



Economic Commission for Europe**Inland Transport Committee****Working Party on Transport Trends and Economics****Thirty-sixth session**

Geneva, 4–6 September 2023

Item 8 (a) of the provisional agenda

Review and monitoring of emerging**issues and sustainable development goals:****Transport Trends and Challenges in the road, rail, and inland waterways sectors****General trends and developments surrounding electric vehicles and their charging infrastructure – setting the scene****Note by the secretariat****I. Introduction**

1. Further to the request of the Working Party on Transport Trends and Economics (WP.5) at its previous session to designate its Transport Trends and Economics 2022–2023 publication on general trends and developments surrounding electric vehicles and their charging infrastructure, a draft publication as contained in ECE/TRANS/2023/4; ECE/TRANS/2023/5; ECE/TRANS/WP.5/2023/6; ECE/TRANS/WP.5/2023/7; and ECE/TRANS/WP.5/2023/8 has been elaborated by the secretariat and an external consultant and will be presented for feedback.
2. The present document describes the role electric mobility can play in reshaping the transport sector and explains how the large scale roll out of electric vehicles can contribute to achieving the 2030 Sustainable Development Agenda.
3. WP.5 delegates are invited to provide feedback and suggestions for improvement of the text and to deliver presentations on national case studies and best practice examples for inclusion in the final version of the publication.

II. Reshaping transportation through electric mobility

4. The transport sector is a significant contributor to global emissions. In 2019, direct greenhouse gas (GHG) emissions from the transport sector accounted for 23 per cent of global energy-related CO₂ emissions (Jaramillo et al. 2022). Most of these emissions come from road transport. The third part of the Sixth Assessment Report of IPCC titled “Climate Change 2022: Mitigation of Climate Change” released in April 2022 suggested that without intervention, CO₂ emissions from transport could grow between 16 per cent and 50 per cent by 2050.



5. To meet the Paris Agreement's objective of limiting global warming to below 2°C compared to pre-industrial levels, it is necessary to achieve rapid decarbonization in all sectors, including transportation. However, the transport sector is currently experiencing a rise in energy demand and GHG emissions, outpacing all other sectors except for industry, and is heavily reliant on fossil fuels. Transitioning to an electric vehicle (EV)-based transport system is an approach that can achieve GHG emissions reductions at the scale necessary to decarbonize transport. This shift would also significantly reduce vehicle pollutant emissions and dependence on fossil fuel imports for transport.

A. Record-breaking electric car sales transforming the automotive industry

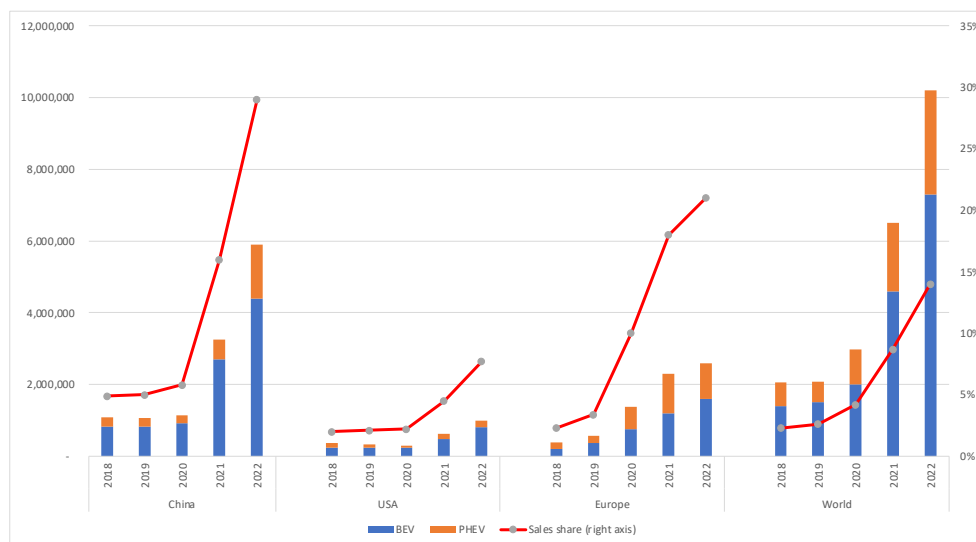
6. According to the International Energy Agency (IEA, 2023), global sales of electric cars are expected to reach record levels in 2023. IEA data reveals that the number of electric cars sold worldwide in 2022 exceeded 10 million, and this figure is projected to rise by an additional 35 per cent in 2023, reaching 14 million units. The substantial growth in electric car sales has significantly impacted their market share within the overall automotive industry. It rose from approximately 4 per cent of total car sales in 2020 to 14 per cent in 2022. The IEA further predicts that by the end of 2023, the market share of electric cars will continue to expand, reaching an estimated 18 per cent for the entire calendar year.

7. This significant market share demonstrates that EVs have established a strong presence in the automotive industry and are set to continue their growth trajectory. In terms of regional markets, Europe currently stands as the world's second-largest market for electric cars, after China. The IEA's report states that Europe represents 25 per cent of all electric car sales globally and accounts for 30 per cent of the global electric car stock (Figure I

Electric car sales, 2018–2022

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Figure I
Electric car sales, 2018–2022

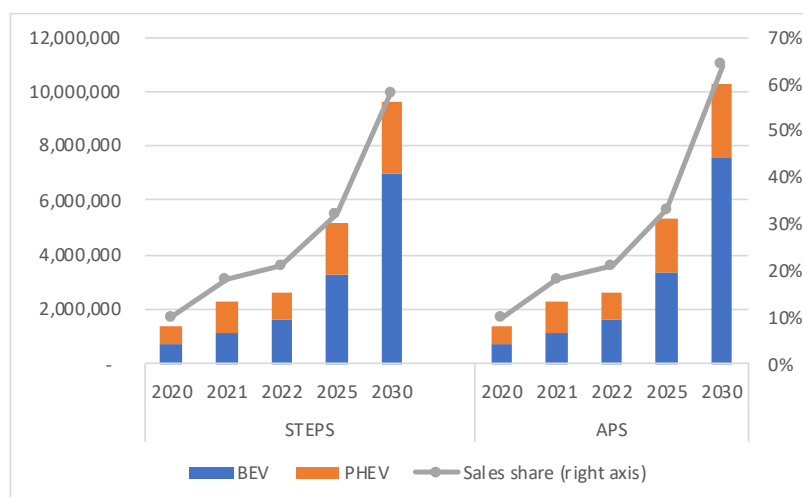


Source: IEA Global EV Data Explorer. Available at www.iea.org/data-and-statistics/data-tools/global-ev-data-explorer. Accessed on 3 May 2023.

8. Zooming in on Europe, based on the estimates of the IEA as depicted in **Error! Reference source not found.II**, there will be a projected 7 million Battery Electric Vehicles (BEVs) and 2.6 million plug-in hybrid electric vehicles (PHEVs) in the region. These EVs are expected to witness a substantial growth in sales share, from 10 per cent in 2020 to a

remarkable 58 per cent in 2030, according to the STEPS¹ scenario. Furthermore, the Announced Pledges Scenario (APS) presents a similar growth pattern, with even higher figures for 2030, projecting an impressive sales share of 64 per cent for EVs. These scenarios clearly highlight the expected rise in popularity and sales of EVs in Europe, indicating a significant shift in market preferences towards sustainable and energy-efficient transportation.

Figure II
Projected electric car sales in Europe



Source: IEA Global EV Data Explorer. Available at www.iea.org/data-and-statistics/data-tools/global-ev-data-explorer. Accessed on 30 May 2023.

