RAMBOLL

The European Rail Atlas

Benchmarking European countries'
rail performance on the national relevance
of rail, performance, safety, market
competition, infrastructure financing,
employment and automation, ERTMS
deployment, and sustainability.

Foreword

Every day, tens of millions of Europeans step onto trains: workers, students, families, and tourists relying on one of the world's most extensive and interconnected rail systems. With more than 200,000 km of railway tracksand over 29,000 stations, rail is an integrated pillar of Europe's transport system, moving people and goods efficiently between cities, regions, and countries. This network is part of Europe's daily pulse, supporting economic growth, connecting communities, and offering sustainable mobility at a continental scale.

The one thing global rail networks have in common is their differences, each with distinct challenges and geographies. Around the world, railway networks have evolved with different strategic priorities. Europe operates one of the most balanced and interconnected rail networks, serving both high-volume passenger travel and a substantial share of freight across borders. North America stands in contrast, with railways dominated by long-haul freight, forming the backbone of its logistics system. Japan has become a global benchmark for high-frequency, high-speed passenger rail. China, meanwhile, has built the world's largest and fastest-growing rail network,

combining an extensive high-speed passenger system with a major freight backbone that supports its industrial economy.

The European Rail Atlas focuses on technical performance, competition, and wide-ranging data on railway infrastructure and operations, what ultimately matters is how these factors affect end customers' experiences. Rail's true purpose is to serve passengers and freight clients by providing reliable, seamless, and sustainable transport. A thriving Europe requires well-functioning rail systems.

The European Rail Atlas has been developed by Ramboll to provide a framework for assessing how countries are progressing on the European Union's three main rail objectives[1]:

- Opening the rail transport market to competition
- Improving interoperability and safety
- Developing rail infrastructure

The Atlas compares performance across eight dimensions related to these objectives: 1) national relevance of rail, 2) performance, 3) safety, 4) market competition,

5) infrastructure financing and utilisation, 6) Employment and automation, 7) ERTMS deployment, and 8) sustainability and environment.

For each dimension, the Atlas features best practice cases, illustrating how specific countries have become strong performers thereby offering inspiration to others.

Countries such as Switzerland, Austria, The Netherlands, Denmark, Finland, and Sweden provide striking success stories in various dimensions. Yet rail development is uneven across Europe, with road transport increasingly dominant in many places. The Rail Atlas highlights both progress and persisting gaps, helping to chart the path towards Europe's rail goals.

Friedemann Brockmeyer
Global Head of Transport, Infrastructure, and Mobility

Executive Summary

The European Rail Atlas offers a structured and comparative assessment of the strengths, constraints, and transformation pathways of rail systems across Europe. It recognises that national railways are the product of deeply rooted geographical, historical, and institutional conditions and that meaningful comparison requires moving beyond one-size-fits-all benchmarks. To address this, the Atlas applies an archetype-based framework, clustering countries with similar structural characteristics to provide clearer insights into how different railway systems perform, invest, and evolve over time.

Across Europe, railways operate under markedly different operating regimes. Network utilisation levels vary widely, fundamentally shaping investment requirements, operational complexity, and performance outcomes such as punctuality and reliability. While highly utilised networks are inherently more exposed to disruption and capacity constraints, the experience of countries such as the Netherlands illustrates that excellent operational performance remains achievable when capacity management, governance, and investment are coherently aligned.

The Atlas further reveals substantial disparities in safety performance, digital maturity, and environmental outcomes. Although rail safety has improved consistently over the past decade, the performance gap between leading and lagging countries remains material. Progress on ERTMS deployment is uneven, continuing to hinder the vision of a seamlessly interoperable European rail system. Similarly, differences in CO_2 emissions largely mirror national trajectories in electrification and the extent to which electric traction has been prioritised.

Beyond infrastructure and technology, the Atlas underscores that the future performance of European railways will be increasingly determined by human capital. Many countries are already experiencing acute labour shortages, with direct consequences for operational resilience, the delivery of investment programmes, and the speed at which digitalisation and automation can be implemented.

Taken together, the European Rail Atlas demonstrates that there is no single blueprint for a successful railway system. However, it also shows a clear pattern: countries with stable, long-term policy frameworks and predictable, multi-year funding such as Switzerland, Austria, and Sweden are consistently better positioned to convert strategic ambition into sustained performance. Their experience highlights that continuity in investment, clarity of direction, and alignment with wider climate and sustainability objectives are decisive in achieving high rail modal shares and in building resilient, future-ready rail systems across Europe.
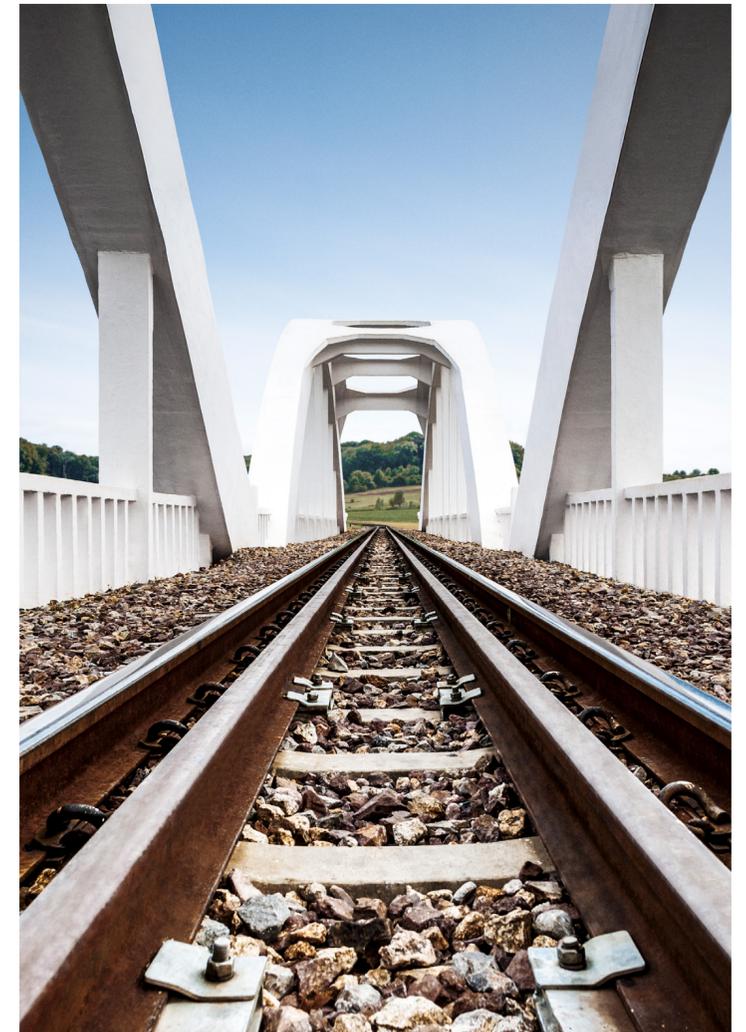
Key policy recommendations

> Embed multi-year rail investment plans in legislation to provide predictable and stable funding.

