MODULE 3 | 3.5

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Rail

SLOCAT Partnership on Sustainable, Low Carbon Transport

Transport, Climate and Sustainability
Global Status Report - 3rd edition

Key findings

- A modal shift to rail, stimulated by policy initiatives based on ambitious targets, can play a decisive role in cutting carbon emissions from the transport sector, according to the International Energy Agency's scenario for net zero emissions by 2050.
- Despite growth in passenger and freight rail activity during 2010-2020, only 6-7% of passenger journeys were made by rail, on average. Freight logistics flows will need to exploit rail's potential to achieve higher volumes and efficiency.

Demand trends

- Global passenger rail activity grew 29% between 2010 and 2019, from 3.22 trillion to 4.16 trillion passenger-kilometres.
- Due to mobility restrictions related to the COVID-19 pandemic, global passenger demand for rail services fell 37.7% in 2020 to 2.59 trillion passenger-kilometres.
- Rail use trends in the first half of 2022 varied widely by region and rail mode (passenger versus freight transport).
- Global rail freight activity increased 12.5% between 2010 and 2019, to 11.3 trillion tonne-kilometres, then fell 4% in 2020 to 10.9 trillion tonne-kilometres. By region, Asia and Oceania accounted for 41% of all rail freight activity in 2020, followed by the Americas (28%).
- The Russian Federation's invasion of Ukraine had strong impacts on passenger and freight rail activity, as rail freight between Asia and Europe dropped by a quarter in 2022.
- Between 2010 and 2020, rail lines globally were extended by nearly 50,000 kilometres to reach 1.1 million kilometres, although very little growth occurred outside of Asia
- High-speed rail activity dropped sharply in 2020, falling 50% on average across countries. However, the pandemic did not stop the development of infrastructure, as the global high-speed rail network expanded by more than one-third from 44,000 kilometres in 2017 to nearly 59,000 kilometres in 2022.
- High-speed rail can increase the modal share of rail by replacing car trips and shorter flights.
- Operators around the world are upgrading their rail fleets, with investments in rail rolling stock projected to increase 6% a year between 2019 and 2024 across all geographies.

Emission trends

- Rail has the lowest greenhouse gas and energy intensity of all transport modes, emitting on average 19 grams of carbon dioxide (CO_2) equivalent per passenger-kilometre in 2021, one-tenth the emissions of a medium-sized passenger car.
- Greater use of rail could reduce global transport emissions 11-16% in 2050 compared to a business-as-usual pathway, saving up to 300 million tonnes of emissions annually in China, India and North America.
- Rail is the most electrified mode of transport, with around 45% of its energy use coming from electricity in 2021. This share is projected to reach two-thirds by 2030 (particularly in freight), and growth in hydrogen use is also anticipated. In 2021, freight rail consumed four times more energy than passenger rail.
- Because trains are large energy consumers, decarbonising the electricity grid through the use of renewable energy is an important step to delivering net zero railways.
- When trains are powered by renewable hydrogen, they provide an almost silent ride and emit only steam and condensed water, avoiding up to 700 tonnes of CO_2 emissions annually compared to the equivalent regional diesel train.

Policy developments

- As part of national plans for pandemic recovery, between 2020 and 2022 governments launched plans to upgrade and develop rail lines and to decarbonise transport, although public spending for road transport remains higher than for rail.
- Shifting transport activity to rail is key to decarbonising the global transport sector. To meet global climate targets for 2050, an estimated 15% of flights and more than 2% of private vehicle road travel need to be moved to high-speed rail.
- Railway expansions (conventional and high-speed rail) are planned in all regions to improve the connectivity and convenience of rail travel. The global high-speed rail network is projected to grow from around 59,000 kilometres in 2022 to 78,000 kilometres in the next years.
- As of 2022, 9 out of the 30 countries that submitted updated Nationally Determined Contributions towards reducing emissions under the Paris Agreement mentioned solutions in the rail sector, mostly as a mitigation action.

Overview

Rail transport is considered to be the cleanest mode of collective passenger transport, as it has the lowest greenhouse gas and energy intensities. High rates of electrification and energy efficiency in operations make rail the least carbon-intensive transport mode per passenger- or tonne-kilometre. The COVID-19 pandemic and related restrictions greatly impacted rail operations worldwide, especially for passenger services. As countries and economies recover, rail demand has gradually returned to near pre-pandemic levels.

A modal shift to rail, stimulated by policy initiatives based on ambitious targets, can play a decisive role in cutting carbon emissions from the transport sector, according to the International Energy Agency's scenario for net zero emissions by 2050. [1] As countries seek to transition to more sustainable transport systems, several economic recovery packages have included efforts to increase the modal share of rail. However, these measures remain insufficient to achieve the emission reductions needed in the transport sector to keep global temperature rise within 1.5 degrees Celsius.

Despite growth in passenger and freight rail activity during 2010-2020, only 6-7% of passenger journeys were made by rail, on average.[2] Studies suggest that this needs to grow more than 40% by 2030 to decarbonise mobility in line with the Paris Agreement goals.[3] **Freight logistics flows will also need to exploit rail's potential to achieve higher volumes and efficiency.**[4]

Demand trends

Global passenger rail activity grew 29% between 2010 and 2019, from 3.22 trillion to 4.16 trillion passenger-kilometres.[5] **Due to mobility restrictions related to the COVID-19 pandemic, global passenger demand for rail services fell 37.7% in 2020 to 2.59 trillion passenger-kilometres.**[6] Despite the restrictions, many rail companies maintained the same level of service to ensure transport for essential workers and equipment across countries.[7] Rail accounted for the lowest share of overall transport demand in 2021, at 3%, followed by aviation (8%).[8]

- By region, the greatest declines in rail passenger traffic in 2020 were in Africa (59.2%) and the Americas (63.4%), whereas passenger traffic was less affected in Asia and Oceania (see Figure 1).[9]
- In 2020, the rail operator SNCF in France used high-speed trains to transport COVID-19 patients and medical staff around the country, adapting double-decker passenger trains to offer medical services and adding extra cars for safety in case of collision.[10]