B. Economic Commission for Europe efforts and roles

9. At its eighty-fifth session held on 21–24 February 2023, the ECE Inland Transport Committee (ITC) organized a roundtable on EV charging infrastructure to explore the policy tools available for countries to overcome barriers to fast electrification, such as the need for harmonized connector design and communication protocols globally to ensure seamless and flawless EV recharge, and harmonized regulation to achieve safe and fast charging, enable grid balancing and appropriate grid and recharging capacity, as well as minimize the carbon footprint of EV recharge. To address these barriers, ITC agreed on dedicated actions to promote the wider adoption of EVs by working towards policy harmonization, improving data collection, and fostering global exchanges among experts in the public and private sector.

10. ECE and its subsidiary bodies fully embrace the electrification of transport through their respective roles. ITC provides a forum for member countries to share experiences and best practices in the adoption and deployment of EVs. It facilitates discussions on policies and regulations to support the growth of EVs and the development of charging infrastructure.

11. WP.5 is mandated by ITC to designate its Transport Trends and Economics 2022–2023 publication on general trends and advancements in EVs and charging infrastructure. The report will explore various aspects, such as accessibility, affordability, and the integration of public EV charging equipment with the electricity grid,² regularly assess the latest developments in this domain, as well as in passenger road transport more broadly, on a biennial basis. Furthermore, WP.5 will prioritize key areas such as harmonizing payment

¹ The Stated Policies Scenario (STEPS) reflects existing policies and measures, as well as firm policy ambitions and objectives that have been legislated by governments around the world. While the Announced Pledges Scenario (APS) assumes that all announced ambitions and targets made by governments around the world are met in full and on time. (IEA, 2023)

² Source: <https://unece.org/transport/inland-transport-committee/85th-itc-side-event-roundtable-electric-vehicle-charging>

systems for public charging and addressing the security concerns related to cyber security and physical security (ECE, 2022).

12. The Working Party on Transport Statistics (WP.6) is actively engaged in assessing data availability and exploring definitions related to EV infrastructure, specifically focusing on EV charging infrastructure. During its seventy-fourth session (15–17 May 2023), WP.6 deemed suitable additional indicators for monitoring transport-related Sustainable Development Goals, including the percentage of new passenger cars that are zero emission. Moreover, an emphasis was placed on the need for more comprehensive data on EV charging infrastructure. As a result, the Working Party agreed to distribute a pilot questionnaire focusing on public charging stations and points. The categories within this questionnaire will align with those defined by the European Alternative Fuels Observatory. The collected data is expected to provide deeper insights into the EV charging landscape, aiding policy-making and sustainable development efforts.³

13. During its sixty-fifth session, the Working Party on Intermodal Transport and Logistics (WP.24) decided to expand its work scope to encompass the advancements in commercial EV fleets, including electric light duty vehicles (LDVs) and heavy-duty vehicles (HDVs), as well as their associated charging infrastructure within the domain of intermodal transport. As part of this effort, WP.24 acknowledged the potential role that intermodal terminals can play in providing charging infrastructure for eLDVs utilized in last-mile deliveries, specifically from the intermodal terminal to the end customer (ECE, 2022). Another potential involvement of this WP is through initiatives like regulations to promote the concept of the physical internet.

14. Among all the subsidiary bodies of ECE, the World Forum for Harmonization of Vehicle Regulations (WP.29) has been at the forefront of EV development for the longest period. WP.29 has been instrumental in creating harmonized regulations for EVs, focusing on safety and environmental regulations, and associated technical requirements. A recent task force on vehicular communication is also investigating the possibility to look at the harmonization of communication protocols between EVs and its recharging infrastructure.

15. The Working Party on Pollution and Energy (WP.29/GRPE) has dedicated activities on EV and the environment. GRPE has recently delivered on minimum in-vehicle battery durability requirements for light duty vehicles as described in United Nations Global Technical Regulation (GTR) No. 22.⁴ United Nations GTR No. 22 has been included in the Euro 7 proposal in the European Union and in the United States of America Environmental Protection Agency (EPA) 2027 GHG proposal. GRPE is now working on similar provision for heavy duty vehicles to ensure long lasting batteries for heavy vehicles, such as buses, coaches and trucks.

16. The Working Party on Road Transport (SC.1) plays a pivotal role in promoting and facilitating international road transport of goods and passengers. Its primary objective is to harmonize and simplify the rules and requirements governing road transportation. SC.1's involvement in EV development includes potential collaboration with WP.5 in addressing the security aspects of charging stations and proposing initiatives to support road transport advancements considering the electrification of both LDVs and HDVs. Furthermore, SC.1 can closely collaborate with WP.24 to explore solutions for efficient charging infrastructure and optimized transport logistics. (ECE, 2022)

17. The Working Party on Inland Water Transport (SC.3) exchanges best practices and supports programmes, pilot projects and measures aimed at modernization and greening of the inland fleet and inland waterway infrastructure, new and enhanced vessel types, low and zero emission propulsion systems including electric propulsion and use of onshore power systems and monitors their implementation.

³ Source: <https://unece.org/sites/default/files/2023-05/ECE-TRANS-WP6-2023-Inf-2%20%28main%20decisions%29.pdf>

⁴ Source: <https://unece.org/circular-economy/press/major-auto-markets-join-forces-draft-un-legislation-electric-vehicle-battery>

C. Economic Commission for Europe study on electric vehicle trends and developments

18. The study will serve as a valuable input to the ongoing efforts of ECE in EV development. Its purpose is to offer recommendations that will help member States overcome barriers and facilitate policymaking to promote the widespread adoption of electric mobility in the ECE region. The focus of the study will be on inland transport modes, including road, rail, and inland water transport.

19. By examining good practices across various important topics within the region and globally, the study aims to enhance the EV expertise of policymakers in ECE member States and beyond. This includes Ministries of Transport, Telecommunications, Environment, Energy, as well as policymakers responsible for mobility, transport infrastructure, and spatial planning development at the local level.

20. Another aim of this study is to actively support the harmonization of policy- and regulatory frameworks. Not only by introducing good practices, but also by acknowledging that the objectives towards zero-emission transport greatly benefit from cross-border harmonization. Aspects such as interoperability and a market driven by open standards are strong facilitators of economic development and for a cost-efficient roadmap towards zero-emission transport.





21. The study will cover a wide range of topics related to EV development, including development agendas mandating EV adoption, issues surrounding the electrification of various transportation modes (public, private, and commercial vehicles), vehicle, charging, and battery technologies, policy harmonization, power systems to support the EV transition, and the role of EVs in integrating renewable electricity sources.

22. While the focus is on EVs, the study will also recognize that in certain areas or specific transport sectors, EV adoption may face challenges or limitations. Therefore, the study will touch upon zero-emission fuel technologies such as hydrogen and biofuels as complementary solutions in situations where EV deployment is not feasible or practical. These technologies will be discussed as alternative options to achieve zero-emission goals in those specific contexts. By providing a comprehensive overview of these topics and showcasing successful case studies, the study will enable countries, especially those in the early stages of EV development, to learn from the experiences of others and leverage the advancements made by countries with a high EV stock.

III. Electric vehicles and its potential to realize the sustainable development agenda

23. EVs are significantly more energy-efficient than traditional fossil-fueled vehicles, resulting in lower emissions per unit of energy used. This efficiency advantage stems from electric motors experiencing minimal heat losses compared to ICEs, in addition to EVs producing no tailpipe emissions. The overall emissions of EVs, however, are influenced by the source of electricity utilized for charging. When powered by electricity from renewable sources, EVs are considered exceptionally clean, emitting nearly zero emissions. Even when charged from a grid that includes non-renewable sources, certain EV segments still exhibit lower emissions when compared to their fossil-fueled counterparts. These factors underscore the significant role EVs can play in achieving sustainable development goals. Table 1 highlights the Sustainable Development Goals and targets related to transport electrification.