> Accelerate ERTMS deployment prioritising high-traffic corridors and cross-border routes to deliver immediate efficiency and safety gains.

> Strengthen modal shift policies with pricing incentives, especially for freight.

> Address rail workforce challenges by promoting gender diversity and reskilling in line with automation.

> Align national energy and transport strategies to maximise the climate benefits of rail electrification.

Europe's rail landscape at a glance: Railway system maturity

The overall maturity map brings together all eight dimensions of The European Rail Atlas to provide a consolidated picture of how each country performs across national relevance, performance, safety, market competition, infrastructure financing and utilisation, employment and automation, ERTMS deployment, and sustainability. All data refers to 2022 unless stated otherwise.

The results reveal a European rail landscape marked by large variation and that no single country leads across all dimensions. Strengths often sit alongside areas for improvement, underscoring the value of a holistic approach that goes beyond individual indicators.

The diversity of results also reflects the differing roles and priorities of rail systems across Europe, shaped by geography, governance models, and national transport strategies.

Taken together, the overall atlas ranking provides a foundation for understanding how shared learning, targeted investment, and stronger cross-border alignment can help Europe move closer to its long-term rail objectives.
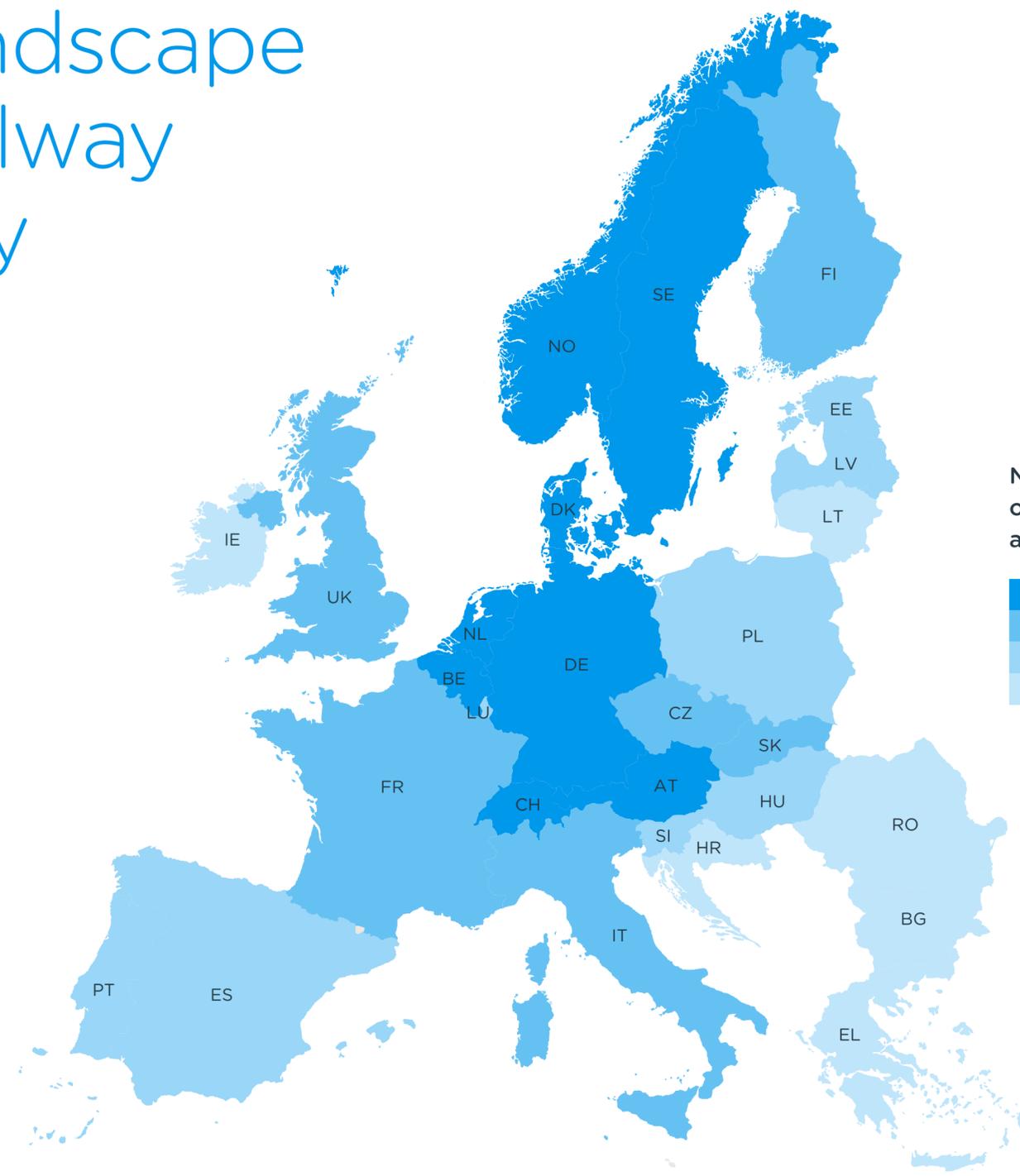
National railway systems, overall maturity across all dimensions

- Highly mature
- Mature
- Developing maturity
- Early maturity

Countries in scope

AT	Austria
BE	Belgium
BG	Bulgaria
CH	Switzerland
CZ	Czechia
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
EL	Greece
FI	Finland
FR	France
HR	Croatia
HU	Hungary
IE	Ireland
IT	Italy
LT	Lithuania
LU	Luxembourg
LV	Latvia
NL	Netherlands
NO	Norway
PL	Poland
PT	Portugal
RO	Romania
SE	Sweden
SI	Slovenia
SK	Slovakia
UK	United Kingdom

Europe's railways: Building a stronger, smarter and more sustainable future

Railways are the backbone of Europe's transition towards sustainable, connected, and competitive societies. They bind regions together, create economic opportunities, and offer one of the lowest carbon modes of transport – essential to meeting Europe's ambitious climate and mobility goals.

The European Rail Atlas provides a benchmark for understanding how countries perform across eight key areas, showing what drives success and how shared progress can accelerate change.

Learning from the leaders

Across Europe, strong examples show how consistent strategies and integrated planning create results. Switzerland continues to lead with the highest passenger rail share, supported by seamless network integration, reliable timetables and effective freight shift policies. Austria's long-term investment framework provides stable funding for modernisation and digital upgrades. The Netherlands demonstrates how dense and heavily used networks can remain reliable through proactive maintenance and close coordination between operators and infrastructure managers. These examples underline a key lesson: long-term

commitment builds public trust, which in turn sustains investment and ridership. When governments, operators and regulators share a clear vision and priorities, rail becomes more than transport, it becomes a national success story.

Diversity as strength

Europe's diversity is also a source of innovation. Central and Eastern Europe lead in freight, while Northern Europe excels in sustainability, digitalisation and automation. Finland's automation strategy shows how technology and rail staff can advance together, while Denmark's nationwide rollout of digital signalling illustrates bold leadership in creating a safer and more efficient network. No single model fits all. Geography, governance, and history shape priorities, but collaboration remains the common thread between ministries, industry partners, and across borders through shared European initiatives.