Rail use trends in the first half of 2022 varied widely by region and rail mode (passenger versus freight transport). Although passenger traffic improved overall compared to 2021, for many companies the total number of passenger-kilometres travelled remained below 2019 levels despite encouraging growth.[11] By 2022, rail ridership returned to near pre-pandemic levels in most developed countries as demand for leisure travel surged.[12] However, business travel by rail has recovered more gradually and may eventually find a new equilibrium below that of 2019 due to more remote working and teleconferencing.[13]

- To boost ridership, the Southeastern Pennsylvania Transportation Authority (SEPTA) in the United States announced various initiatives under its 2023 budget, including a USD 10 Neighborhood FleX DayPass targeting riders travelling shorter distances, which can be used for up to 10 rides in a single day across various transport modes (including buses, subways, trolleys and regional rail).[14]
- In Japan, JR East expanded its in-station and in-train services to retain business travellers by providing shared offices and tools to improve concentration for work in trains, such as augmented-reality glasses and separation screens.[15] It also created new services to encourage "workation" (work and vacation trips) by combining railway, hotel, car rentals and remote-work offerings.[16]
- In Switzerland, rail projects planned for 2025 and 2035 could help raise public transport's share of total traffic by 3% to 24%.[17]

Global rail freight activity increased 12.5% between 2010 and 2019, to 11.3 trillion tonne-kilometres, then fell 4% in 2020 to 10.9 trillion tonne-kilometres.[18] **By region, Asia and Oceania accounted for 41% of all rail freight activity in 2020, followed by the Americas (28%)** (see Figure 2).[19]

- As of 2021, around 10% of cargo in South Africa – a total of 6.7 million tonnes – had been shifted from road to rail through the Transnet Road to Rail Migration Plan.[20]

FIGURE 1. Passenger rail activity by region, 2010-2020

Source: See endnote 9 for this section.

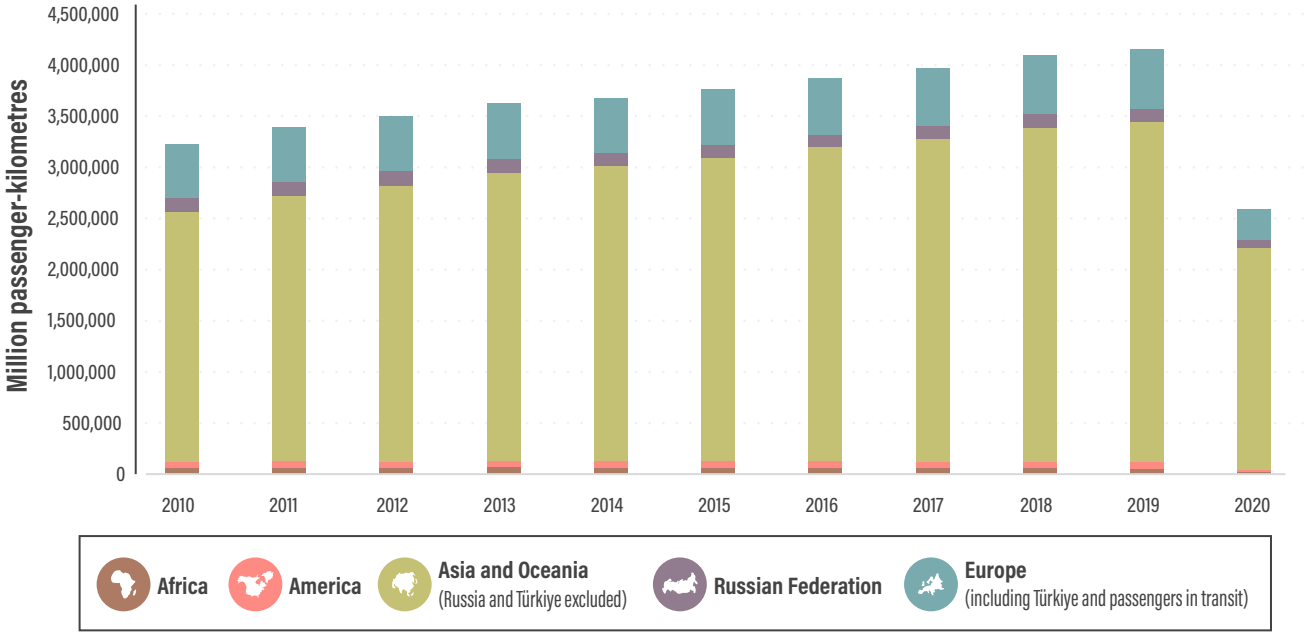


FIGURE 2. Freight rail activity by region, 2004-2020

Source: See endnote 19 for this section.

