RENEWABLE ENERGY IN TRANSPORT

KEY FACTS FOR 2024

- Transport-related energy use surpassed pre-pandemic levels in 2023, increasing 3.6% year-on-year.
- Despite growth, renewables accounted for only 3.9% of transport energy use in 2022.
- Electric vehicles accounted for over 20% of global car sales in 2024 and 4% of the global passenger car stock.
- Two- and three-wheelers are on track for net-zero by 2050, with 340 million vehicles already on the road.
- Global investment in electrified transport reached USD 757.4 billion in 2024, with China contributing over half.

17 million
electric vehicles were sold in 2024

At least 35 countries
have biofuel blending mandates in place

At least 47 countries
have EV incentives in place and at least 68 have EV targets

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3.9%

of transport energy consumption came from renewables in 2022 – a modest rise from 2.9% a decade earlier.

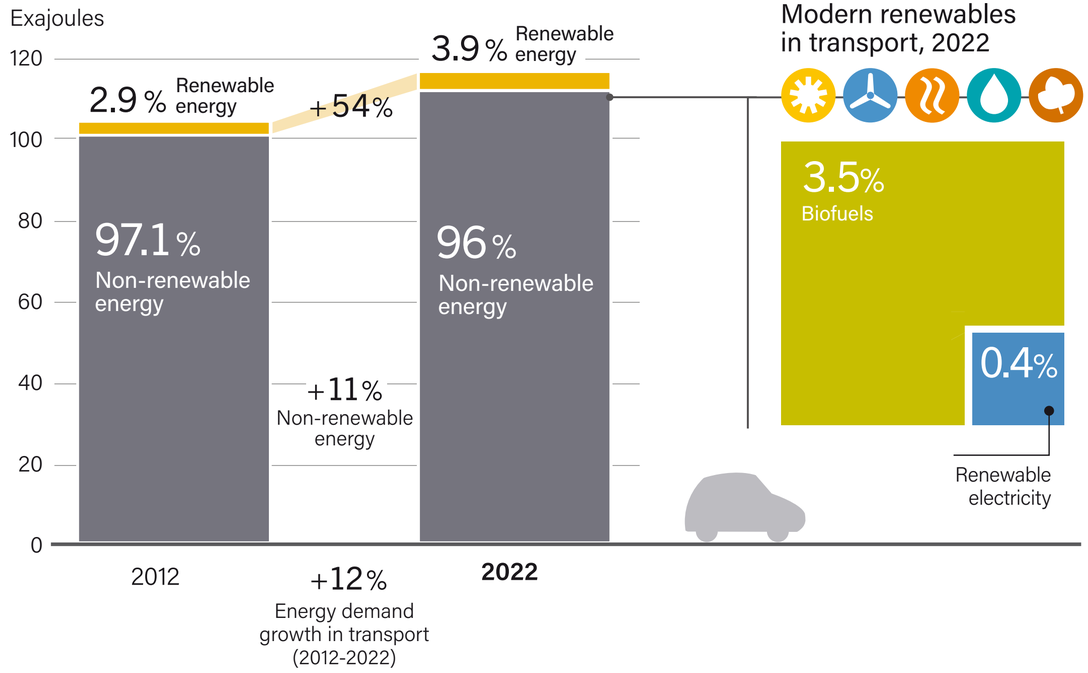
INTRODUCTION

Between 2022 and 2023, transport-related total final energy consumption (TFEC) increased 3.6%, for the first time surpassing the pre-pandemic level by 0.8%.[1] Fossil fuel use in the sector grew 2.7%, while renewable energy consumption increased 6.7%, doubling the previous year's 3.0% growth rate. [2,3]

Despite a 54% increase in the use of renewable energy in transport between 2012 and 2022, the transport sector remains overwhelmingly dependent on fossil fuels (→ *See Figure T-1*).[4] In 2022, renewables accounted for just 3.9% of TFEC, a modest increase from 2.9% in 2012.[5] During the same period, overall transport energy demand grew by 12%, and non-renewable energy use rose by 11%. Of the modern renewables used in 2022, biofuels represented the vast majority at 3.5% of TFEC, while renewable electricity made up only 0.4%.[6]

Between 2021 and 2022, renewable electricity use increased by 15.8%, largely driven by electric vehicle adoption and the expansion of supporting infrastructure. Total electricity use in transport grew 9.0%, while the use of biofuels increased by 5.7%, indicating a gradual shift towards pursuing electrification over the use of biofuels in decarbonisation efforts.[7]

FIGURE T-1.
Renewable Share of Total Final Energy Consumption in Transport, 2011 and 2021



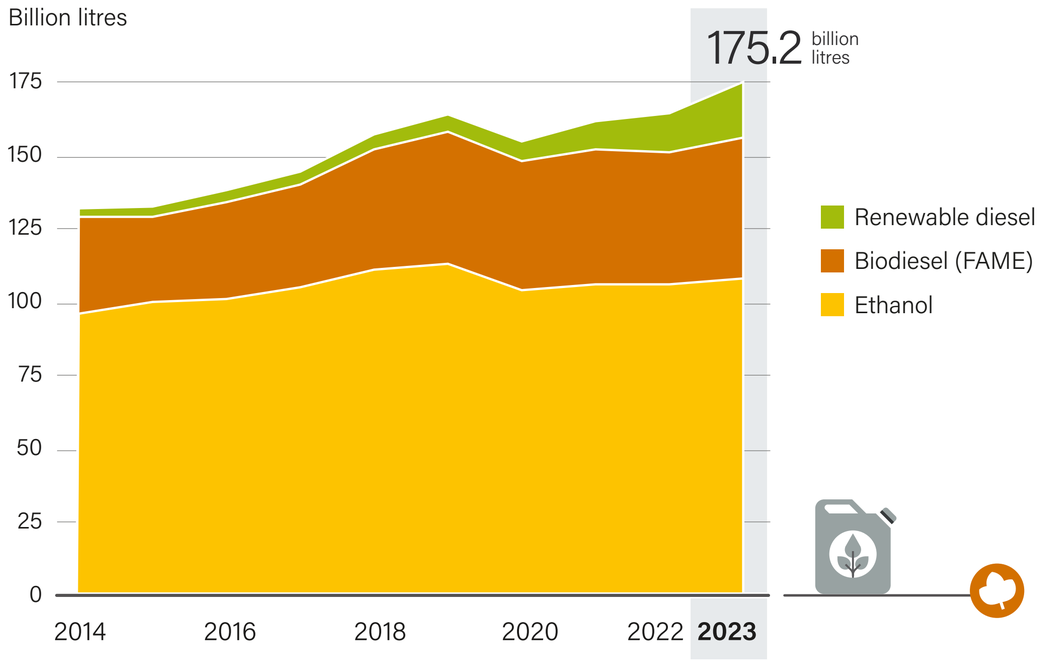
Source: See endnote 4 for this section.