Table 1
EV-related Sustainable Development Goals and targets

Goal	Targets
	7.2 By 2030, increase substantially the share of renewable energy in the global energy mix
	7.3 By 2030, double the global rate of improvement in energy efficiency
	11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.
	13.2 Integrate climate change measures into national policies, strategies and planning.
	17.14 Enhance policy coherence for sustainable development
	
	

IV. Driving forces of electric vehicle development

24. The driving forces for advancing electric mobility may vary depending on each country's unique challenges and priorities. However, there are several common drivers that have played a significant role in promoting electric mobility across the ECE region.

A. Environmental concerns

25. Numerous European countries, such as Germany, the Netherlands, and Norway, are actively promoting electric mobility as a solution to reduce GHG emissions and enhance air quality. Similarly, improving air quality is a key policy objective driving China's ambitious EV program.

26. Despite producing and exporting oil, Norway is regarded as the land of EV and making progress towards its goal of registering all new passenger cars and light vans as zero-emission vehicles by 2025.⁵ Its political commitment to reverse the climate change impacts has driven its ambitious transport decarbonization policies. The country uses its oil-wealth to fund various EV incentives policies.

B. Energy security

27. The role of EVs in reducing oil demand is especially relevant for oil importers. Türkiye, for instance, is heavily dependent on oil imports, with 91 per cent of its oil

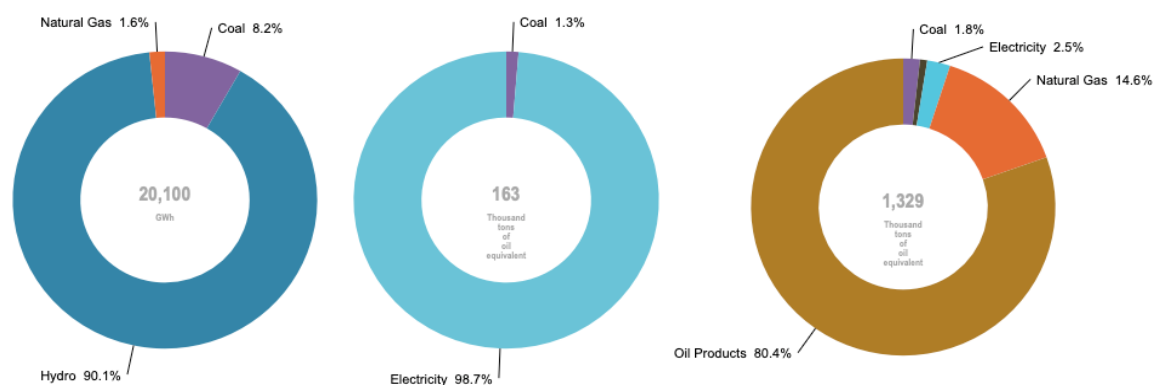
⁵ Source: <https://www.oecd.org/climate-action/ipac/practices/norway-s-evolving-incentives-for-zero-emission-vehicles-22d2485b/>

consumption in 2019 being met by imports (IEA, 2021a). The country is one of the 27 signatories of the Global Memorandum of Understanding on Zero Emission Medium- and Heavy-Duty Vehicles, committing to work together to enable 100 per cent zero-emission new truck and bus sales by 2040.⁶ EV approach is one of the means to reduce the additional importation of oil into the country. By promoting the adoption of EVs, countries can reduce their reliance on foreign oil imports and increase energy security. This dependency is even more critical in view of oil price increase in early 2022 to the levels before the 2008 financial crisis.

28. Another interesting example is Tajikistan, which generates 90 per cent of its electricity through hydropower, exports it and simultaneously imports oil products for its energy needs. By promoting EV, the country can boost its domestic electricity consumption, decrease its reliance on imported oil, and thereby enhance its energy security while saving foreign exchange.

Figure III

Electricity production (left), energy exports (middle), and energy imports (right) by product in Tajikistan, 2020



Source: Asia Pacific Energy Portal. Available at asiapacificenergy.org. Accessed on 21 April 2023.

C. Technological innovation

29. The development of EVs and associated infrastructure represents a significant technological challenge, but also an opportunity for innovation. Many countries, particularly developed countries, are investing in research and development to drive innovation in electric mobility technology. In Sweden for instance, automotive and smart mobility are key industries, providing a supportive environment for startups in electric mobility.⁷

D. Consumer preferences

30. Consumer demand for EVs is also driving the adoption of electric mobility in various countries. As the technology improves and becomes more affordable, more consumers are opting for EVs as a clean, efficient and practical mode of transportation. According to IEA (2021a), electric cars registration increased in major markets, such as the United States and Europe, in 2020 despite the overall decline in the car market due to the COVID-19 pandemic.

V. Potential barriers to mass electric vehicle adoption

31. Cost: EVs are often more expensive than their conventional counterparts, primarily due to the high cost of battery technology. While the prices of EVs have been gradually decreasing over the years, upfront costs remain a significant consideration for many

⁶ Source : <https://globaldrivetozero.org/mou-nations/>

⁷ Source: www.trade.gov/market-intelligence/sweden-electric-vehicles-market-overview

consumers. The availability of affordable EV models and financial incentives can help mitigate this barrier.

32. **Range anxiety:** Although the range of electric vehicles has improved significantly, some consumers still worry about finding charging stations or experiencing insufficient range for longer trips.

33. **Availability of charging infrastructure:** To alleviate concerns about range limitations, a robust and widespread charging network is essential. Accessible charging stations at home, workplaces, public areas, and along highways are crucial for the convenience and peace of mind of EV owners. Expanding the charging infrastructure is a vital step to support mass EV adoption.

34. **Demand for critical raw materials:** The global shift towards electric mobility has created a surge in demand for EVs, triggering an exponential increase in the need for lithium, cobalt, and nickel. These materials are essential in the production of EV batteries; lithium provides high energy density and durability, while cobalt and nickel enhance stability and energy storage capacity. This increased demand for raw materials presents a significant challenge to the large-scale production of EVs.

VI. Accelerating electric vehicle adoption to fulfill political commitments

35. Countries in the ECE region are already making strides towards electrification, and they are expected to continue progressing further as the majority of these countries have committed to adopting zero tailpipe vehicles in the coming decades.

A. Nationally determined contributions

36. When examining the Nationally Determined Contributions (NDC) registered by the United Nations Framework Convention on Climate Change (UNFCCC), it becomes apparent that only a small number of countries in the ECE region have explicitly mentioned EVs. It is important to note that many countries may have EV targets and ambitions, but these are often set outside of their NDCs and outlined in separate national EV plans, such as the United Kingdom approach (Table). In addition, some countries have included targets or measures that indirectly support the adoption of EVs. Furthermore, there are countries that have incorporated the development of sectoral strategies to decarbonize transport.

Table 2

ECE member States indicating EVs in their Nationally Determined Contributions

<i>Country⁸</i>	<i>Transport and EV-related NDC</i>
Armenia	Increased efficiency of public transport, use of renewable energy, stimulation and support in uptake of electric vehicles.
Azerbaijan	Use of environmentally friendly forms of transport, enhancement of the use of electric vehicles at public transportation, electrification of railway lines and the transition to alternative current system in traction.
European Union (one joint NDC)	By 2030, CO ₂ emissions per kilometer from road-based transport modes sold in the European Union must be reduced from 2021 levels: 37.5 per cent for passenger cars, 31 per cent for new vans, and 30 per cent for new large lorries.
Canada	Transport GHG emissions reduction target in 2030 is 27–32 per cent below 2007 levels Supporting the development and deployment of low and zero-emissions technologies, and ensuring that Canadian companies can capitalize on opportunities to manufacture zero-emissions parts and vehicles in Canada.