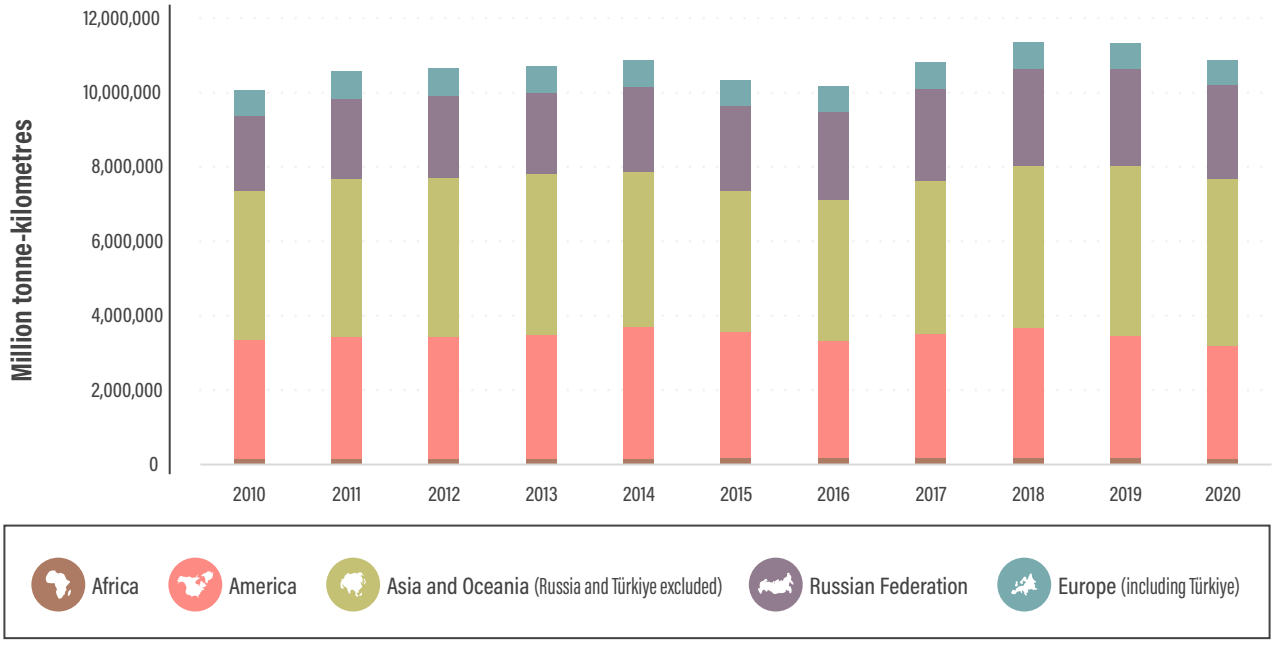


TABLE 1. Status of high-speed rail lines, by region, as of 2021 (in kilometres)

Source: See endnote 31 for this section.

Region	In operation	Under construction	Planned	Long-term planning
Africa	186	0	2,210	4,195
Asia-Pacific	44,428	14,367	6,893	18,320
Europe	11,990	3,062	5,913	3,316
Latin America	0	0	0	638
Middle East	1,501	2,006	3,139	1,831
North America	735	274	1,488	5,307
Total	**58,840**	**19,709**	**19,643**	**33,607**

The Russian Federation's invasion of Ukraine had strong impacts on passenger and freight rail activity, as rail freight between Asia and Europe dropped by a quarter in 2022.[21] Rail-based container-traffic between Europe and China fell 22% in 2022.[22] Rail freight activity along the Middle and Southern Silk Roads, which do not go through the Russian Federation, is expected to grow from 6,900 twenty-foot equivalent in 2021 to 760,000 twenty-foot equivalent in 2030.[23]

- In 2022, Germany implemented the "9 Euro" ticket in response to the energy crisis spurred by the Russian invasion of Ukraine. For a reduced monthly fare of EUR 9 (USD 9.6), users were able to use local and regional public transport from June to August 2022, leading to a 3% decline in car traffic compared to the same period in 2019.[24] A survey found that 35% of 1,000 respondents used public transport more often and 22% shifted their trips from private to public transport.[25] In January 2023, Germany introduced the successor Deutschlandticket, a EUR 49 (USD 52) monthly ticket for public and regional transport.[26]
- In 2022, German rail freight operator DB Cargo implemented measures to alleviate supply chain constraints following the Russian invasion of Ukraine, particularly in delivering grain across the region (see Box 1).[27]

Between 2010 and 2020, rail lines globally were extended by nearly 50,000 kilometres to reach 1.1 million kilometres, although very little growth occurred outside of Asia (see Figure 3).[28]

High-speed rail activity dropped sharply in 2020, falling 50% on average across countries.[29] **However, the pandemic did not stop the development of infrastructure, as the global high-speed rail network expanded by more than one-third from 44,000 kilometres in 2017 to nearly 59,000 kilometres in 2022** (see Figure 4).[30] The network is expected to grow another one-third in length in the coming years, with 19,709 kilometres of high-speed lines under construction as of 2022 and a further 19,643 kilometres planned (see Figure 5 and Table 1).[31] **High-speed rail can increase the modal share of rail by replacing car trips and shorter flights** (see Figure 6).[32]

BOX 1. Support from the international railway community following the Russian invasion of Ukraine

Following the Russian Federation's invasion of Ukraine in February 2022, the International Union of Railways (UIC) launched the Refugee Task Force in March to support companies, partner associations and organisations to tackle the challenges arising from this humanitarian crisis. The Task Force exchanged best practices and know-how on the management of migration flows, establishing information exchange in real time between train operators and infrastructure managers to accommodate Ukrainian refugees in railway stations, preparing communication plans and addressing any security issues.

- Ukrainian railways reported that the number of passengers leaving and entering Ukraine by train had evened out by mid-2022. Of 30,800 rail passengers on international routes in the week of 4 July, 15,500 left Ukraine and 15,300 entered the country.

In 2022, Germany's rail freight operator DB Cargo announced a "grain bridge" for Ukrainian exports to German ports in Rostock, Hamburg and Brake (near Bremerhaven). The network created for the transport of relief goods to Ukraine would be "rotated" for this purpose, according to the company, with several trains running per week. Much of the transport would go through Romania, but DB Cargo's subsidiaries in Poland and other countries were also involved.

Source: See endnote 27 for this section.

FIGURE 3. Length of rail lines by region, 2010-2020

Source: See endnote 28 for this section.