Investing for impact

Commitment is the clearest indicator of success. Countries such as Austria, Norway and Luxembourg invest more than €300 per capita in rail annually.

Stable multi-year funding frameworks give confidence to planners and engineers, allowing large-scale projects to be delivered efficiently and sustainably. Where such frameworks exist, rail networks achieve higher utilisation, better punctuality, and greater public support.

Europe's rail workforce is ageing and still imbalanced by gender. Closing the gap through diversity and reskilling is key to maintaining excellence. Finland and Sweden stand out for digital upskilling. A future-ready railway depends not only on technology but also on people who are empowered, skilled, and motivated.

Towards a sustainable future

Digitalisation and decarbonisation are shaping the future of rail. The rollout of the European Rail Traffic Management System (ERTMS) is improving safety and interoperability, while electrification, renewable power, and new technologies such as hydrogen and battery trains are reducing emissions. Countries aligning rail with their national energy transitions, such as Sweden and the Netherlands, are setting new standards for climate leadership.

The European Rail Atlas shows that while challenges remain, the direction of travel is clear. Collaboration, consistent investment, and innovation are building the foundation for resilient and sustainable rail systems that serve people and economies across Europe.
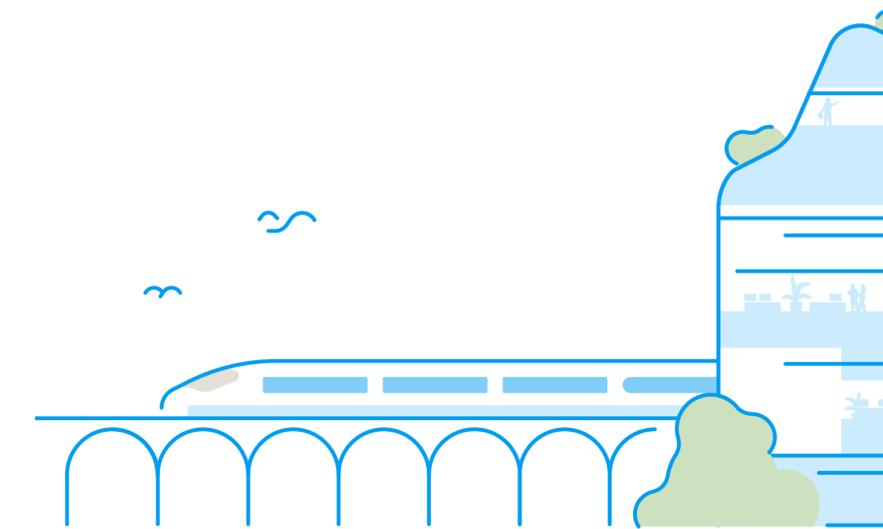
Holistic assessment of the European rail sector

The Atlas and this report aim to provide a **holistic view of how European countries perform across eight key dimensions.** The main body of the report consists of eight deep dives – one for each dimension – with the findings represented on a European map, presenting an analysis of the underlying data, and showcasing a best practice example providing inspiration for actions that can improve performance within the dimension.

Click on the dimensions to learn more ⬀

The assessment dimensions

National relevance of rail

Central Europe leads in rail modal share for both passenger and freight transport.

The role of rail within national transport systems varies widely across Europe, reflecting geographical and policy differences as well as variations in the availability and condition of rail infrastructure. On average, rail accounts for 7% of passenger journeys in Europe, yet this figure masks striking differences.

Switzerland stands apart with a 23% passenger modal share, followed by Austria, the Netherlands, France, and Sweden which are all above 10%. Switzerland, Austria and the Netherlands illustrate how integrated planning, dense networks, and long-term investment can support rail's role in everyday mobility.

A different picture emerges in relation to freight. Based on tonne-kilometres, the average share of freight carried by rail in Europe is around 21%. Latvia leads with 53%, while Lithuania, Switzerland, Slovenia, Slovakia, and Austria all exceed 30%.

Regional variations in passenger and freight use

The data shows three clear regional patterns, which can be explained by geographical, economical, and political factors. Western Europe generally records higher shares in passenger traffic owing to a large concentration of urban centres and established high-speed markets. Freight shares are lower, partly due to the comparatively low density of manufacturing industries.

Eastern Europe places greater importance on freight, with rail playing a central role in transporting raw materials and heavy goods across long distances.

Central Europe is primarily dual use, balancing robust passenger ridership with competitive freight operations, thereby forming the central railway core of Europe. Ireland and Greece emergence as outliers in this analysis, exhibiting very low modal shares in both passenger and freight transport partly due to their geographical location.
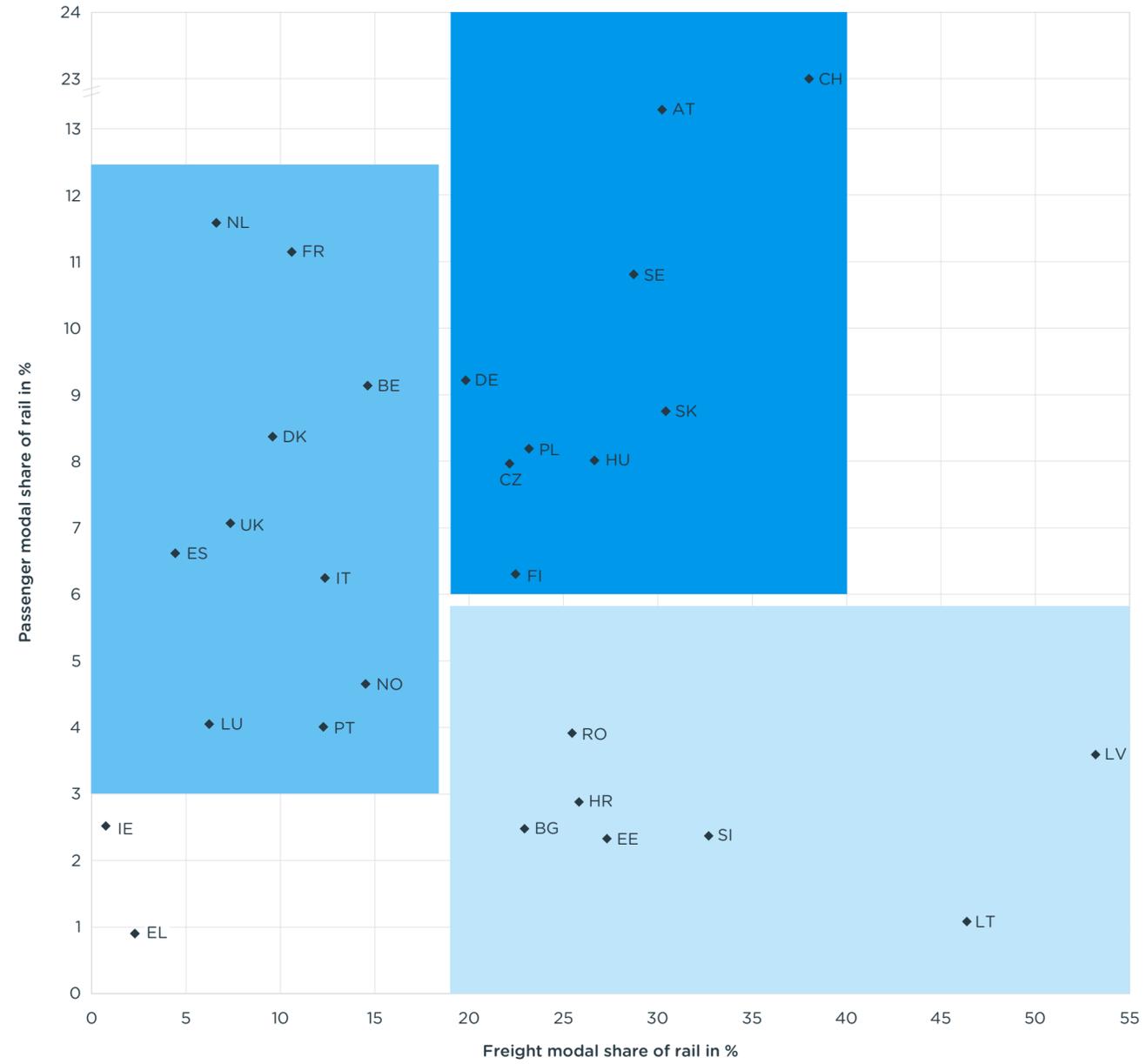
Quick facts