Global demand for **liquid biofuels** reached 175.2 billion litres in 2023, continuing a steady increase over the past decade (→ *See Figure T-2*).[8] Bioethanol remained the dominant biofuel, accounting for the largest share of demand, followed by biodiesel (FAME) and renewable diesel. While demand for biodiesel plateaued in recent years, the market for renewable diesel has grown over the same period, reflecting increasing interest in drop-in fuels compatible with existing infrastructure.

3.5%

liquid biofuels cover 3.5% of total energy demand in transport.

FIGURE T-2.
Global demand of Bioethanol, Biodiesel and Renewable Diesel, 2014-2023



Source: See endnote 8 for this section.

Electrification allows for a higher share of renewable energy in total transport demand, however, renewable electricity still accounted for less than **0.5%** of transport TFEC in 2022.[9] Nonetheless, several promising trends can be identified. Electric vehicles (EVs) accounted for more than a fifth of global car sales in 2024, and electric truck sales grew by nearly 80%, reaching close to 2% of the total truck market.[10] In maritime transport, battery-electric shipping corridors began to take shape, though they remain largely limited to short sea routes in Northern Europe.[11] Aviation also saw early innovation, with the successful test flight of a four-tonne electric civil aircraft codeveloped by battery manufacturer CATL marking a notable step towards electrifying short-haul aviation.[12]

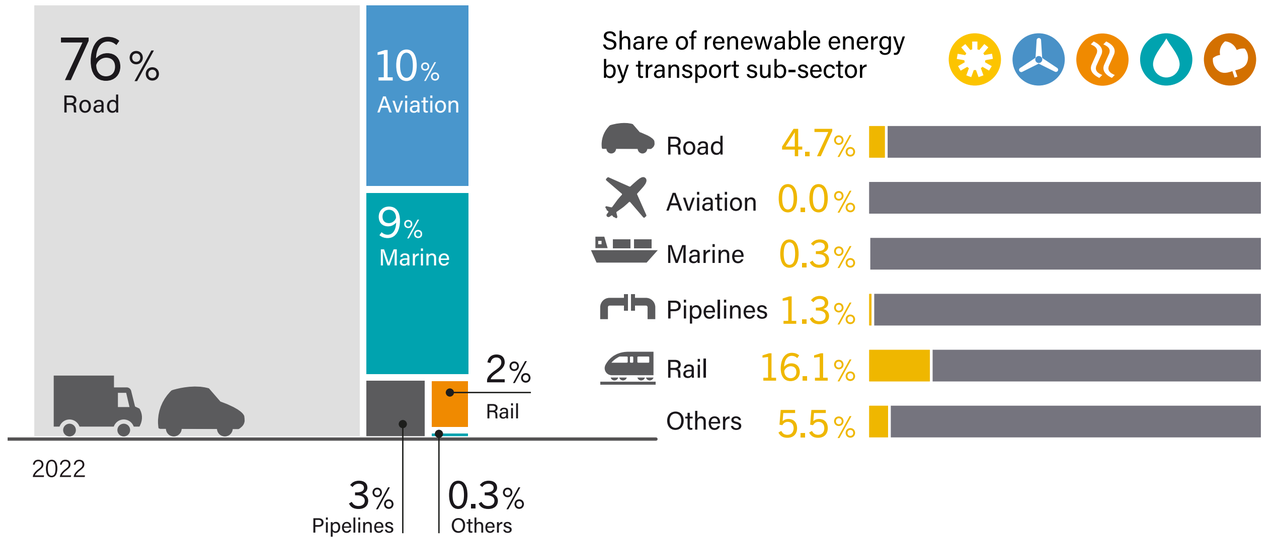
ROAD TRANSPORT

Road transport is responsible for the majority of total global transport **energy use and emissions**, generated by the approximately 1.3 billion passenger vehicles and 83 million commercial vehicles on the road.[13] In 2022, road transport accounted for 76% of total final energy use in the transport sector (→ *See Figure T-3*).[14] Passenger vehicles contributed 53% of road transport emissions, while medium and heavy commercial vehicles generated an additional 30%. Despite growing electrification, fossil fuels remain the sector's primary energy source. However, progress is evident: in 2024, electric vehicles (cars and vans) displaced 1.3 million barrels of oil per day, a significant increase from 0.3 million barrels per day in 2018.[15]

As of the end of 2024, **electric vehicles** (EVs) accounted for roughly 4% of the global passenger car stock, nearly 58 million vehicles, up from just 16 million in 2021.[16] Electric car **sales** exceeded 17 million globally in 2024, over 20% of total sales.[17] China maintained its lead in the EV market, with electric cars accounting for almost half of all car sales in 2024; as a result of continued strong growth, 1 in 10 cars on Chinese roads is now electric. Meanwhile, Norway remains the world's leader in EV market share, with 89% of new cars sold being fully electric in 2024.[18]