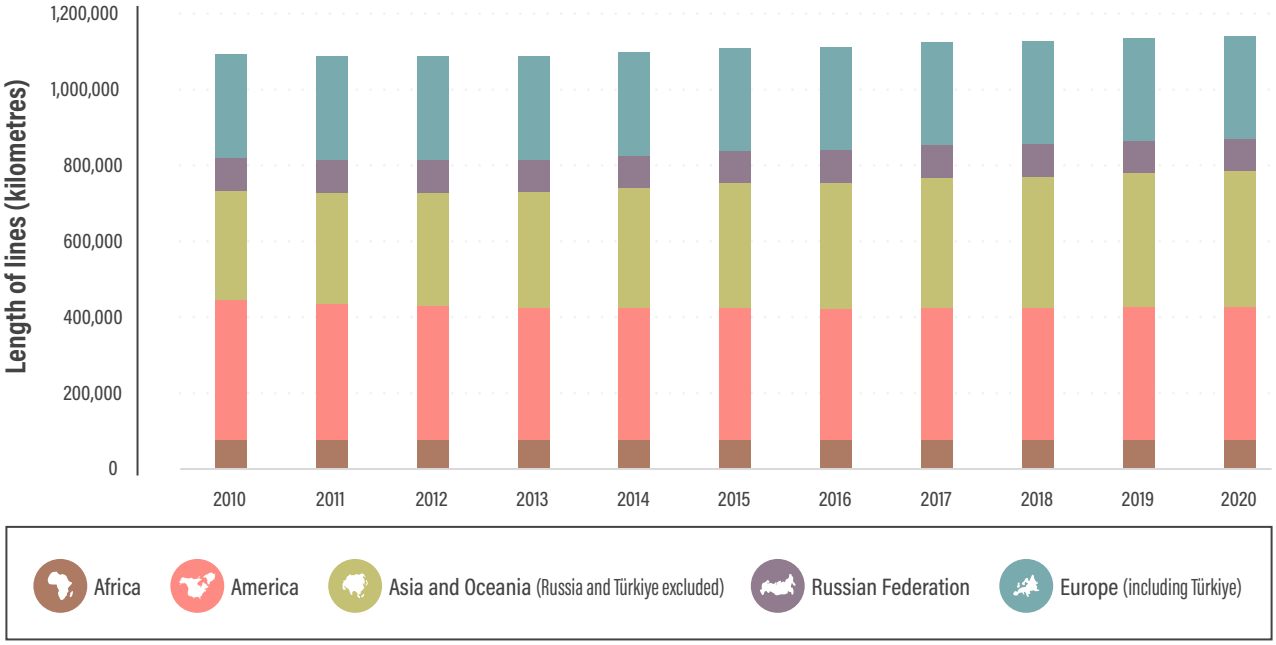


FIGURE 4. High-speed rail development in selected countries/regions, 2010-2021

Source: See endnote 30 for this section.

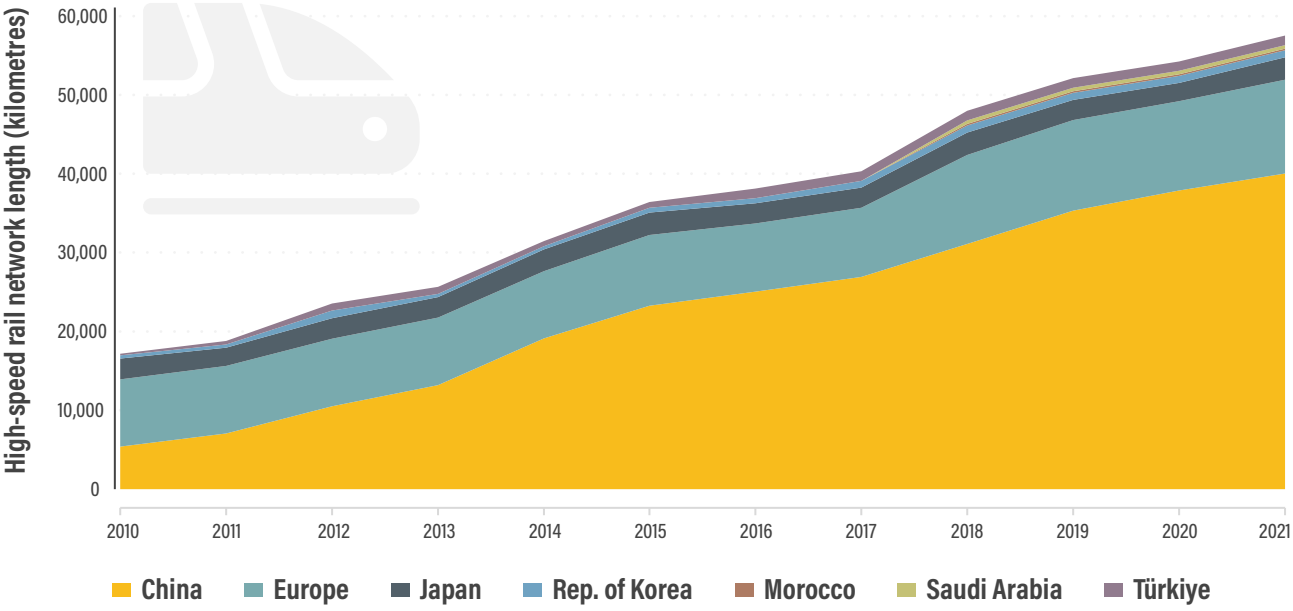


FIGURE 5. Status of global high-speed rail network by country/region, as of 2021

Source: See endnote 31 for this section.