Rail accounts for an average of 7% of all passenger journeys in Europe with a high of 23% in Switzerland. 21% of freight is carried by rail in Europe with a high of 53% in Latvia.
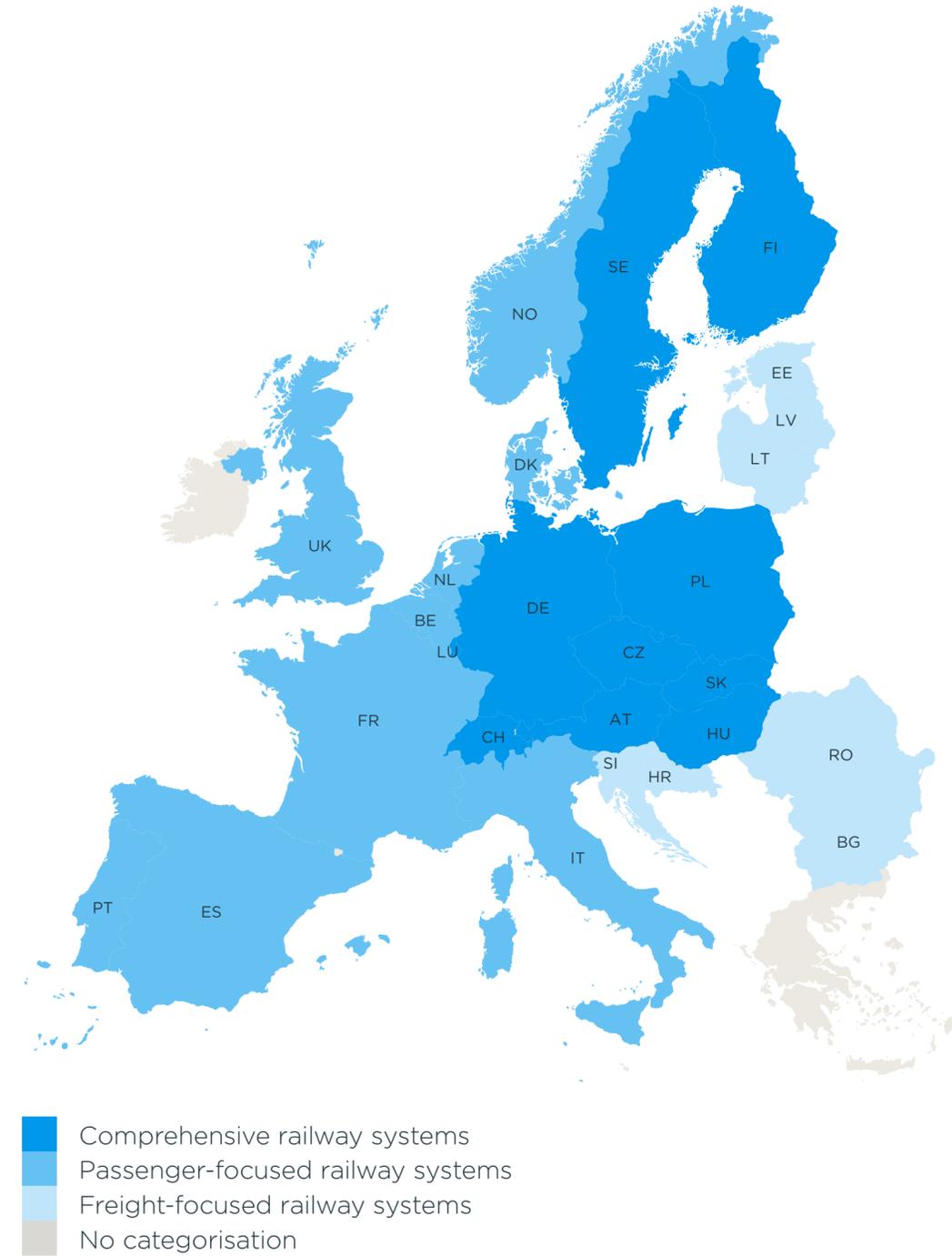
Railway systems by passenger and freight modal share of rail

Graph 1

Passenger modal share of rail in %

Freight modal share of rail in %

- Comprehensive railway systems
- Passenger-focused railway systems
- Freight-focused railway systems

Figure 1

- Comprehensive railway systems
- Passenger-focused railway systems
- Freight-focused railway systems
- No categorisation

Switzerland

Switzerland leads Europe in rail passenger modal share with 23% and also ranks among the top countries in freight transport, with a share of 38%. This success is rooted in consistent long-term federal funding and stable investment frameworks beyond political cycles.

For passengers, the nationwide clock-face timetable introduced in 1982 provides regular and reliable connections around the clock, linking even small towns to the rail network and integrating the nation's bus services for wider public transport coverage.

Freight rail benefits from a strong modal shift policy: the 1994 Alpine Protection initiative constitutionally restricts trans-Alpine truck traffic, supported by a night-time truck ban and a moratorium on expanding road capacity. In addition, two thirds of heavy truck toll revenues are directed to rail infrastructure, providing a stable and long-term source of financing.

The national railway company of Switzerland, SBB, complements these policies with high fleet availability, robust connection hubs, and multimodal integration to ensure punctuality and accessibility. Public trust and political consensus make rail central to the Swiss identity, demonstrating the impact of coherent, long-term planning.

Key learnings

> Stable, multi-decade funding and political backing are decisive for rail growth and performance.

> Strong modal shift policies can rebalance freight towards rail.

> Integrated timetables and multimodal links expand accessibility beyond cities.