Europe saw sales stagnate in 2024 as subsidy schemes and other supportive policies waned, but the share of electric car sales remained around 20% as growth in some countries compensated for lower sales in others. In the United States, EV sales grew about 10% from 2023-2024, from 1.42 million vehicles to 1.56 million, which represented 10% of total vehicle sales.[19] EV adoption is expanding beyond high-income countries, with emerging economies such as Thailand, India, Turkey and Brazil reporting record sales.[20] In Southeast Asia, EV sales grew by nearly 50% to represent 9% of all car sales in the region, with notably higher sales shares in Thailand and Viet Nam. In Brazil, the largest car market in Latin America, EV sales more than doubled to 125,000, or over 6% of total sales, in 2024. Sales in Africa also more than doubled, mostly due to growing sales in Egypt and Morocco, though EVs still represent less than 1% of total car sales across the continent. Policy support and relatively affordable EV imports from China played a central role in increasing sales in some emerging EV markets; for example, 85% of EVs sold in both Brazil and Thailand were Chinese-made. Across all emerging economies outside of China, Chinese imports made up 75% of the increase in EV sales in 2024.

FIGURE T-3.
Share of Total Final Energy Consumption in Transport, by Mode, 2022



Source: See endnote 14 for this section.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+80%

Electric truck sales surged by nearly 80% in 2024 – reaching close to 2% of the global truck market for the first time.

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Electric truck sales increased by nearly 80% globally in 2024 to reach close to 2% of total truck sales. In 2024, US nonprofit Climate United, with backing from the federal Greenhouse Gas Reduction Fund, launched a USD 250 million programme to lease up to 500 electric Class 8 trucks, alongside charging infrastructure provided by Forum Mobility, aiming to phase out diesel-powered drayage trucks at California's busiest seaports by 2035.[21]

Two- and three-wheelers are the road transport segment which is most advanced in terms of electrification; over 40% of two-wheelers and over 80% of three-wheelers sold in 2023 were electric.[22] As a result, 2/3-wheelers are the only vehicle category currently on track to achieve a net-zero fleet by 2050.[23] The rapid uptake of electric 2/3-wheelers is driven by low-cost technologies, low operating costs and supportive policies in key markets. Globally, their number has reached 340 million and they have come to play a critical role in transport decarbonisation, especially in emerging economies where two- and three-wheelers dominate short-distance and last-mile transport.[24] Viet Nam is among the fastest-growing markets for electric 2/3-wheelers, exceeding 100,000 units sold in 2023.

Public charging infrastructure has expanded rapidly, with the number of charging points doubling globally between 2021 and 2023. By the end of 2023, there were approximately 4.5 million public charging points worldwide, up from around 2.3 million in 2021.[25] China continues to dominate charger deployment, having installed more than 65% of both fast and slow public chargers globally. Fast charging infrastructure is expanding quickly, particularly along motorways and freight corridors. Globally, the number of DC fast chargers grew by 45% in 2023, with a notable rise in megawatt-scale chargers to accommodate commercial EV fleets and electric trucks.[26]

China continues to be the world's **EV manufacturing** hub, accounting for more than 70% of global production.[27] Chinese-headquartered automakers sold around 1.9 million EVs domestically – nearly 60% of their output – while exporting about 1.25 million units and accounted for nearly all of the 25% increase in global EV production.[28] In the European Union, production plateaued at 2.4 million electric cars in 2024.[29] North America saw contrasting trends: US EV production hovered around 936,000 units in 2024, while Mexico's EV output nearly doubled, from about 109,700 units in 2023 to an estimated 161,000 in 2024, driven by comparatively lower manufacturing costs.[30] Roughly 70% of Mexico's output was by US-headquartered manufacturers. Production also increased by 15% in Asia-Pacific countries other than China, reaching about 1 million EVs, mostly by incumbent carmakers from Japan and Korea.[31] In addition, massive overcapacity in EV battery production is driving global prices down, sharply reducing EV costs. US automakers have slashed prices by over USD 10,000, while Chinese manufacturers cut prices by USD 1,600 from 2022 levels.[32]

POLICY AND INVESTMENT IN ROAD TRANSPORT

Biofuel blending mandates have been implemented in at least 35 countries as of 2024 (→ *See Figure T-5*).[33] In February 2023, Indonesia set the world's most ambitious biodiesel blending mandate, which requires a blending rate of 35% starting in 2025.[34] Norway's 2024 National Budget mandates 19% biofuel blending for road transport fuels.[35] Belgium's 2024 regulation requires all fuel suppliers to achieve a biofuel blending rate of at least 5.7%.[36] Japan announced in November 2024 a national target for gasoline blending: 10% ethanol (E10) by 2030, with a further goal of 20% ethanol (E20) by 2040.[37] While most countries focus on mandates and blending targets, **fiscal and financial incentives for biofuels** remain limited. Only a handful of countries – such as Brazil, Canada, India, and Viet Nam – have adopted such measures. Brazil reinstated ethanol import duties, raising the rate to 18% in 2024 to protect domestic producers.[38] Canada provides tax exemptions on gasoline blends exceeding 10% ethanol and diesel blends above 5%, to reduce carbon tax exposure.[39] India has expanded excise tax exemptions to E12 and E15 gasoline, as well as to 20% biodiesel blends, while also taxing unblended fuels to encourage uptake.[40] Viet Nam reduced its ethanol import tariff from 15% to 10% in 2023 to support greater domestic biofuel use.[41]