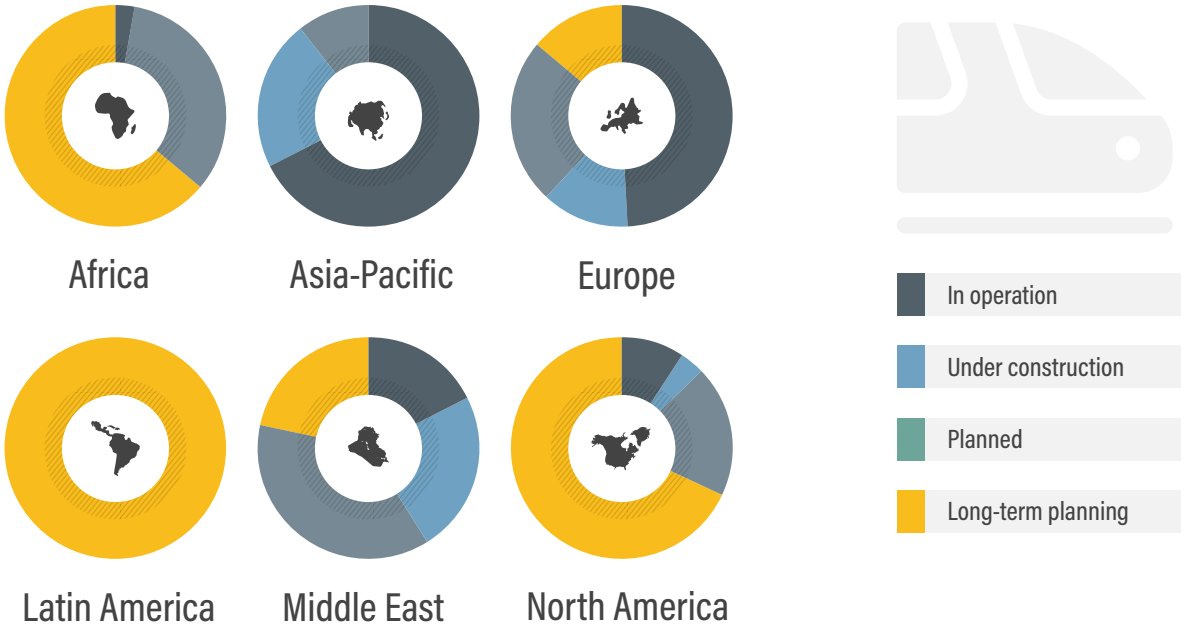
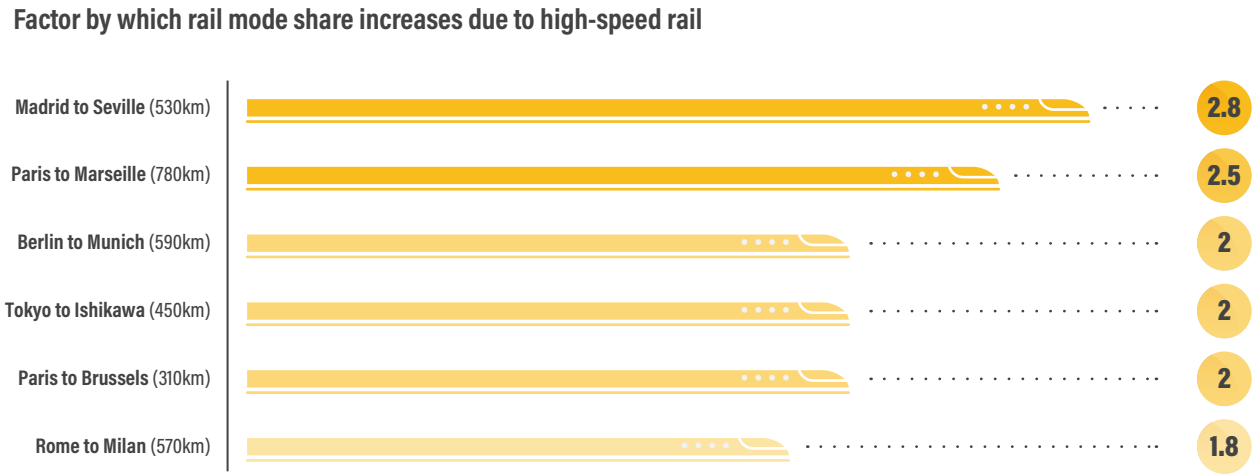


FIGURE 6. Increases in rail modal share due to high-speed rail

Source: See endnote 32 for this section.



- China has led the high-speed rail expansion, adding around 80% of the new infrastructure between 2017 and 2022.[33] China's high-speed rail network grew from 33,330 kilometres in 2020 (already the world's largest network), to 40,040 kilometres in 2021, to around 42,000 kilometres by the end of 2022 (see Figure 4).[34]
- Europe boasts the second largest high-speed rail network and aims to double its ridership by 2030 compared to 2015, with a vision of replacing short-haul flights with convenient and sustainable high-speed rail service.[35]
- Latin America does not have existing high-speed rail, but projects are planned in Brazil, Chile and Mexico.[36]
- In Africa, where existing railways are mostly single lines connecting larger cities to ports (except in northern Africa and South Africa), numerous high-speed projects have been proposed or started but have faced delays due to political conflict, funding and the pandemic. Morocco opened Africa's first high-speed rail service (323 kilometres) in 2018 and aims to expand it by 492 kilometres in the coming years.[37] Egypt is developing the Electric Express Train project, a 660 kilometre high-speed rail that will connect the port cities of Ain Sokhna, Marsa Matrouh and Alexandria.[38]

Operators around the world are upgrading their rail fleets, with investments in rail rolling stock projected to increase 6% a year between 2019 and 2024 across all geographies.[39] Countries have added new high-speed rail as well as standard-speed services.

- Brazil has plans for 10 new rail lines totalling 3,300 kilometres and USD 10.1 billion, under its new regulatory framework for railways, approved in 2021.[40]
- Romania plans to construct a high-speed railway from Bucharest to Budapest (Hungary).[41]
- Overnight trains have experienced a revival in Western Europe in recent years. In 2021, SNCF in France re-established night train connections between Paris and Nice and launched the Paris-Munich-Vienna service in partnership with Austria's ÖBB.
- Other operators in Europe, such as FlixTrain in Germany, revived slower long-distance trains with intermediate stops at smaller cities.[42]

Emission trends

Rail has the lowest greenhouse gas and energy intensity of all transport modes, emitting on average 19 grams of carbon dioxide (CO_2) equivalent per passenger-kilometre in 2021, one-tenth the emissions of a medium-sized passenger car.[43] Overall, energy use and emissions from rail have fallen since 2000 due to rising energy efficiency and the phasing out of diesel fuel (see Figure 7).[44] However, emissions increased in 2020 because trains continued to run to ensure transport for essential workers and equipment, but were operating with fewer people, leading to an increase in the carbon intensity of operations per passenger-kilometre.[45]

FIGURE 7. CO_2 emissions intensity of global rail, 2000-2020

Source: See endnote 44 for this section.