⁸ Only countries' NDCs submitted in English and Russian are included in the analysis.

Country ⁸	Transport and EV-related NDC
	Require 100 per cent of new light-duty vehicle and passenger trucks sold in Canada to be zero-emissions by 2035 Invest \$287 million to extend the Incentives for Zero-Emissions Vehicles program beyond its \$300 million initial investment, and invest an additional \$150 million in charging and refueling stations across Canada.
Georgia	Transport GHG emissions reduction target in 2030 is 15 per cent below 1990 level
Israel	Transport GHG emissions reduction target in 2050 is 96 per cent below 2015 levels As of 2026, all new municipal buses purchased will be clean vehicles
Monaco	Public transport will be gradually replaced to reach zero emissions by 2030 Support the replacement of ICE vehicles with EVs
Switzerland	Transport GHG emissions reduction target in 2040 and 2050 is 57 per cent and 100 per cent respectively below 1990 levels
United Kingdom	Referring to the Transport Decarbonisation Plan ⁹

Source: UNFCCC Nationally Determined Contributions Registry. Available at <https://unfccc.int/NDCREG>. Accessed on 21 April 2023.

B. Fit for 55

37. Fit for 55 refers to the European Union's target of reducing net GHG emissions by at least 55 per cent by 2030 compared to 1990 levels. As part of the European Green Deal, the European Commission adopted a package of legislative proposals in 2021, aimed at modernizing existing legislation to align with the European Union's 2030 climate target. The package also introduces new policy measures to facilitate the necessary transformative changes in the economy, society and industry to achieve climate neutrality by 2050. European Union countries are working on developing new legislation to meet these ambitious goals.

38. At the time of writing, the Fit for 55 package includes 14 measures, two of which are specifically related to EV adoption. The first measure, "Towards more sustainable transport", mandates the establishment of an adequate network of recharging points and alternative fuel refueling points across the European Union to support cars, planes and ships. The Alternative Fuels Infrastructure Regulation (AFIR) sets specific targets for deploying such infrastructure in the European Union in the coming years (Table 2). The second measure, "Why the European Union is toughening CO₂ emission standards for cars and vans", sets a new target of achieving 100 per cent reduction in CO₂ emission by 2035. This means that all new cars or vans entering the European Union market from 2035 onwards must be zero-emission vehicles.

Table 2

European Union targets for deployment of recharging stations for inland transport

Road transport

For passenger cars and trucks < 3.5 tonnes

Recharging stations at least every 60 km in each direction of TEN-T core network by end of 2025

For trucks > 3.5 tonnes

Recharging stations at least every 60 km in each direction of TEN-T core network by end of 2030

⁹ Source: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1009448/decarbonising-transport-a-better-greener-britain.pdf

Road transport

400 kW power output (at least one 150 kW recharging point) by end 2025

600 kW power output (at least two 150 kW recharging points in each safe and secure parking area) by end 2027 and four by end 2030

New infrastructure will have to allow ad-hoc charging, accept electronic payments, and clearly inform users about pricing options

PortsIn the busiest seaports:

At least 90 per cent of container and passenger ships to have access to shore-side electricity supply

In most of the inland waterway ports:

At least one installation providing shore-side electricity (by 2030)

Source: European Union¹⁰

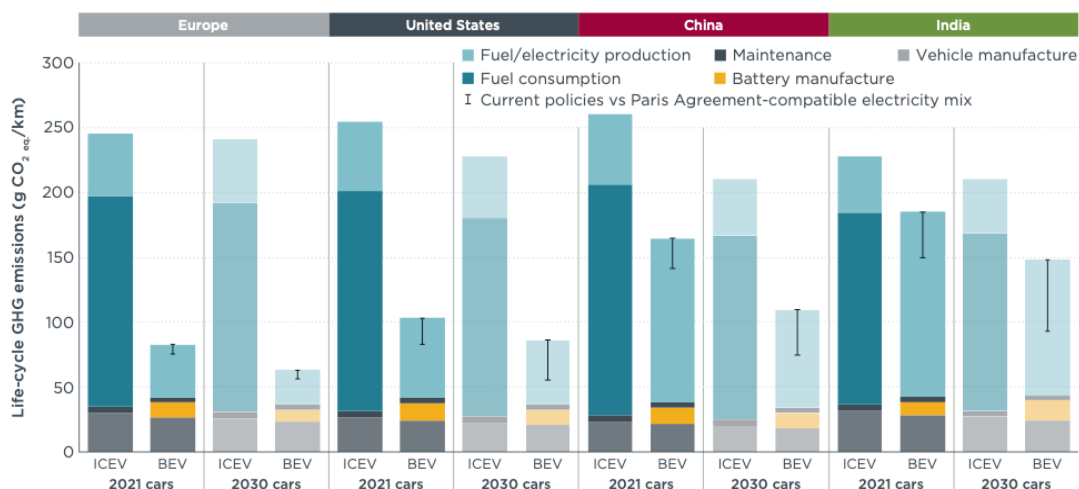
VII. The true environmental footprint of electric mobility

39. The projected increase in EVs (**Error! Reference source not found.II**) and the subsequent demand for batteries raises important concerns regarding the availability of materials required for battery manufacturing, as well as end-of-life and waste management. The growing demand for battery materials necessitates an increase in the extraction of raw materials. However, these reserves are limited, and the emissions generated during extraction, processing, and transportation may undermine decarbonization efforts.

40. According to a report by ICCT (2021a), which examined the life-cycle emissions of various passenger car types (such as ICEVs, HEVs, OHEVs, BEVs, FCEVs) and different fuel sources (including gasoline, diesel, natural gas, biofuels, e-fuels, hydrogen, and electricity), Europe's new passenger car markets offers a significant reduction in life-cycle GHG emissions only with BEVs and FCEVs. The study assessed the life cycle GHG emissions of passenger cars registered in 2021 and those expected to be registered in 2030. Even when powered by average grid electricity, BEVs demonstrate a substantial advantage in terms of GHG emissions. On the other hand, FCEVs require a considerable supply of renewable energy or dependence on carbon capture and storage (CCS) to be considered a low-carbon powertrain option. None of the other powertrain types investigated in the study offer any significant reduction, or at best, only minor reductions, in expected life cycle GHG emissions when compared to conventional gasoline or diesel cars. The study considers both the vehicle cycles (which include emissions from vehicle production, maintenance, and recycling) and the fuel cycle (which covers emissions from fuel and electricity production ("well to tank", WTT) as well as fuel consumption in the vehicle ("tank to wheel", TTW)).