In 2024 only Ecuador announced a new EV target, with a goal to electrify 20% of its public vehicle fleet, bringing the total number of countries with official **EV targets** to at least 68 globally.[42] At least 16 countries plus all 27 members of the EU have officially committed to banning **internal combustion engine (ICE) vehicle sales** by set target dates, though none were enacted in 2024.[43] At least 47 countries offer **fiscal or financial incentives for EV** adoption, through a total of 71 policies: 37 tax deductions or exemptions, and 34 subsidies or loans. New additions in 2024 include Belize, which waived EV import duties and launched a charging station plan, coordinated by Belize Electricity Limited, and Indonesia, which extended its incentives, waiving import taxes until the end of 2025, removing the luxury tax on all EVs and reducing VAT from 11% to just 1% for EV buyers throughout 2024.[44] The Netherlands introduced a national EV subsidy scheme that includes truck subsidies, tax deductions for vans, and grants for construction equipment and charging projects.[45] New Zealand's Low Emissions Heavy Vehicle Fund, launched in the second half of 2024, provides USD 27.75 million in grants – covering up to 25% of purchase or conversion costs – to help firms adopt zero- and low-emission heavy trucks, buses and vans.[46] China announced the extension in 2024 through 2027 of the Vehicle Purchase Tax Exemption policy for New Energy Vehicles.[47] Italy in 2024 introduced a USD 1.18 billion (EUR 1 billion) subsidy program for new EVs, providing buyers with up to USD 16,194 (EUR 13,750) per purchase.[48] Hong Kong has extended First Registration Tax (FRT) concessions for EVs until 31 March 2026, with electric commercial vehicles, motorcycles and motor tricycles continuing to receive a full FRT waiver.[49] Thailand in 2024 provided tax incentives to companies upgrading their fleets to electric trucks and buses.[50] South Korea allocated approximately USD 1.3 billion (KRW 1.7 trillion) in EV purchase subsidies, including USD 713 million (KRW 932 billion) for light-duty passenger vehicles, USD 107 million (KRW 140 billion) for light- and medium-duty commercial vehicles and USD 482 million (KRW 630 billion) for heavy-duty commercial vehicles.[51]

The global EV trade landscape continued to change in 2024, partly due to significant actions taken by the United States and the growing influence of bilateral trade relations with China. **Tariffs and local manufacturing incentives** implemented or announced included the European Union's newly imposed tariffs on EVs manufactured in China and the United States, with rates ranging from 7.8% for Tesla to 35.3% for SAIC and non-cooperating companies.[52] Canada introduced in October 2024 a 100% surtax on all Chinese-made EVs, alongside a 25% surtax on steel and aluminium imports from China.[53] In parallel, it introduced a 10% Electric Vehicle Supply Chain Investment Tax Credit in 2024 to support domestic production of cathodes, anodes, and battery cells and packs, aiming to reduce capital costs and strengthen its EV battery manufacturing sector.[54] Switzerland reinstated a 4% import duty on EVs, effective 1 January 2024, ending a tax exemption that had been in place since 1997.[55] Turkey initially imposed a 40% additional tariff (or a minimum of USD 7,000 per vehicle) on Chinese-made EVs in June 2024, effective from July 7, but later exempted Chinese automakers that committed to local investment in Turkey from the additional duty.[56] Germany has received USD 1.06 billion (EUR 902 million) in state aid from the European Commission to support the construction of a battery cell gigafactory in Heide, via grants and loan guarantees approved in January 2024 under the State aid Temporary Crisis and Transition Framework.[57] Thailand's new National EV roadmap targets 30% zero-emission vehicle production by 2030.[58] Bolivia introduced tax credits for domestically produced EVs and lithium

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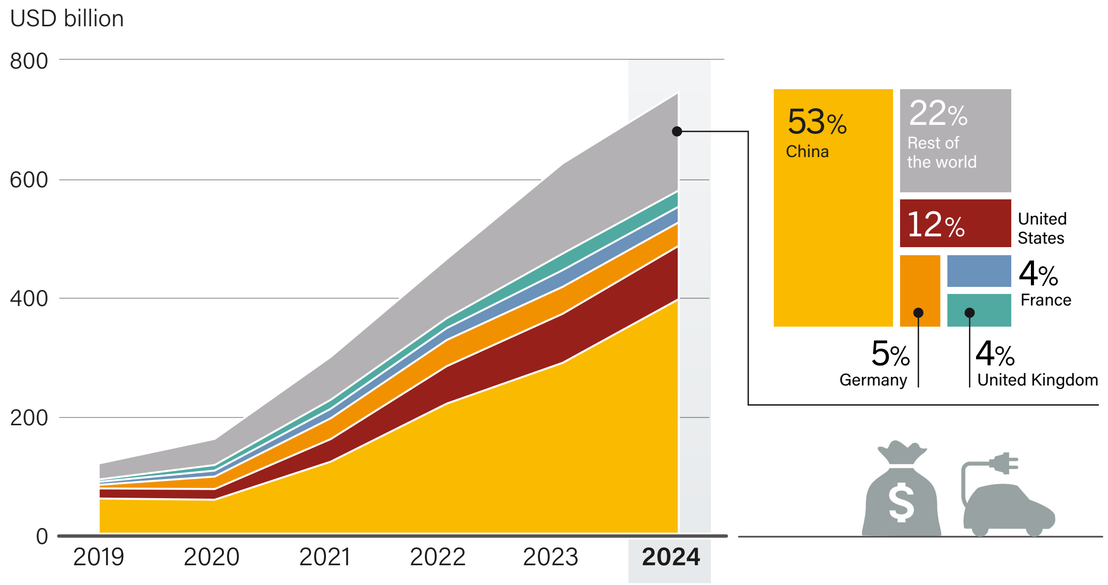
68 countries

had official EV targets by 2024, driven by growing national commitments to electrify fleets and reduce transport emissions.