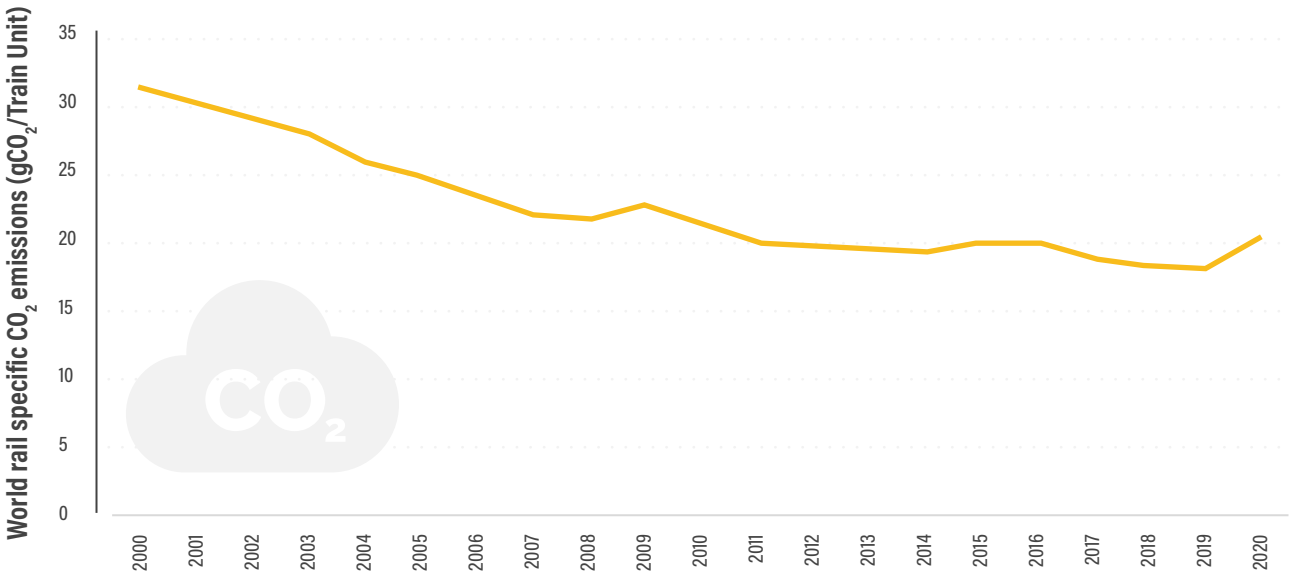
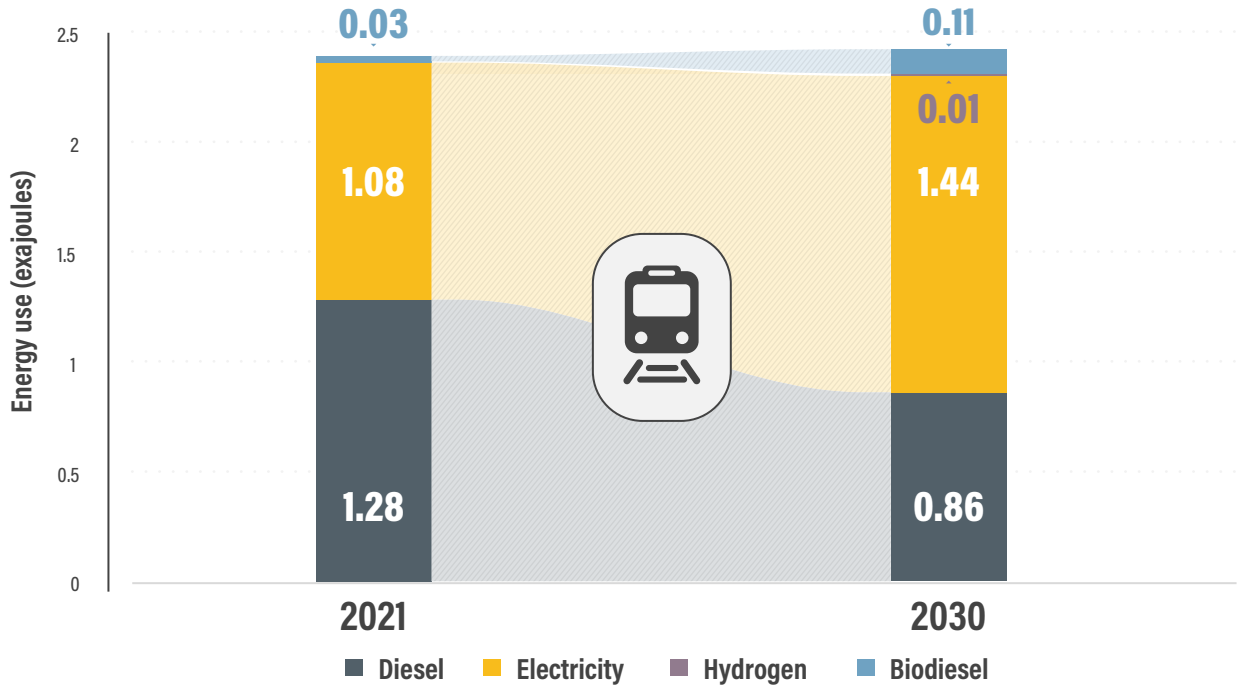


FIGURE 8. Energy use in the rail sector by source, 2021 and projections for 2030

Source: See endnote 51 for this section.