¹⁰ Source: <https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition/>

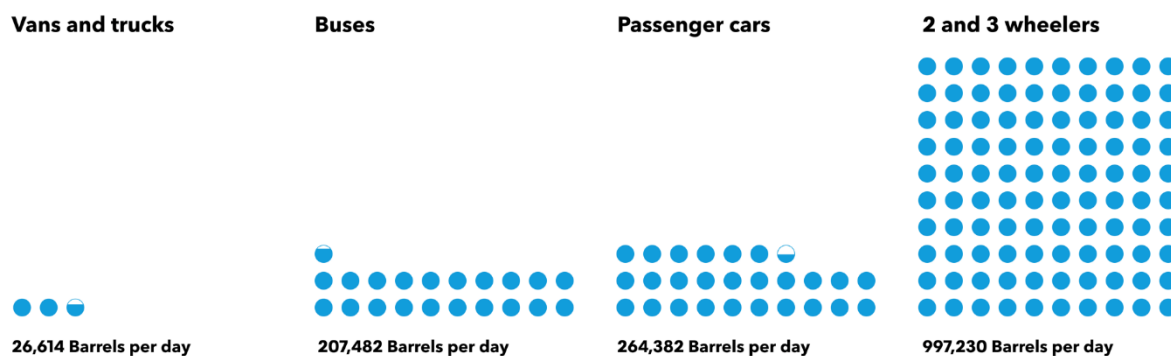
Figure IV
Life-cycle GHG emissions of average medium-size ICEVs and BEVs registered in four major markets



Source: ICCT (2021a)

41. According to BloombergNEF,¹¹ EVs of all types are already displacing 1.5 million barrels per day of oil usage, equivalent to about 3 per cent of total road fuel demand, as depicted by Figure VI below.

Figure V
Oil displacement by vehicle segment



Source: BloombergNEF, Electric vehicle outlook 2023

VIII. Recycling ecosystem of electric vehicle batteries

42. A robust and efficient recycling infrastructure is essential for managing EV batteries. Recycling batteries secures key raw materials, reduces the need for new mineral extraction, and decreases environmental impact. It minimizes the footprint associated with battery production and disposal. After their use in EVs, batteries have three options:

- Repurposing for secondary applications, which involves utilizing the battery in stationary batteries for grid storage systems or as a standby power source;
- Recycling to recover valuable materials, which can be used in the production of new batteries or other products; and
- Landfill disposal (least desirable due to environmental harm and resource waste), which should be avoided whenever possible.

¹¹ Source : <https://about.bnef.com/electric-vehicle-outlook/>

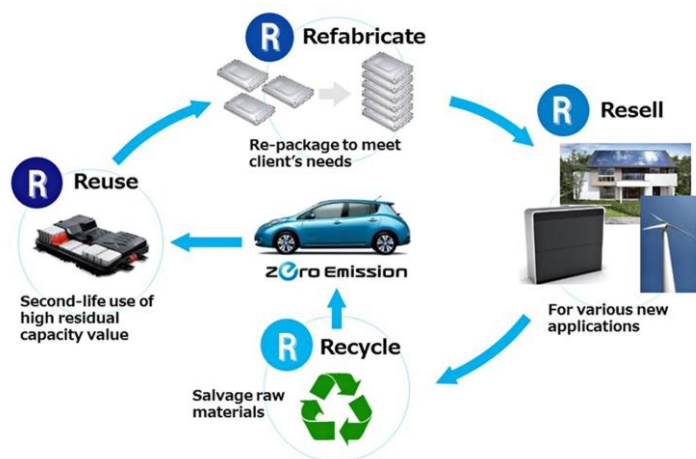
43. Extended Producer Responsibility (EPR) has been adopted and expanded upon by numerous countries and regions worldwide. European Union member states implemented EPR policies through various directives, such as the Waste Electrical and Electronic Equipment (WEEE) Directive and the Batteries Directive. These directives introduced EPR requirements for specific product categories, including electronic waste and batteries. While the specific design and scope of EPR systems may vary among jurisdictions, the underlying principle of holding producers responsible for managing their products throughout their lifecycle remains consistent.

44. **Error! Reference source not found.** describes an EPR implementation in Japan, which has been implementing EPR policies as early as the late 1990s. These policies establish specific obligations for battery manufacturers and importers. Their responsibilities include the establishment of collection and recycling systems, ensuring proper treatment and disposal of used batteries, and meeting recycling targets mandated by the government.

Box 1

Nissan's 4-R Energy Corp and the 4-R approach to battery recycling

The following figure illustrates Nissan's approach to recycling depleted EV batteries through its partnership with Sumitomo Corporation in the establishment of 4R Energy Corp in 2010. The purpose of this venture is to develop the necessary infrastructure and technology for refurbishing, recycling, reselling, and reusing batteries from future Nissan EVs. 4R Energy Corp operates Japan's first specialized factory for the reuse and recycling of used lithium-ion batteries from EVs. Their "4R" business model focuses on the reuse, reselling, refabrication, and recycling of lithium-ion batteries for various energy storage applications.



Upon receiving a battery pack at 4R Energy, it undergoes analysis and grading. Packs with components in excellent condition receive an A grade and can be used in new EV battery packs. Those graded as B have components powerful enough for industrial machinery and large stationary energy storage units, such as those used to store solar energy for night-time power usage in buildings. Even components receiving the lowest grade, C, find purpose in various applications, such as backup power for instances of grid failure. An exemplary demonstration is the innovative battery management system on Koshikishima, a man-made island off the coast of southwestern Japan. It hosts the world's first large-scale energy storage system that utilizes wind and solar energy to power a charging network supporting a fleet of all-electric vehicles. The facility incorporates 16 refurbished lithium-ion EV batteries to manage energy fluctuations and store the generated power.

Source: autoevolution.¹² Accessed on 2 June 2023.

¹² Source: www.autoevolution.com/news/how-nissan-recycles-depleted-ev-batteries-and-rescues-them-to-power-japan-155773.html#

IX. Global initiatives on electric mobility

45. This section provides an overview of various global initiatives that are driving the transition towards electric mobility. The provided list is non-exhaustive and primarily covers intergovernmental initiatives. These initiatives play a pivotal role in accelerating the adoption of EVs and promoting sustainable transportation systems worldwide. By bringing together governments, businesses, and organizations, these initiatives aim to address the challenges and seize the opportunities presented by the shift to electric mobility. They are catalysts for change, driving innovation, awareness, and collaboration among key stakeholders. It is highly recommended that United Nations member States actively engage in the available global initiatives to reap the benefits of collective efforts and expertise.

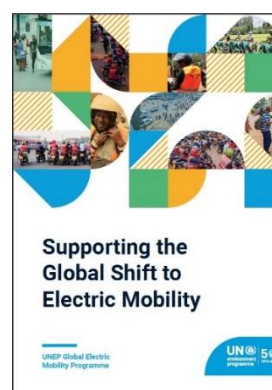
46. The Accelerating to Zero (A2Z) Coalition¹³ is a collaboration led by organizations such as the ICCT and COP26 Presidency. It serves as a platform for governments, business, investors and other stakeholders to coordinate and accelerate their efforts towards a faster transition to a sustainable future. The coalition was officially launched at COP27 in 2022 and has garnered the support of over 200 signatories. The coalition offers signatories valuable access to a network of support, allowing them to effectively deliver on their commitments. By fostering connections and leveraging international best practices, signatories can draw upon the wealth of knowledge and expertise within the coalition.



47. AVERE is a European association that represents and advocates for electromobility in Europe. It aims to promote the use of electric vehicles (EVs) and phase out internal combustion engine (ICE) vehicles by 2030. AVERE engages in advocacy activities at the European Union and national levels and provides a platform for members to exchange knowledge and ideas. Their policy priorities include strengthening CO2 reduction targets, introducing an ICE phase-out date, and implementing ambitious reduction trajectories for vehicle emissions. They also focus on establishing a high-quality and dense EV charging infrastructure network that is consumer-friendly and suitable for heavy-duty vehicles. AVERE supports renewable energy uptake, smart charging, and vehicle-to-grid technology. They emphasize the need for a sustainable and competitive European battery industry and advocate for a comprehensive regulatory framework for connected and automated mobility. Membership offers benefits such as influencing policy debates, accessing a network of experts, and participating in European Union-funded projects and global events on electromobility.