FIGURE T-4.
Global Investment in Electric Vehicles and Charging Infrastructure by Major Country, 2019-2024



Source: See endnote 65 for this section.

757 USD billion

was invested globally in electrified transport in 2024, with over half coming from China alone.

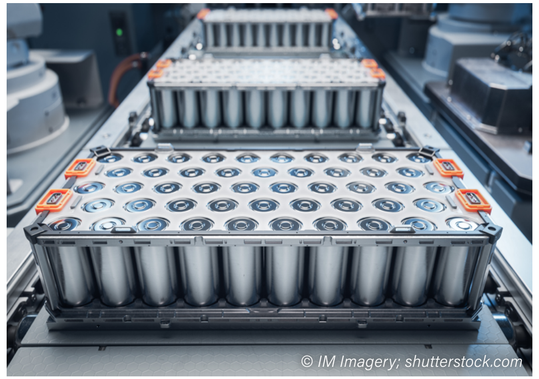
batteries.[59] Uganda approved a stamp duty tax exemption for EV manufacturers employing at least 80% Ugandan staff and meeting environmental standards.[60]

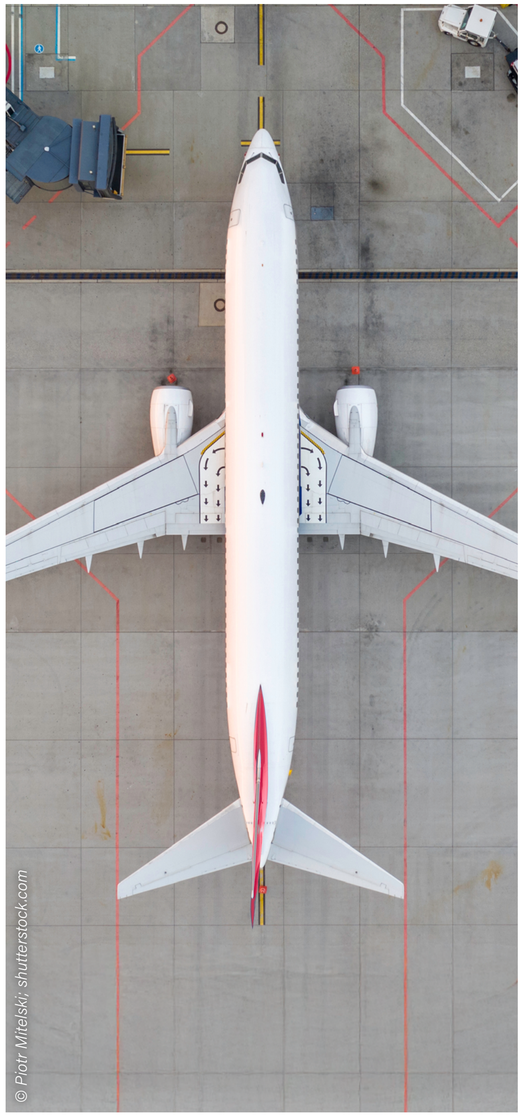
In 2024, several countries advanced policies to expand **EV charging infrastructure** as part of broader transport decarbonisation efforts. Korea finalised subsidy guidelines for EV charging facilities and will launch an installation support project in early 2025.[61] Belgium is funding new deployments of charging stations alongside LED lighting and solar panels in federal public buildings.[62] Croatia is investing in charging stations for buses, trains and maritime transport in the North Adriatic region.[63] Slovenia is financing charging infrastructure deployment coupled with pilot programmes deploying electric and hydrogen-powered buses.[64]

In 2024, **global investment in electrified transport** reached USD 757.4 billion, with the majority directed towards electric road vehicles (→ *See Figure T-4*).[65] China was responsible for the majority of the global total, USD 397.5 billion, with growth driven by widespread domestic EV adoption across various vehicle segments. EU member states invested USD 146.9 billion, including USD 39.5 billion by Germany, USD 27.2 billion by France and USD 8.2 billion by Italy. The United States invested USD 89.8 billion, reflecting a 9% growth in electric vehicles and supporting infrastructure.[66] Although China tops total investment, the EU boasted the highest per capita spending on electrified transport in 2024.[67]

INNOVATION IN ROAD TRANSPORT

The United Kingdom is piloting large-scale second-life battery programmes targeting commercial fleets – especially buses and trucks – to validate the residual value of used EV batteries. In partnership with operators, utilities and energy storage firms, these pilots test the real-world deployment of retired batteries, aiming to create a robust marketplace for second-life batteries. This could significantly improve the financial viability of commercial EV fleets.[68] Brazil is pioneering flex-fuel hybrid vehicles that can run on ethanol, gasoline or electricity – an innovation led by automakers like Toyota, GM and Stellantis.[69] These hybrids leverage Brazil's extensive ethanol infrastructure to offer a lower-emission, cost-effective alternative to fully electric vehicles, accelerating decarbonisation in the near term. China is funding the development of EV charging and battery swapping facilities across selected provinces[70] and has earmarked new funds for fuel cell vehicle demonstration projects.[71]

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AVIATION

Aviation remains one of the most energy- and emissions-intensive transport subsectors per passenger-kilometre travelled. As of 2023, aviation generated around 2.4% of total global CO_2 emissions. In the same year, it accounted for approximately 10% of global transport final energy consumption,[72] but around 12% of transport-related emissions, due to its near-total reliance on fossil fuels.[73] In 2023, global aviation fuel demand reached approximately 300 million tonnes, nearly on par with pre-COVID-19 levels, with commercial air traffic exceeding 90% of 2019 levels.[74] Despite efficiency improvements, including new aircraft technologies and operational measures, total emissions from aviation continue to rise, driven by sustained growth in air travel, particularly in Asia and the Middle East.