Performance

Over 80% of passenger trains in most European countries are punctual.

Train punctuality is a key measure of network performance. However, it is a complex issue that should be assessed from a system-wide perspective, considering responsibilities, root causes, measurement methods, and cancellation policies. In the Rail Atlas we apply the RMMS five-minute threshold for passenger services and 15 minutes for freight, ensuring comparability across networks.

Passenger services generally perform strongly: 22 of 28 nations record average punctuality above 80%, and 11 exceed 90%. Freight punctuality is significantly lower, with eight countries reporting averages below 50%. This reflects different market requirements, as freight relies less on minute-precise arrivals and more on predictable delivery within agreed time windows.

Variations in passenger train punctuality

Drivers behind these differences in punctuality levels include network segmentation, railway undertakings' (RUs) operational effectiveness, and network utilisation. As per Graph 2, European rail systems

can be grouped into four clusters based on passenger train punctuality and varying degrees of network utilisation. The Netherlands, Austria, Denmark, Switzerland, Belgium and the UK manage to achieve high punctuality despite having heavily utilised networks. Baltic countries also record high punctuality, which can be attributed to low network utilisation with fewer traffic conflicts.

Low network utilisation does not guarantee high punctuality

Intuitively, low network utilisation might be expected to result in higher punctuality, as fewer trains should mean fewer conflicts. In reality, causes for delays are multifaceted, and network utilisation is only one of several contributing factors.

Germany and Italy illustrate how heavily utilised networks can struggle with punctuality. At the same time, punctuality levels from Romania, Croatia, Slovenia and Hungary show that even on less intensively used networks, high punctuality is far from guaranteed. Infrastructure condition,

operational practices, rolling stock reliability, and traffic management all play a critical role. As Europe rolls out ERTMS and follows new EU regulations aimed at modernising and harmonising rail capacity management across member states, the expectation is that there will be fewer path conflicts and more reliable operation of both passenger and freight traffic.

ⓘ

Punctuality definitions

Punctuality definitions vary widely. Switzerland counts trains as punctual if they arrive within three minutes, while the UK uses thresholds of five minutes for regional and commuter services and ten minutes for long-distance routes. To ensure comparability, the Rail Atlas applies RMMS' five-minute threshold for passenger services and 15 minutes for freight.

Passenger trains punctuality vs. Network utilisation

Graph 2
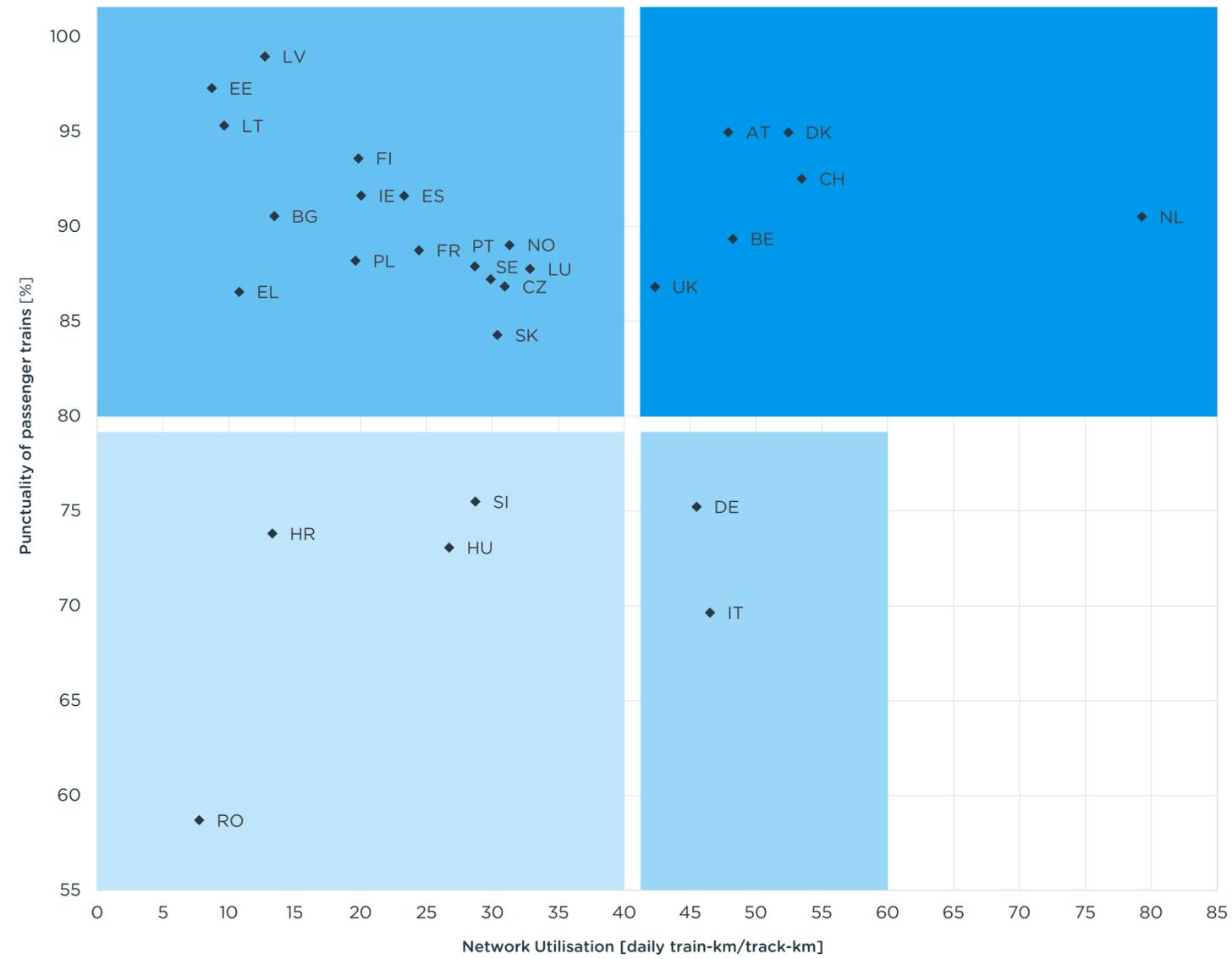
Figure 2

Source: 9th RMMS report (2022 data)

Legend (Graph 2):
- High utilisation-high punctuality
- Low utilisation-high punctuality
- High utilisation-low punctuality
- Low utilisation-low punctuality

Legend (Figure 2):
- High utilisation-high punctuality
- Low utilisation-high punctuality
- High utilisation-low punctuality
- Low utilisation-low punctuality

