more than 180 training opportunities and 55 online courses.[93]

At the national level, a €1.5 billion federal aid program in Germany that ran from 2020 to 2024 assisted manufacturers and suppliers in the transition to e-mobility, with a portion of the funding dedicated to workforce retraining programs.[94] An example of a retraining program at the local level is France's Battery Training Center, created through a public-private partnership between the Hauts-de-France regional government, Stellantis, and the Union of Metal Industries and Trades association.[95] The program reskills workers previously involved in combustion engine production for roles in the EV sector and is expected to generate 15,000 to 20,000 jobs in the region over the next decade. [96]

TABLE 5

Supply chain and industrial competitiveness

Key performance indicator	Status	
Vehicle production and trade	European automakers can capitalize on their expertise to secure a strong position in the global electric vehicle market	
Exports of EVs	**35%** Export of EVs in the European Union **14%** EVs manufactured in Europe that are sold worldwide	As of 2024, the European Union is a net exporter of EVs (exports 35% of production). Most EV exports are to non-EU European countries, while ICEV exports (47% net export) are more diversified.
Battery cell	**~ 50%** EVs produced in Europe have a battery also produced in Europe	Europe produces almost half of the batteries needed for domestic EV production. Vehicle battery cells made in Europe accounted for about 7% of the global market share in 2024.
Energy trade	**€291 billion** Net EU energy imports	Transitioning to EVs can boost energy independence and benefit the European Union economically. In 2023, the European Union was a net exporter of electricity and a net importer of fossil fuel, with 98% of its petroleum being imported. In 2024, the Euro area spent €291 billion on net energy imports.
Battery production and raw material access	Building up production capacities for batteries and raw material access within Europe requires concerted efforts as well as market confidence	
Battery production capacities	**99%** Battery demand covered by EU battery cell production capacity, if all announced projects are realized	If total announced battery cell production capacities in the European Union are met, they would cover up to 99% of road transport and non-vehicular battery capacity demand by 2030. Market confidence and additional policy support could ensure that a large share of this capacity is realized on schedule and is cost competitive to support a high utilization rate.
Raw material availability and global mining capacities	**2 times more** Reserves for battery raw materials available worldwide than needed until 2050	Even when assuming no technological progress and no further exploration of deposits, cumulative battery material demand through 2050 would correspond to less than half of global land-based lithium, cobalt, and nickel reserves. Domestic reserves can partially meet EU raw material demand for certain minerals. With a continuation of the increase in the market share of LFP-based batteries, lithium, nickel, and cobalt mining capacities anticipated in 2030 would meet all annual global demand from vehicle batteries and other applications.
Battery recycling capacities	**20%–30%** Reduction in raw material due to recycling in 2050	Battery recycling can help to reduce annual raw material demand in the long term, with a projected reduction of 1% in 2035 and up to 20%–30% in 2050. Cumulative planned capacities for recycling will exceed the supply of scrap in the coming years.
Workforce	The transition to EVs will result in new jobs created, but will also require workforce management and re-skilling	
Job creation and losses	**19,000** New supplier jobs created due to electrification	Between 2020 and 2024, about 19,000 newly created automotive supplier jobs in Europe can be directly related to the transition to EVs.
Programs for re-skilling the workforce	**2.4 million** Workers to be retrained in the European Union by 2035	Targeted national programs and EU-wide initiatives can help to build the skilled workforce needed for the transition to EVs.

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