- For European rail networks, CO_2-equivalent emissions from passenger rail fell by around one-third between 2005 and 2021 (34.3% market based or 26.6% location-based).[46]
- The carbon intensity of rail freight continued to improve in 2021, showing a 4.3% reduction in grams of CO_2-equivalent per tonne-kilometre.[47]

Greater use of rail could reduce global transport emissions 11-16% in 2050 compared to a business-as-usual pathway, saving up to 300 million tonnes of emissions annually in China, India and North America.[48] To achieve these reductions, key trends include a modal shift towards rail in combination with electrification, the integration of renewable power, digitalisation and energy efficiency. Reducing and shifting personal vehicle use and aviation to rail (urban and inter-city rail), as well shifting freight activity from road transport to rail, could reduce around 2 gigatonnes of CO_2-equivalent well-to-wheel emissions.[49]

Rail is the most electrified mode of transport, with around 45% of its energy use coming from electricity in 2021.[50] In 2021, global energy use for rail was spilt roughly evenly between diesel fuel (1.28 exajoules) and electricity (1.08 exajoules), with a small contribution from biodiesel (see Figure 8).[51] With the modal shift from aviation and road transport to rail, energy use in rail will continue to grow. **Globally, the share of electricity use in rail is projected to reach two-thirds by 2030 (particularly in freight), and growth in hydrogen use is also anticipated.**[52]

In Europe, the electricity share was already close to 60% as of 2021.[53] **In 2021, freight rail consumed four times more energy than passenger rail.**[54]

The share of electrified lines globally increased steadily between 2011 and 2020, although growth was minimal in Africa and has fallen slightly in the Americas (see Figure 9).[55]

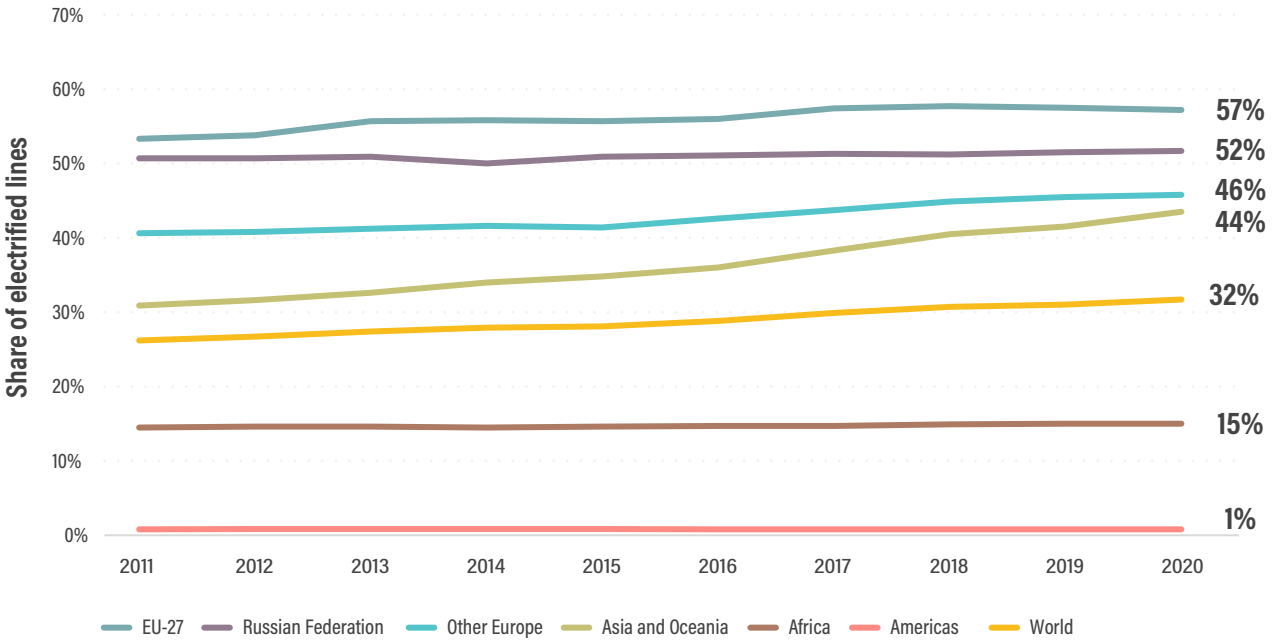
- In 2020, Indian Railways set an ambitious target to electrify all rail routes by December 2023 and to add more than 500 megawatts of renewable power (solar and wind).[56]
- Romania has allocated EUR 3.9 billion (USD 4.2 billion) from European Union (EU) recovery funds for rail modernisation – including electric and other locomotives with zero emissions – as part of the government commitment to abolish coal use for electricity generation by 2032.[57]
- Scotland's Rail Services Decarbonisation Action Plan aims to decarbonise passenger rail by 2035 through significant rail electrification, a large-scale modal shift to rail, and some battery or hybrid trains.[58]

Because trains are large energy consumers, decarbonising the electricity grid through the use of renewable energy is an important step to delivering net zero railways.

- The Italian railway company FS is investing EUR 1.6 billion (USD 1.7 billion) in a plan to install 2 gigawatts of solar

FIGURE 9. Share of electrified rail lines by region, 2011-2020

Source: See endnote 55 for this section.



photovoltaic plants across its real estate assets (stations, railway workshops, warehouses, industrial areas, offices); the plants will produce 2.6 terawatt-hours of electricity per year, covering at least 40% of the FS Group's power needs and saving 800,000 tonnes of CO_2 emissions.[59]

- Indian Railways is working with partners to install and connect new renewable power generation facilities, including solar farms that directly feed rail traction power.[60]

When trains are powered by renewable hydrogen, they provide an almost silent ride and emit only steam and condensed water, avoiding up to 700 tonnes of CO_2 emissions annually compared to the equivalent regional diesel train.[61]

- The world's first hydrogen-powered train, the Coradia iLint developed by Alstom, began serving passengers in 2018.[62]
- In 2022, the first hydrogen train route went into service in north-west Germany, with other fleets of Alstom hydrogen trains to be launched in Frankfurt, Italy's Lombardy region and across France.[63]
- Romania plans to modernise its rail with the acquisition of 12 hydrogen-powered electric trainsets and 55 upgraded electric locomotives.[64] In addition, 20 shunting locomotives will be upgraded from diesel to electric and plug-in, and all purchases of new rolling stock will have the European signalling system ETCS on board.[65]

Policy developments

As part of national plans for pandemic recovery, between 2020 and 2022 governments launched plans to upgrade and develop rail lines and to decarbonise transport, although public spending for road transport remains higher than for rail.