Graph 2 axes:
- Y-axis: Punctuality of passenger trains [%]
- X-axis: Network Utilisation [daily train-km/track-km]
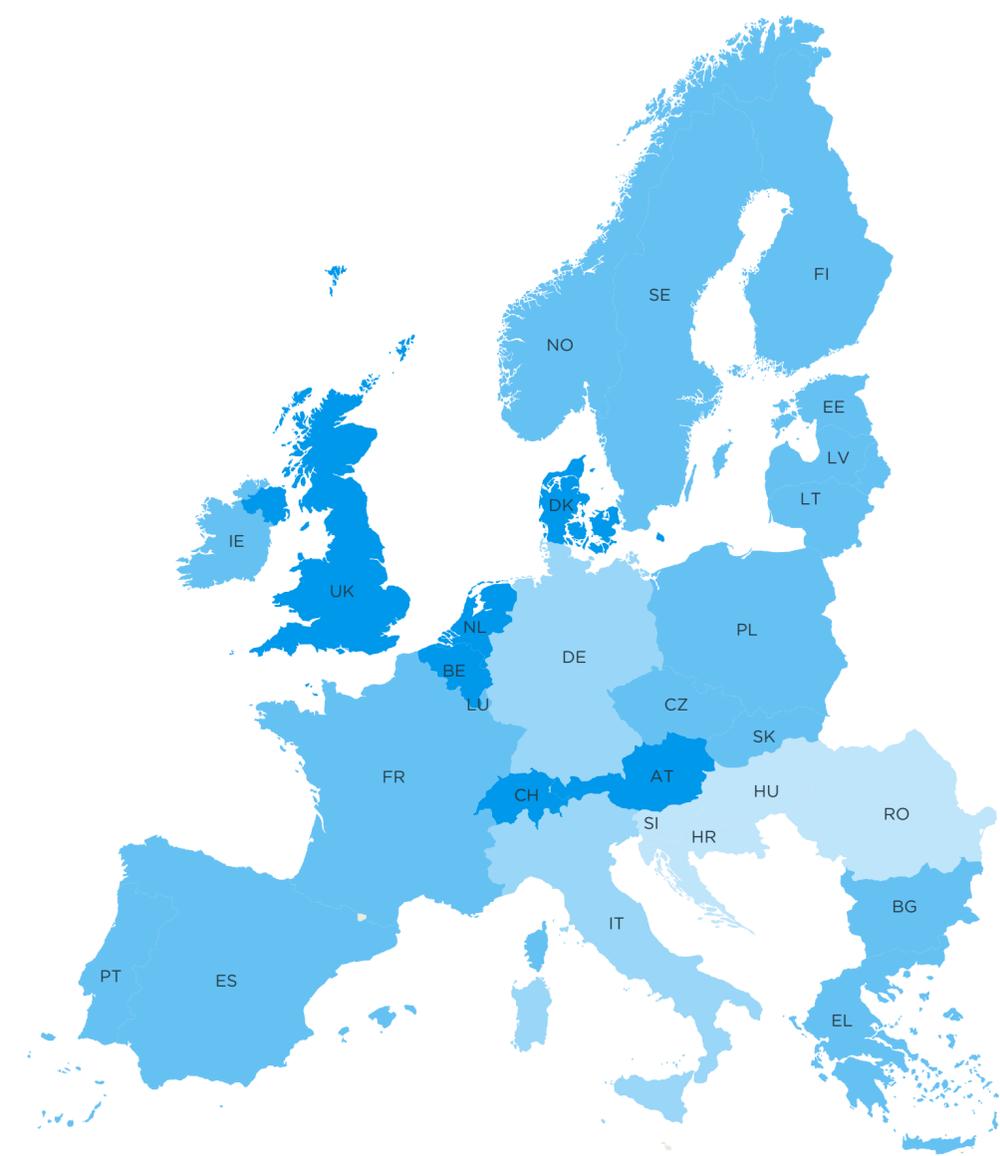
Belgium

In 2022, Belgium's national railway operator SNCB recorded punctuality levels of approximately 89 percent for passenger trains and 67 percent for freight trains. This is in the context of Belgium's dense rail traffic, the high share of cross-border services, and ageing infrastructure.

To address punctuality challenges, SNCB has developed a comprehensive, multi-year action plan to reduce the number of incidents affecting punctuality and limit their impact when they occur. The plan aims to improve the reliability and availability of rolling stock through continuous technical monitoring, targeted fleet modernisation, and the gradual withdrawal of obsolete vehicles.

The action plan strengthens operational processes and coordination by investing in high-performance maintenance workshops, optimising working procedures, and enhancing information flows to ensure that staff receive timely and actionable data. Attention is given to the initial departure of trains, where close coordination among multiple actors is essential to prevent delays.

Daily operational cooperation between SNCB and the infrastructure manager Infrabel, including joint traffic management and coordinated planning of infrastructure works, balances network capacity, safety requirements, and punctuality objectives.

Key learnings

› High punctuality can be achieved even in highly utilised networks.

› Varying national priorities affect passenger and freight punctuality.

› System-wide coordination between railway undertakings, infrastructure managers, and regulators helps drive performance.

Safety

There is safety gap between Eastern and Western European countries

Continuously decreasing the number of accidents towards zero is a critical goal of the European rail sector. Major causes of railway accidents include the high density of level crossings, ageing rolling stock, track defects, switch failures, and human errors.

In 2022, there were 1,566 significant railway accidents in the EU. The number of significant railway accidents has gradually decreased since 2010, with 663 fewer accidents in 2022 than in 2010. More than a quarter of fatalities from railway accidents in the EU occur at level crossings.

Level crossings key to safety performance

Safety performance varies across the continent. Western European countries have invested heavily in protected level crossings, automated signalling, and robust safety strategies. Eastern European networks, where passive crossings remain more common, show higher accident rates, reflecting infrastructure gaps rather than weaker safety ambitions.

Increasing maintenance and renewal backlog raise the risk of derailments, which are among the deadliest railway incidents. In addition, the growing volume of maintenance and renewal work makes workforce safety another critical issue. To enhance workforce safety, the Netherlands already introduced an operational policy of total track closures during maintenance works in the 1990s, which is one of the reasons it maintains Europe's strongest railway safety record.

The importance of safety culture

Beyond assets, fostering a strong safety culture including embedding learning systems, harmonised reporting, and human factors approaches is a key recommendation from the European Union Agency for Railways[2].

ⓘ

Quick facts

1,566 significant railway accidents occurred in the EU in 2022 and the number of accidents has fallen by nearly a third (-30%) since 2010. Passive level crossings are one of the leading causes of fatalities.