Sustainable aviation fuel (SAF) is widely viewed as the most viable decarbonisation solution for aviation in the medium term, but currently plays a marginal role in the sector. Global SAF production more than doubled from 2022 to 2023 but reached only 600 million litres, about 0.2% of total aviation fuel use.[75] Several significant challenges have thus far prevented SAF's widespread adoption. Cost remains a major barrier, with SAF priced two to five times higher than conventional jet fuel.[76] Supply constraints stemming from limited availability of sustainable feedstocks (e.g. waste oils, agricultural residues and biomass) prevent large-scale production. Technological and economic hurdles also persist, with high capital costs and the need for certification slowing expansion.[77]

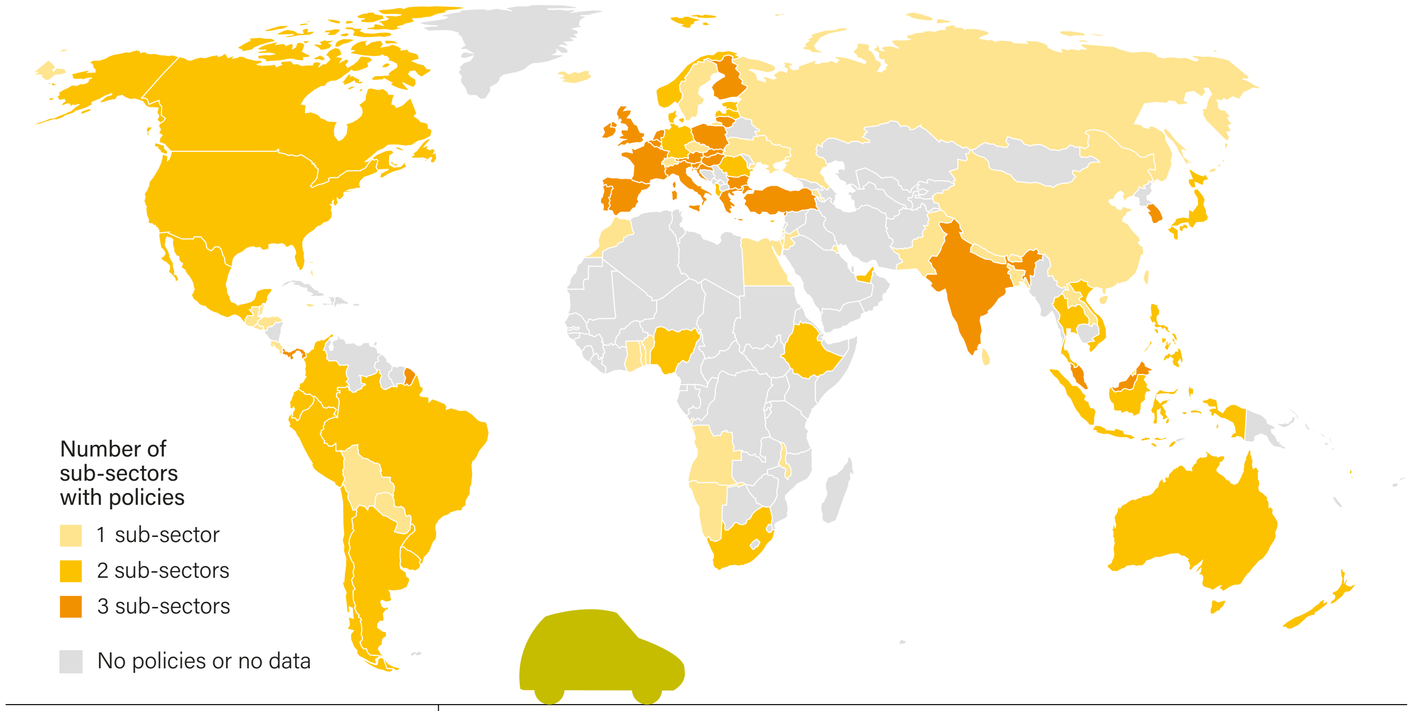
POLICY AND INVESTMENT IN AVIATION

In 2024, policy momentum around SAF accelerated globally, with at least six countries introducing mandates, targets, and funding mechanisms to support SAF adoption and broader decarbonisation of the aviation sector. Chile established a national SAF Roadmap in April 2024, setting a target for 50% SAF use in the aviation sector by 2050.[78] Singapore announced in its 2024 Sustainable Air Hub Blueprint a requirement for all flights departing from the country to use at least 1% SAF, starting in 2026.[79] In august 2024, South Korea, the world's largest exporter of jet fuel, implemented a SAF mandate, requiring all international flights to use at least 1% SAF starting in 2027.[80] This will increase to 3-5% SAF by 2030, contingent on global developments and SAF availability. Norway's 2024 National Budget mandates a biofuel blending rate of 0.5% for aviation.[81] Brazil adopted the Fuel of the Future law, which includes the National Program for Sustainable Fuel for Aviation, requiring fuel operators to reduce carbon emissions from domestic flights by 1% by 2027 and 10% by 2037 through the use of SAF.[82] In 2024, the United Kingdom enacted legislation for sustainable aviation fuel initiatives, setting minimum blending rate targets of 2% by 2025, 10% by 2030 and 22% by 2040, including specific sub-targets for synthetic fuels.[83]