48. The Electric Vehicles Initiative (EVI)¹⁴ is a forum led by the IEA and supported by 16 countries. Its main goal is to accelerate the global adoption of EVs. This forum has various campaigns and declarations that drive the transition to electric mobility. The EV30@30 campaign, launched in 2017, aims to achieve at least 30 per cent new EV sales by 2030 and focuses on different vehicle types and charging infrastructure. The EVI Call to Action, introduced in 2021, seeks to bridge the gap between projected EV sales and the goals of the Paris Agreement through practical actions. The Zero-Emission Government Fleet Declaration, announced in 2022, commits supporting governments to significantly reduce emissions and aim for 100 per cent zero-emission vehicle acquisitions in their fleets by 2035. Additionally, the EVI promotes the Global EV Pilot City Programme, which facilitates information exchange,



¹³ Source: <https://acceleratingtozero.org>

¹⁴ Source: <https://www.iea.org/programmes/electric-vehicles-initiative>

best practice replication, and analytical outputs among a network of at least 100 cities. This program is coordinated by the IEA and Shanghai International Automobile City.

49. UNEP Global Electric Mobility Programme¹⁵ supports over 50 low- and middle-income countries in transitioning from fossil fuel to EVs. The program operates at national, regional, and global levels. Nationally, it assists countries in their shift to electric mobility. Regionally, it collaborates with partners like the Asian Development Bank, European Bank for Reconstruction and Development, and Centro de Movilidad Sostenible to establish Support and Investment Platforms in Africa, Asia and the Pacific, Central and Eastern Europe, West Asia and Middle East, and Latin America & the Caribbean. At the global level, the programme advocates for e-mobility targets and policies and forms Global Working Groups with the IEA to provide policy advice and support national projects. The programme focuses on electric two and three wheelers, light-duty vehicles, and buses. UNEP also offers free tools, including the eMob calculators, to estimate the energy and emission savings and costs associated with adopting electric mobility.

50. The Urban Electric Mobility Initiative (UEMI) was launched by UN-Habitat to promote sustainable urban development and equal access to urban basic services in Latin America, Asia, and Africa. UEMI serves as the Mobility Hub of the Urban Living Lab Center and is actively involved in coordinating international projects across these regions as well as in Europe. With a strong commitment to local implementation actions for sustainable and low-carbon cities, UEMI works alongside over 100 partners worldwide to drive sustainable projects and initiatives in the field of urban electric mobility.



51. The International Zero-Emission Vehicle Alliance (ZEV Alliance)¹⁶ is a collaborative effort among national and subnational governments with the aim of accelerating the adoption of ZEVs. The primary objective of the alliance is to establish ambitious and achievable targets for ZEV deployment and encourage other jurisdictions to do the same. The participants work together on action plans to achieve these targets,



demonstrate the momentum of ZEV adoption, and raise global awareness about the expanding ZEV markets. The alliance engages in outreach and coalition building, capacity building, knowledge development, and policy-making and implementation. They regularly set targets, support ongoing policy and technology developments, share best practices, conduct research, and implement various support policies such as consumer incentives, infrastructure deployment, and public education campaigns to promote ZEVs.

X. Policy instruments to support electric vehicle adoption

A. Fiscal and financial incentives

52. The expansion in global EV markets has been strongly supported by generous incentives and policies such as direct purchase incentives, tax credits, indirect mechanisms, and special treatments. According to Li et al. (2021), in the top 13 countries with the highest EV sales in the world, the total financial incentives provided to EV buyers amounted to \$43 billion from 2013 to 2020. The average incentive from the central government in these countries is about \$3,400 per vehicle and can reach as high as \$56,000 for certain models.

53. Subsidy scheme for purchasing EVs. While EVs are widely regarded as the future of transportation, their capital costs typically exceed those of conventional ICE vehicles. This poses a significant hurdle to their adoption, particularly in developing economies where cost sensitivity is high. To boost EV sales, various nations offer purchase incentives, but these

¹⁵ Source: <https://www.unep.org/explore-topics/transport/what-we-do/global-electric-mobility-programme>

¹⁶ Source: <https://zevalliance.org>

incentives tend to focus on passenger vehicles, leaving LCVs largely overlooked in the electric LDV market. Although incentives can help drive EV market growth, achieving widespread market penetration will ultimately depend on making EVs cost competitive. In 2022, 21 of 27 European Union member states offer EV purchase incentives.¹⁷ Croatia, for example, offered a purchase incentive of €9,333 for BEVs and €5,333 for PHEVs. In Finland, households can receive a purchase incentive of €2,000 until 2023, and e-vans and e-trucks are eligible for incentives of €2,000-€6,000 and of €6,000-€50,000, respectively, from 2022-2025.

54. The subsidy can be gradually reduced once the desired number of EVs has been attained. This approach has been adopted by China (Box 2). It is important to note that some argue that EV subsidies should be carefully evaluated due to their potential impact on income distribution, especially in light of limited government resources.

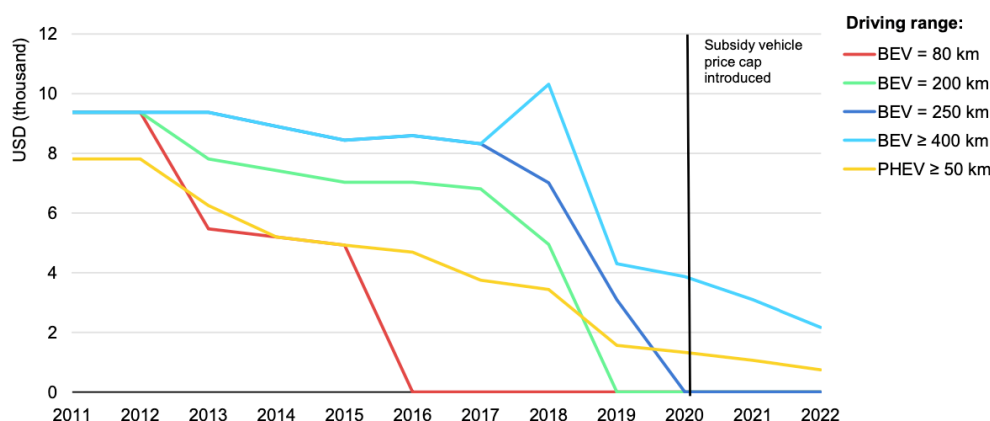
Box 2

China's phased-out subsidy program for NEVs

In 2013, China introduced a subsidy program for new energy vehicles (NEVs) to initiate the EV market. As a result, the market saw significant growth from 2013 to 2017 (ICCT, 2020), demonstrating the necessity of the subsidies to support the industry. However, the subsidies also placed a significant burden on the national budget and led to over-reliance on government support. Consequently, in 2014 China began to phase out subsidies for NEVs, including BEVs and PHEVs. In 2016, the NEV subsidy program was restructured to reward vehicles with greater electric range, meaning that vehicles with a longer electric range received a higher subsidy (Figure II). In 2019, the subsidy for electric passenger cars, commercial passenger vehicles, and truck-BEV was reduced by at least 40 per cent compared to the previous year (ICCT, 2019). The subsidy reduction was increased each year, and the subsidy was entirely phased out by the end of 2022.¹⁸

Figure VI

Purchase subsidies for NEVs in China, 2011-2022



Source: IEA (2022)

55. Tax benefits for purchasing EVs. Tax benefits for purchasing EVs are one of the key policy measures that governments around the world have implemented to support the adoption of EVs. By offering tax incentives, governments aim to make EVs more affordable. Several types of tax benefits are commonly offered for EV purchases, including tax credits, tax deductions, and exemptions from certain taxes. ECE countries such as Austria, Hungary, and Uzbekistan, offer VAT deduction and exemption from tax for zero-emission cars. Croatia exempts EVs from excise duties and environmental tax. Finland, Latvia, and Lithuania exempt EVs from registration tax.¹⁹

¹⁷ Source: <https://www.acea.auto/files/Electric-Vehicles-Tax-Benefits-Purchase-Incentives-2022.pdf>

¹⁸ Source: <https://www.reuters.com/world/china/china-cut-new-energy-vehicle-subsidies-by-30-2022-2021-12-31/>

¹⁹ Source: <https://www.acea.auto/files/Electric-Vehicles-Tax-Benefits-Purchase-Incentives-2022.pdf>

56. Evidence from several studies suggests that tax benefits can be an effective tool for increasing EV sales. Cities with high EV shares such as Amsterdam and Oslo commonly offer annual national tax breaks on vehicle registration and operation, whereas markets such as Brussels and Madrid that have not addressed cost barriers on car purchase or annual ownership tax typically experience slower EV uptake (Wappelhorst et al., 2020).