Safety Score - Story chart (Accidents and weighed fatalities per million train-km)

Higher Safety
Lower Safety

Source: ERADIS

Higher Safety
Lower Safety

BEST PRACTICES CASE STUDY
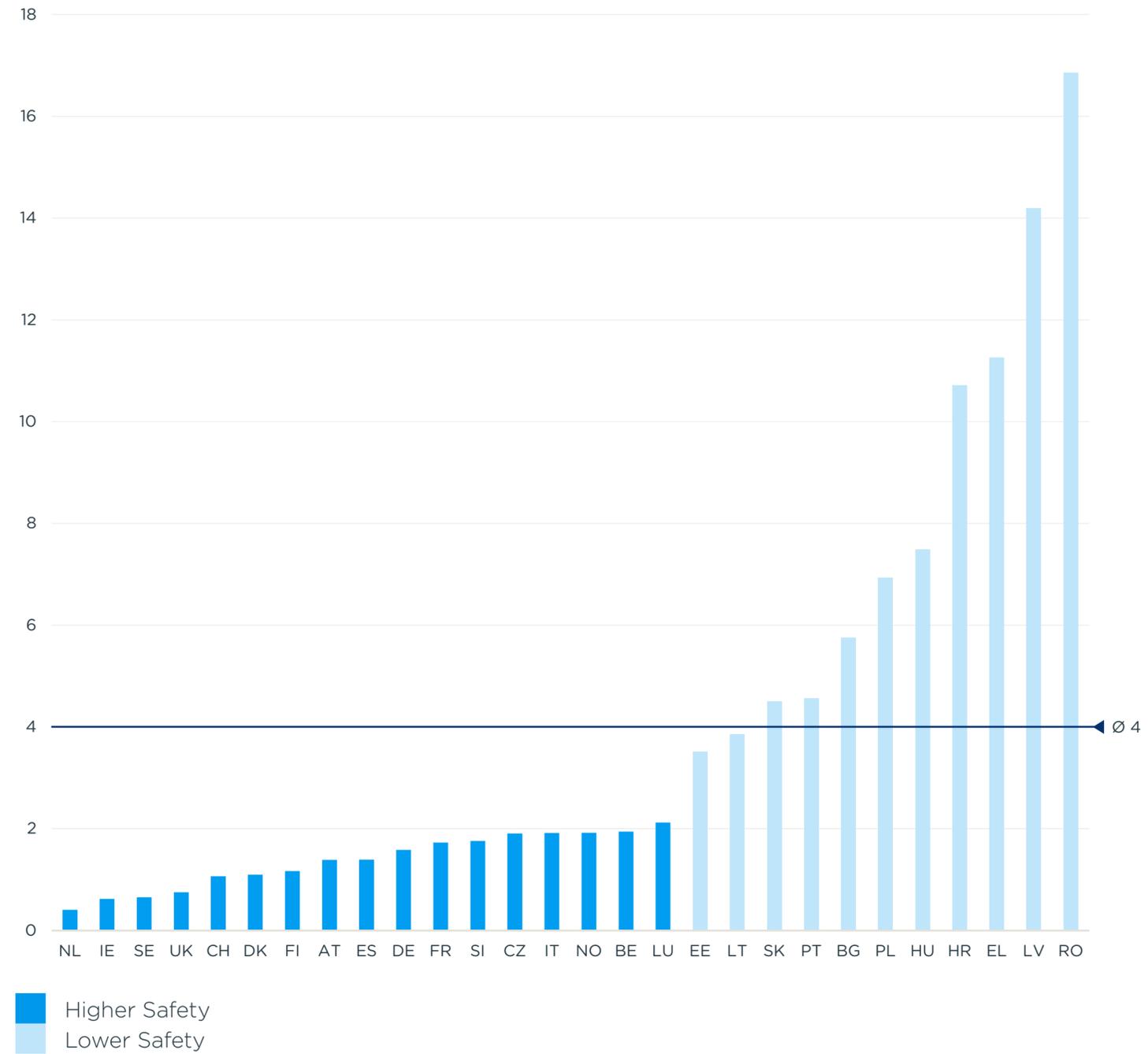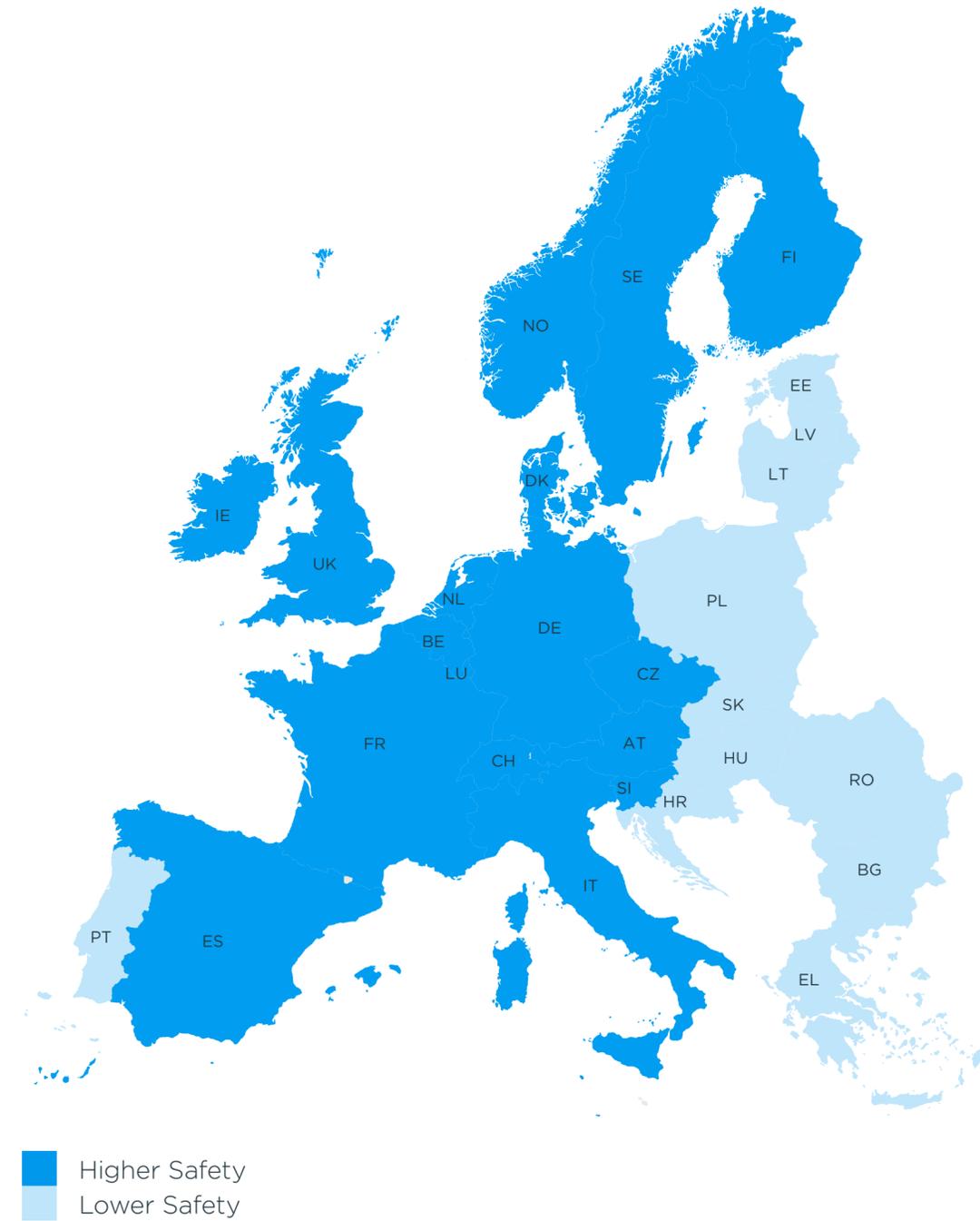
The Netherlands

The Netherlands stands out for achieving high safety and reliability despite operating one of Europe's densest and most intensively used rail networks. A long-term national safety strategy, developed from the late 1990s onward, set clear targets, timelines, and budgets to ensure continuous improvement.