INNOVATION IN AVIATION

Incremental improvements in engines, materials and aerodynamics have led to marginal emissions reductions in aviation, but revolutionary changes – including new airframe configurations and alternative propulsion technologies using electricity or hydrogen – will be essential to the decarbonisation of the sector.[84] In December 2023, Toulouse-Blagnac Airport in France inaugurated Europe's first airport-based green hydrogen production and distribution station. The station produces over 400 kg of green hydrogen daily, using 100% renewable electricity from local solar and hydropower sources. The project is a partnership with Airbus and local manufacturers and is backed by the French government with an investment of USD 6.1 million (EUR 5.2 million).[85] In late 2023, Airbus successfully tested the iron pod, a hydrogen propulsion system designed for its ZEROe hydrogen-powered aircraft concept. This system combines hydrogen fuel cells and electric motors to deliver 1.2 megawatts of power, marking a key milestone toward Airbus's goal of launching a hydrogen aircraft by 2035. The next steps include flight testing planned for 2026.[86] A Chinese battery manufacturing company, CATL, conducted successful test flights with a four-tonne electric aircraft and aims to launch an eight-tonne model by 2027-2028, with a range of 2,000 to 3,000 km. Commercial deployment of the electric aircraft is also planned for 2027-2028.[87]

FIGURE T-5.
Countries with Transport Policies (Incentives, Targets or Mandates) for EVs, Biofuels and Aviation, 2024



99 countries with transport policies

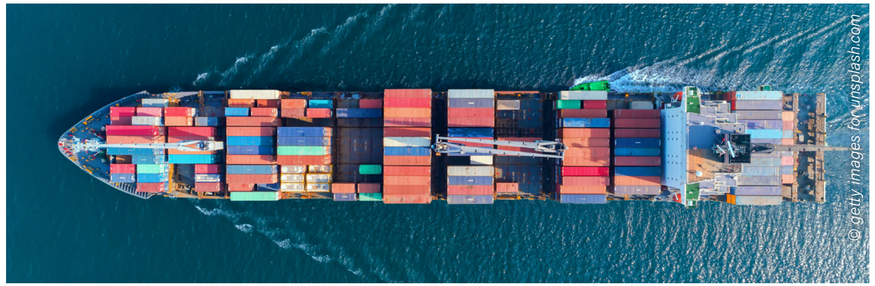
Number of countries with policies for EVs, biofuels or aviation

44 in one sub-sector

32 in two sub-sectors

23 in three sub-sectors

Source: See endnote 33 for this section.



SHIPPING

Shipping industry emissions increased 5% in 2022 to 2% of the global total. The industry remains almost entirely reliant on fossil fuels, with oil products supplying over 99% of international shipping energy demand. Biofuels met less than 0.5% of demand in 2022. Although EU regulations, hydrogen and ammonia pilot projects, and investment in innovative vessels signal a growing commitment to decarbonisation, advancements have been uneven and have thus far fallen short of the ambition required to meet long-term decarbonisation targets.[88]

Recent ship orders indicate a clear shift towards alternative fuels, with major shipping company Maersk commissioning 19 methanol dual-fuel containerships in 2022. Other major companies, such as CMA CGM, Cosco and Cargill, have since placed similar orders. Given long vessel lifetimes and slow turnover, these orders are crucial for gradually decarbonising the maritime fleet. China, Japan and Korea are at the forefront of designing and constructing ammonia-ready vessels, with innovative vessels awarded an Approval in Principle, the initial certification that verifies compliance with essential safety and regulatory standards before detailed design and construction proceed.[89]

New fuelling infrastructure is essential for decarbonisation because renewable fuels such as ammonia, hydrogen and biofuels require specialized storage, handling and delivery systems that differ significantly from those of traditional fossil fuels. Without appropriate bunkering facilities and shore-side power connections, ships cannot effectively use these cleaner fuels, limiting their adoption.

POLICY AND INVESTMENT IN SHIPPING

Very few policies and regulations are in place for clean shipping and binding regulations remain limited, with the most notable efforts currently concentrated in Europe. Norway's 2024 National Budget mandates **biofuel blending** of 6% for shipping.[90] In July 2023, the International Maritime Organization (IMO) adopted a revised decarbonisation strategy aiming for net-zero emissions from international shipping by 2050, with interim reduction targets of 20-30% by 2030 and 70-80% by 2040 relative to 2008.[91]

Effective January 2024, the EU Emissions Trading System (ETS) includes shipping emissions from vessels with a gross tonnage (gt) of over 5,000, requiring companies operating in the European Economic Area to surrender allowances covering 40% of emissions in 2024, 70% in 2025 and 100% in 2026.[92] The FuelEU Maritime Regulation, which began implementation in August 2024, sets progressively stricter emissions intensity limits for ships over 5,000 gt calling at European ports, aiming to reduce emissions by 2% in 2025 and eventually by 80% by 2050.[93]

Sixty-two **green shipping corridor initiatives**[i] have been announced globally, including 18 new ones since 2023. Green corridors cover all world regions and nearly all ocean-going vessel segments, and involve just under 245 stakeholders from the shipping and energy value chains. Methanol is the leading fuel promoted by the initiatives, featured in 18 corridors. Ammonia features in 15 initiatives, primarily in bulk carrier projects and some fuel-agnostic efforts for container ships. Of the 15 battery-electric initiatives, 12 target batteries as the main propulsion, while 3 use it in hybrid systems; most of these projects focus on short sea routes in Northern Europe.[94]

Germany, Singapore and South Korea have each developed **national hydrogen strategies with a strong maritime focus**, targeting shipping emissions and port-based infrastructure.[95] Each strategy reflects national strengths – shipbuilding, import infrastructure and global port integration – while aligning with global maritime decarbonisation goals.