57. While the subsidy scheme has been proven to increase EV adoption, there is ongoing debate about the distributional effects of these subsidies, particularly considering limited government resources, as they often benefit higher-income households. In light of this, alternative policy options such as a feebate system can be considered. This system involves imposing a fee on vehicles with low fuel economy (high CO₂ emissions per km) while providing a rebate to vehicles with high fuel economy (low CO₂ emissions per km). Several countries, including Belgium, France, the Netherlands, Norway, and Sweden, have implemented feebate systems to promote EV adoption. France notably introduced the "Bonus-malus" feebate system in 2008 and is often recognized as one of the pioneering countries in implementing the system.

58. According to a study by CE Delft (2014), feebate systems offer an intriguing policy option for developing and transition countries. These systems are self-financing instruments that do not impact the government budget, making them particularly attractive. Moreover, they have the potential to influence the fuel efficiency of imported vehicles, which is of particular significance for countries that rely heavily on vehicle imports rather than domestic production.

59. Li et al. (2021) argue that investment in charging infrastructure would have been much more cost-effective than consumer purchase subsidies in promoting EV adoption. Improving the quantity and quality of charging infrastructure is crucial for promoting the EV market uptake and pivotal in encouraging private investment. A robust network of charging infrastructure is essential in reducing range anxiety, a significant hurdle that must be overcome to promote the adoption of EVs.

60. While home charging is relatively straightforward and can be cost-effective when utilizing off-peak electricity tariffs, the development of non-home-based charging points or stations necessitates substantial investment. This is partly due to the more complex requirements of public charging stations, which include higher safety standards and the implementation of payment systems. Government intervention and supportive regulations on public charging infrastructure are therefore crucial. The financial contribution of the public sector and private investors in the early phase of EV development is also observed in EV front-runner countries in Europe.

Box 3

The United States subsidy NEVI program for public charging infrastructure

In 2022, The U.S. Department of Transportation's (DOT) NEVI Formula Program provided funding to states to strategically deploy EV charging stations and establish an interconnected network for efficient data collection, access, and reliability. The funding covered up to 80 per cent of eligible project costs, which included:

- Acquisition, installation, and network connection of EV charging stations.
- Proper operation and maintenance of EV charging stations;
- Long-term sharing of EV charging station data.

To meet the requirements of the program, EV charging stations had to be non-proprietary, allow for open-access payment methods, be publicly available or accessible to authorized commercial motor vehicle operators from multiple companies, and be located along designated FHWA Alternative Fuel Corridors (AFCs).

It is worth noting the specific requirements outlined by NEVI for the installation of charging infrastructure to ensure the achievement of the aforementioned objectives. The NEVI Standards and Requirements explicitly describe payment standards and price displays, the use of established standards such as OCPP and ISO15188 to enable Plug&Charge functionality, and the utilization of OCPI to achieve complete interoperability among charging operators and service providers.

The funding is expected to last for five years and amounts to over \$4 billion in total.²⁰

Source: US department of Energy (2022)

B. Regulatory measures

61. Regulatory measures typically involve the implementation of policies and regulations that promote or mandate the use of EVs, and at the same time tighten or restrict the use of internal combustion engine vehicles (ICEVs).

62. Demand-side regulatory measures are implemented to promote the adoption and usage of EVs by creating a supportive environment and providing incentives. Analyzing the implementation and impact of these regulations allows us to gain valuable insights into their effectiveness in accelerating the transition towards sustainable and zero-emission transportation systems.

63. Provision of parking privileges to EV drivers involves granting priority parking in certain locations, particularly near charging stations. This policy aims to provide an incentive for drivers to switch to EVs by reducing the inconvenience associated with parking. Similar to the implementation of LEZs, this policy is typically carried out at the local level. Although the specific details of the policy can vary between cities, it is often designed to benefit EV drivers who rely on on-street parking the most. In Amsterdam, for instance, EV owners are given priority on the waiting list for a parking permit.²¹

64. Low-emission zones (LEZs) are designated areas in a city that restrict access for vehicles with poor environmental performance. In other words, only vehicles that meet certain emissions criteria or standards are allowed to enter the area. The specific standards and restricted times can vary between cities and countries. It is important to note that LEZs are typically implemented by local governments, rather than national governments. The main goal of LEZs in urban areas is to reduce air pollution, and they have been adopted in many

²⁰ Source: https://www.fhwa.dot.gov/bipartisan-infrastructure-law/evs_5year_nevi_funding_by_state.cfm

²¹ Source: <https://www.amsterdam.nl/en/parking/electric-charging/>

European cities. While most LEZs restrict access for HDVs, some countries, such as Germany, and cities like London and Lisbon, also include LDVs.

65. Implementing LEZs is also one approach to accelerate the electrification of light commercial vehicles (LCVs). The surge in e-commerce and home deliveries, particularly since the COVID-19 pandemic, has intensified the need to decarbonize last-mile logistics. According to ITF (2020), accessing city centers is crucial for vehicles used in last-mile delivery operations and existing experiences show that the prospect of access restrictions sends a strong signal to operators to electrify. This approach can encourage companies to electrify their first- and last-mile logistics, which tend to be shorter and pass through high-traffic areas.

Box 4

London's Ultra Low Emission Zone

In 2019, London introduced the Ultra-Low Emission Zone (ULEZ), which requires drivers of older and highly polluting vehicles to pay a daily charge for operating within the zone. The ULEZ was expanded in October 2021 and is planned to cover the entire Greater London area by August 2023. These measures aim to reduce emissions and improve air quality across the city.

The implementation of the ULEZ coincided with an increase in the share of plug-in cars in new car sales in London. In 2021, the share of plug-in cars reached 21 per cent, surpassing the national average of 12 per cent in the United Kingdom. Additionally, London had notable sales of new plug-in cars among European cities in 2021.²² These figures may suggest a potential link between the ULEZ and the adoption of cleaner vehicles in the city, even though it is challenging to establish a direct cause-and-effect relationship between the ULEZ and the increased adoption of plug-in cars in London.



Further research and analysis are needed to evaluate the full impact of the ULEZ on vehicle choices and the overall reduction in emissions. Nonetheless, the implementation of the ULEZ reflects London's dedication to addressing air quality concerns and promoting sustainable mobility.

Image source: <https://tfl.gov.uk/modes/driving/ultra-low-emission-zone/ulez-expansion-2023#map>

66. The following section sheds light on the significance of supply-side regulatory measures in promoting the widespread adoption of EVs and related infrastructure. The presented measures are not exhaustive and serve as key examples of the policies and regulations employed to drive the production, distribution, and availability of EVs.