- The European Green Deal, a major stimulus package focused on sustainability released in 2020, included an estimated EUR 87.5 billion (USD 93.4 billion) in investment related to rail infrastructure.[66] The European Commission aims to double high-speed rail traffic by 2030 and to triple it by 2050; it also aims for all scheduled collective travel of under 500 kilometres to be carbon neutral within the EU by 2030.[67]
- In the United States, the 2022 Infrastructure Investment and Jobs Act allocated USD 66 billion in funding and grants for rail corridor development, track upgrades and safety improvements.[68]
- The 2021 US Bipartisan Infrastructure Bill includes USD 66 billion in new rail infrastructure funding from 2022 to 2026, the biggest investment in passenger rail transport in the history of rail provider Amtrak.[69]
- A rail company in Saudi Arabia received 28,000 applications for a job posting to recruit 30 female train drivers, who would drive high-speed trains between the holy cities of Mecca and Medina following a year of training.[70]

Shifting transport activity to rail is key to decarbonising the global transport sector. To meet global climate targets for 2050, an estimated 15% of flights and more than 2% of private vehicle road travel need to be moved to high-speed rail.[71]

- The African Union Commission is promoting and facilitating rail transport under its Programme for Infrastructure Development in Africa, which focuses on developing an integrated transport network for the continent; railways have been considered as the backbone of transport networks at all levels.[72]
- In 2022, the European Commission approved France's proposal to prohibit short-haul flights between cities that are linked by a train journey of less than 2.5 hours when a reliable rail alternative exists.[73] The measure, enacted in May 2023, applied initially for three routes from Paris-Orly to Bordeaux, Lyon and Nantes.[74]
- Switzerland has revised its long-term rail strategy, Rail 2050, in favour of improving short- and medium-distance rail services; this is expected to result in a 10% increase in both domestic and import/export rail freight by 2050.[75]

Railway expansions (conventional and high-speed rail) are planned in all regions to improve the connectivity and convenience of rail travel. The global high-speed rail network is projected to grow from around 59,000 kilometres in 2022 to 78,000 kilometres in the next years.[76]

- In 2023, 4,500 kilometres of high-speed rails were announced to connect the Three Seas Region (including Austria, Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, the Slovak Republic and Slovenia), for planned completion in 2028.[77]
- Efforts to improve rail connectivity and convenience are ongoing in Asia, where more than 70% of the growth in the global high-speed rail network is expected to occur. High-speed rail expansions are expected in India, Indonesia, Iran, Thailand, Türkiye and Viet Nam.[78]
- Regional collaboration in Africa continued to advance efforts to build rail infrastructure to ensure reliable, efficient and sustainable transport service for the future. An integrated African high-speed rail network is at the heart of the region's Agenda 2063.[79] The Integrated High Speed Train Network project aims to connect all African capitals and commercial centres through an African high-speed train network, thereby facilitating the movement of goods, services and people; reducing transport costs and relieving congestion of systems.[80]
- In 2022, Egypt signed an EUR 8 billion (USD 8.5 billion) deal with Siemens for a high-speed rail system, contributing to the building of the world's sixth-largest rail network, which will connect cities along the Nile with the Red and Mediterranean seas.[81]
- Tanzania and Burundi agreed in 2022 to jointly build a 282-kilometre-long standard gauge railway to connect the countries.[82]
- In 2022, Senegal announced the launch of the operating phase for the Regional Express Train (TER), which is expected to carry some 115,000 passengers daily and will connect Dakar to the new city of Diamniadio, around 40 kilometres to the east.[83]
- Oman and the United Arab Emirates agreed in 2023 to build a USD 3 billion rail link between the two countries.[84]

As of 2022, 9 out of the 30 countries that submitted updated Nationally Determined Contributions towards reducing emissions under the Paris Agreement mentioned solutions in the rail sector, mostly as a mitigation action.[85] The shift from road transport to rail or inland waterways was the most popular freight-related mitigation action in the second generation of NDCs (14 NDCs) as of the end of 2022.[86] In total, rail-focused mitigation actions were covered by 37 second-generation NDCs.[87]

- India's NDC commits to raising the share of rail traffic for freight from 35% in 2022 to 45% by 2030.[88]
- Egypt is promoting green finance (green bonds) for clean transport – introducing high-speed rail and expanding metro, monorail and light rail – and has also set specific transport emission targets.[89]
- Thailand is promoting a road-to-rail modal shift for both freight and passenger traffic, as part of the Environmentally Sustainable Transport System Plan.[90]
- The United Arab Emirates is promoting greater use of public transport (such as the urban metro in Dubai) and building new freight lines that will greatly reduce emissions, as part of a road-to-rail modal shift.[91]

Partnership in action

- The **UIC International Union of Railways** is the worldwide professional association representing the railway sector and promoting rail transport.[92] In 2022, the UIC released a manifesto for the UIC Centenary setting the scene for the main deliveries from the global railway community over the next decade, and describing how the global railway community will help bring to life the 2030 Vision.[93]
- The **UIC and the International Union of Public Transport** issued a joint statement for the Transport thematic day of the 2021 United Nations Climate Change Conference in Glasgow, United Kingdom (COP 26) on the need for a greater focus on rail and public transport on the climate agenda.[94]

3.5 RAIL

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9 **Figure 1** from UIC, op. cit. note 5.

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