Clean shipping investment remained limited between 2022 and 2024, reaching only USD 0.5 billion in 2024. Spending increased in Europe, the Middle East and Africa, notably in the EU-27, while investment stagnated in Asia-Pacific. Methanol-capable vessels dominated orders. Although modest, the rise in Europe suggests a gradual but uneven momentum toward low-carbon maritime technologies.[96]

INNOVATION IN SHIPPING

In 2024, the maritime shipping industry witnessed advancements in advanced fuel applications and dual-fuel engines. Orders for alternative-fuel-capable vessels surged by over 50% to 600, bringing the total alternative-fuel order book to approximately 1,740 ships.[97] The largest group of orders, 119, was for methanol-capable ships, led by Maersk, which took delivery of nine new dual-fuel methanol vessels and retrofitted its first large container ship, the *Maersk Halifax*. The use of ammonia also gained momentum, with Fortescue's Green Pioneer conducting the world's first ammonia bunker trial in Singapore in early 2024, providing critical real-world validation and earning regulatory approvals.[98]

At the same time, major container shipping companies such as Maersk, CMA CGM, COSCO and MSC are increasingly turning to dual-fuel engines as a hedge against future uncertainty in fuel availability and regulation. As of October 2024, dual-fuel vessels represented 65% of all container ship orders, a sharp rise from just 4% in 2018, with 522 vessels on order capable of operating on LNG, methanol, hydrogen or ammonia.[99] While LNG remains the dominant choice and can deliver emissions reductions of up to 23%, concerns over methane slip and long-term viability persist. To diversify further, companies such as CMA CGM are blending in biofuels, achieving up to 50% emissions reductions on select routes.[100]

62 green corridors

have been announced globally, connecting ports and stakeholders to accelerate the shift to low- and zero-emission shipping.

The Green Pioneer, sailing along the river Thames; London, United Kingdom

i **Green shipping corridor initiatives** refer to collaborative efforts between ports, shipping companies and governments to establish specific maritime routes where low- or zero-emission vessels are prioritised and supported through enabling infrastructure, fuels and regulatory frameworks.

RAIL TRANSPORT

The global rail sector is highly energy-efficient, carrying approximately 8% of the world's passengers and 7% of freight yet generating only about 2% of total transport energy demand[101] and 2% of transport-related emissions.[102] Per passenger-kilometre, rail produces the fewest emissions of any motorised mode of transportation: around 19 g CO_2-equivalent, one-third of the emissions of buses and one-sixth of those of air travel.[103]

Rail is often cited as a decarbonisation success story, thanks largely to extensive electrification and the increasing use of renewable energy. India exemplifies this progress: as of early 2024, approximately 94% of Indian Railways' broad-gauge network was electrified, a dramatic rise from just 33% in 2014.[104] Indian Railways aims to achieve net-zero emissions by 2030, primarily by completing 100% electrification and transitioning toward 100% renewable electricity for its operations.[105] The Netherlands already powers its electric trains fully with wind energy.[106] Globally, rail networks continue to develop steadily. In 2024, EU member states focused on modernising rail infrastructure and improving cross-border connectivity.[107] China continued to expand its high-speed rail system at an unprecedented pace, with the goal to complete 60,000 km of high-speed lines by 2030.[108] While in South Africa, the African Development Bank is supporting a USD 8.1 billion investment plan by Transnet that includes a major rail revamp and regional freight corridor development.[109]

POLICY AND INVESTMENT IN RAIL

Strong policy support and investment are driving further rail electrification and infrastructure modernisation especially in Europe and Asia. Germany has set a goal of electrifying 75% of its rail network by 2030, though reaching this target will require accelerated efforts.[110] EU recovery and resilience programmes have also channelled resources into improvements such as new electrified lines, the removal of infrastructure bottlenecks (like cross-border gaps) and the deployment of advanced signalling technologies. Norway's 2024 National Budget allocated about USD 3 billion (NOK 32 billion) to modernisation of its railway network, including major infrastructure projects and a nationwide rollout of a digital signalling system (ERTMS) to improve capacity and reliability.[111] Beyond tracks and signals, operators are investing in energy-saving technologies like LED lighting and efficient equipment as part of network modernisation. The Delhi Metro in India recently retrofitted 155 stations and facilities with nearly 100,000 LED lights, reducing energy consumption substantially.[112] Similar lighting upgrades and station energy efficiency retrofits are being implemented in Europe. Meanwhile, many countries offer subsidies or green bonds to shift freight from road to rail and to procure electric locomotives and rolling stock.[113]

INNOVATION IN RAIL

Hydrogen-powered and battery-electric trains are gaining traction as alternatives to electrification of railway lines. In 2022, Germany inaugurated the world's first all-hydrogen train fleet on a regional line, with 14 hydrogen trains replacing diesel units on 100 km of track.[114] Several other European countries have ordered hydrogen trains as they seek to eliminate the use of diesel on secondary routes. Japan, meanwhile, has unveiled "HYBARI," a prototype hydrogen-hybrid train that combines fuel cells and batteries, aiming for full commercial operation by 2030.[115] Battery-electric engines are also increasingly used. Japan's BEC819 series (DENCHA) trains – the world's first battery-powered passenger trains charged from overhead wires – have been in service since 2016, running mainly on non-electrified lines and recharging on electrified segments.[116] Over five years, the DENCHA fleet has eliminated around 2.7 million kg of CO_2 emissions and demonstrated the effectiveness of batteries in replacing diesel on low-traffic routes.[117] In Europe, manufacturers are also deploying new battery and hybrid rolling stock. Italy's Trenitalia recently introduced a quadruple-mode train that can run on electricity from overhead wires, diesel, battery power or a hybrid diesel–battery mode for greater efficiency and flexibility on non-electrified routes.[118] There is also a move toward establishing low-carbon rail corridors. For instance, in California a nine-mile commuter rail line is serving as a testbed for hydrogen-powered trains, where the FLIRT H_2 train will run exclusively.[119]

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JR Kyushu BEC819 series commuter train. Battery-powered train, that can be operated on a non-electrified line; Fukuoka, Japan

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