67. Regulating emission standards of new vehicles. The policy of regulating emissions of new vehicles produced, which mainly targets the automotive industry, aims to promote the production and marketing of low and zero-emission vehicles (LZEVs) and to accelerate the economies of scale, leading to reduced technology costs.

68. In January 2020, the European Union implemented CO₂ performance standards for new passenger cars and vans, which included a mechanism to incentivize the adoption of LZEVs. As a result, the average CO₂ emissions of newly registered passenger cars in Europe decreased by 12 per cent in 2020 compared to the previous year, while the share of electric cars tripled.²³ The regulation also sets European Union fleet-wide targets for 2025 and 2030, which are essential for creating a sense of urgency and contributing to the achievement of the European Union's commitments under the Paris Agreement.

²² Source: <https://acceleratingtozero.org/london-is-the-newest-signatory-to-the-zev-declaration/>

²³ Source: https://climate.ec.europa.eu/eu-action/transport-emissions/road-transport-reducing-co2-emissions-vehicles/co2-emission-performance-standards-cars-and-vans_en

69. Establishing standards and targets for EV charging infrastructure. To ensure interoperability across different EV charging systems, including payment methods and compatibility with a broad range of plug-in EV models, EV charging standards must be harmonized. By doing so, users will be able to take advantage of all available charging infrastructure.

70. Including targets for the amount of charging infrastructure in policy documents is also essential. This allows national governments to allocate the necessary budget for the required infrastructure, while also increasing enterprises' and investors' trust in the expansion of alternative energy vehicle markets (ITF, 2021). Germany's experience with its master plan provides a great example of this. The government's plan not only allocates a significant budget to the expansion of charging infrastructure but also sends a strong signal to the private sector that there is a significant demand for charging infrastructure in the country (

In 2019, Germany announced its "Masterplan Ladeinfrastruktur" (master plan for charging infrastructure), which indicates its ambition to increase the number of charging stations to one million by 2030. To achieve this goal, the government has approved a budget of 6.3 billion euros over three years to rapidly scale up the number of charging stations for EVs across the country, as part of its push towards achieving net-zero emissions. This initiative includes the installation of 1,000 fast charging stations for long-distance mobility.

The car industry has also pledged to install at least 15,000 additional public charging points by 2022 and 100,000 charging points on its business premises and at affiliated dealers by 2030. While these targets have not yet been met, there were 77,000 charging points in Germany in 2022, representing an increase of over 150 per cent since 2019.

Figure VII
EV charging points in Germany, 2012–2022).

Box 5
One million charging points in Germany

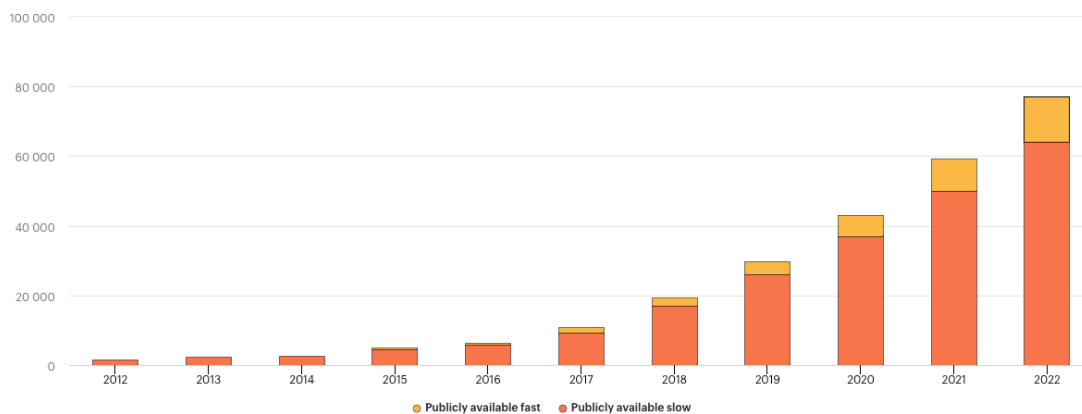
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²⁴ Source: <https://www.reuters.com/business/autos-transportation/germany-spend-63-bln-euros-push-electric-car-charging-points-2022-10-19/>

²⁵ Source: <https://www.bundesregierung.de/breg-en/issues/climate-action/climate-friendly-transport-1795842>



Source: IEA Global EV Data Explorer. Available at <https://www.iea.org/data-and-statistics/data-tools/global-ev-data-explorer>. Accessed on 1 May 2023.

XI. Technical Regulations

71. ECE, through its WP.29, has developed a comprehensive framework to ensure the safety, functionality, and proper handling of EVs while addressing potential safety risks and promoting global harmonization. Within this framework, several legally binding technical regulations have been established, along with a forthcoming initiative, that will play a crucial role in shaping the EV industry, fostering sustainability, and ultimately bolstering consumer confidence.

72. United Nations Regulation No. 100²⁶ establishes uniform provisions for the approval of vehicles with specific requirements for the electric power train. It serves as a comprehensive guide to: (a) ensure the safety of all road users, including vehicle occupants, in terms of electric shock protection; (b) regulate the functional safety aspects of the electric power train and ensure proper, safe handling of the vehicle during normal operation; and (c) stipulate requirements for manufacturers to provide necessary information to users and third-party services for the safe handling of EVs. Additionally, the regulation includes specifications for the electric energy storage system, such as performance and durability criteria

73. GTR on EV Safety, introduced in 2018 to address potential safety risks of EVs in both LDVs and HDVs through performance-oriented requirements. The requirements are divided into in-use (occupant protection, charging, safety of the rechargeable energy storage system), and post-crash (electrical isolation, battery integrity, guidelines for manufacturers and/or emergency first responders, battery discharge procedures) categories.²⁷

74. United Nations Global Technical Regulation (GTR) No. 22 on “In-vehicle Battery Durability”, which was adopted in March 2022 provides a worldwide harmonized method to set and verify minimum performance requirements on in-vehicle battery durability of Pure Electric Vehicles (PEVs) and Off-vehicle Charging Hybrid Electric Vehicles (OVC-HEVs).²⁸ Under this regulation, manufacturers are obliged to ensure that the batteries' State of Certified Energy (SOCE) and State of Certified Range (SOCR) meet the stipulated Minimum Performance Requirements (MPRI). According to these requirements, batteries should retain at least 80 per cent of their initial SOCE for up to 5 years or 100,000 kilometers, and no less than 70 per cent for up to 8 years or 160,000 kilometers. It is important to note that, currently, this regulation only covers cars, and phase two for vans and heavy-duty vehicles has been initiated.

²⁶ Source: <https://unece.org/sites/default/files/2022-07/R100r3e.pdf>

²⁷ Source: <https://unece.org/fileadmin/DAM/trans/main/wp29/wp29wgs/wp29gen/wp29registry/ECE-TRANS-180a20app1e.pdf>

²⁸ Source: https://unece.org/sites/default/files/2022-04/ECE_TRANS_180a22e.pdf

75. Automotive Life Cycle Assessment (to be adopted in 2025).²⁹ ECE Working Party on Pollution and Energy has approved the formation of an Informal Working Group on Automotive Life Cycle Assessment. The group aims to establish an internationally harmonized method for assessing the carbon footprint of all types of vehicles, regardless of their technology. This would allow for comparability between different vehicle models using the same technology. A resolution incorporating this standardized procedure is targeted for adoption by 2025 under the ECE World Forum for Harmonization of Vehicle Regulations, applying to all vehicles. In April 2023, a special session on automotive lifecycle assessment will be held, inviting all relevant stakeholders to participate in the process.

²⁹ Source: <https://unece.org/media/transport/Vehicle-Regulations/news/375420>