Most notable, the Niet Actief Beveiligde Overwegen (NABO) programme targets passive crossings without lights or barriers, which pose the highest safety risk. Since 2018, ProRail and the Ministry of Infrastructure have removed or upgraded most of these sites, with over 150 crossings addressed and the remaining cases scheduled for completion by 2028. The Netherlands shows that eliminating high-risk crossings is not only a safety measure but also an enabler of capacity and punctuality. By closing or modernising crossings, train speeds can increase, maintenance is simplified, and service disruption is reduced. Performance oversight complements these efforts. Government-set punctuality targets are embedded in a public service contract with the Dutch primary passenger operator, NS, and supported by the predictive planning and maintenance regime implemented by the national infrastructure manager, ProRail. This alignment of policy, operations, and infrastructure investment enables the Netherlands to sustain both high punctuality and exceptional safety performance.

Key learnings

> National rail safety strategies with strict closure rules protect staff and passengers.

> Systematic removal of unprotected crossings raises long-term safety.

> Government performance targets ensure rail operator accountability.

Market competition

Market opening diverges between freight and passenger transport

Creating a competitive and integrated European railway market remains one of the EU's central transport objectives. The Rail Atlas examines how far liberalisation has progressed in both freight and passenger transport, measuring the number of operators and their market shares across Europe.

Among countries with a high degree of liberalisation in passenger rail, some have successfully introduced open-access competition. The UK was one of the frontrunners in liberalisation but is currently undergoing a renationalisation of passenger transport operations, which is likely to alter this landscape in the near future. Public Service Obligation (PSO) contracts represent another pathway to liberalisation. Countries such as Sweden, Poland, and Norway make extensive use of PSO contracts.

In Germany, the local incumbent RU, Deutsche Bahn, remains dominant in long-distance services. For regional services, DB Regio is still the largest operator but is less dominant compared to the long-distance market. In Italy, non-incumbent operators have a higher market share in long-distance services than in Germany. However, the incumbent RU, Trenitalia, remains the market leader.

Freight liberalisation outpaces passenger market competition

Freight markets are generally more open than passenger markets. In many countries, non-incumbents now handle between one third and one half of total freight volumes. Romania, the Netherlands, Hungary, and France have liberalised their freight markets, while their passenger markets remain restricted.

Despite wider market opening, the overall volumes of freight carried by rail have remained relatively stable in many countries. This suggests that factors such as network capacity, infrastructure quality, terminal access, and regulatory frameworks influence the level of competition. In several markets, high track access charges or capacity shortages limit the ability of new operators to expand their services.

Quick facts

100% of freight traffic in Denmark, Estonia, the Netherlands and Portugal is operated by non-incumbents. UK passenger traffic is also currently completely liberalised, but will shortly be renationalised.
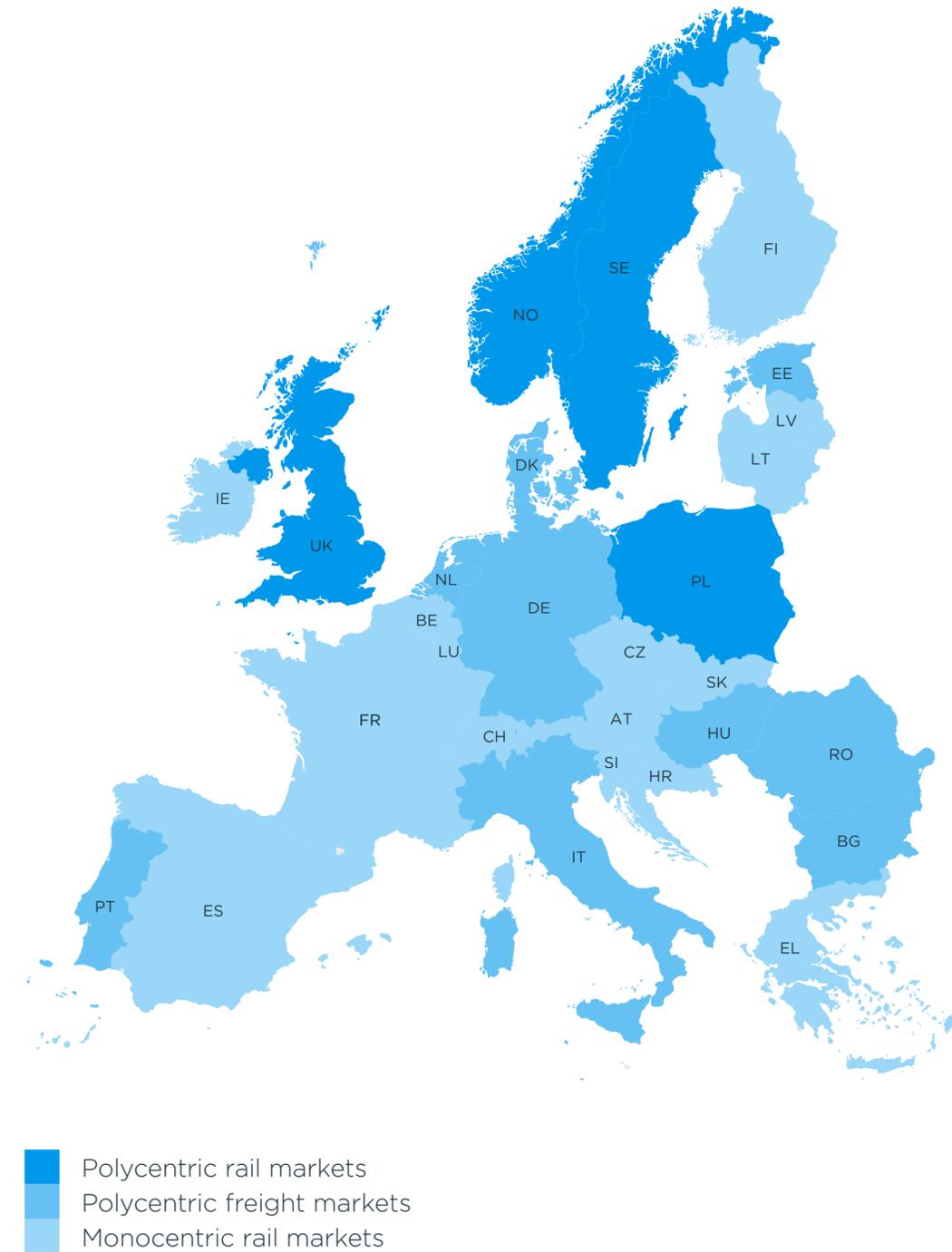
Railway markets by market share of non-incumbent RUs

Graph 4

Market share of non-incumbent RUs in passenger traffic [% of pax-km]

Market share of non-incumbent RUs in freight traffic [% of tonne-km]
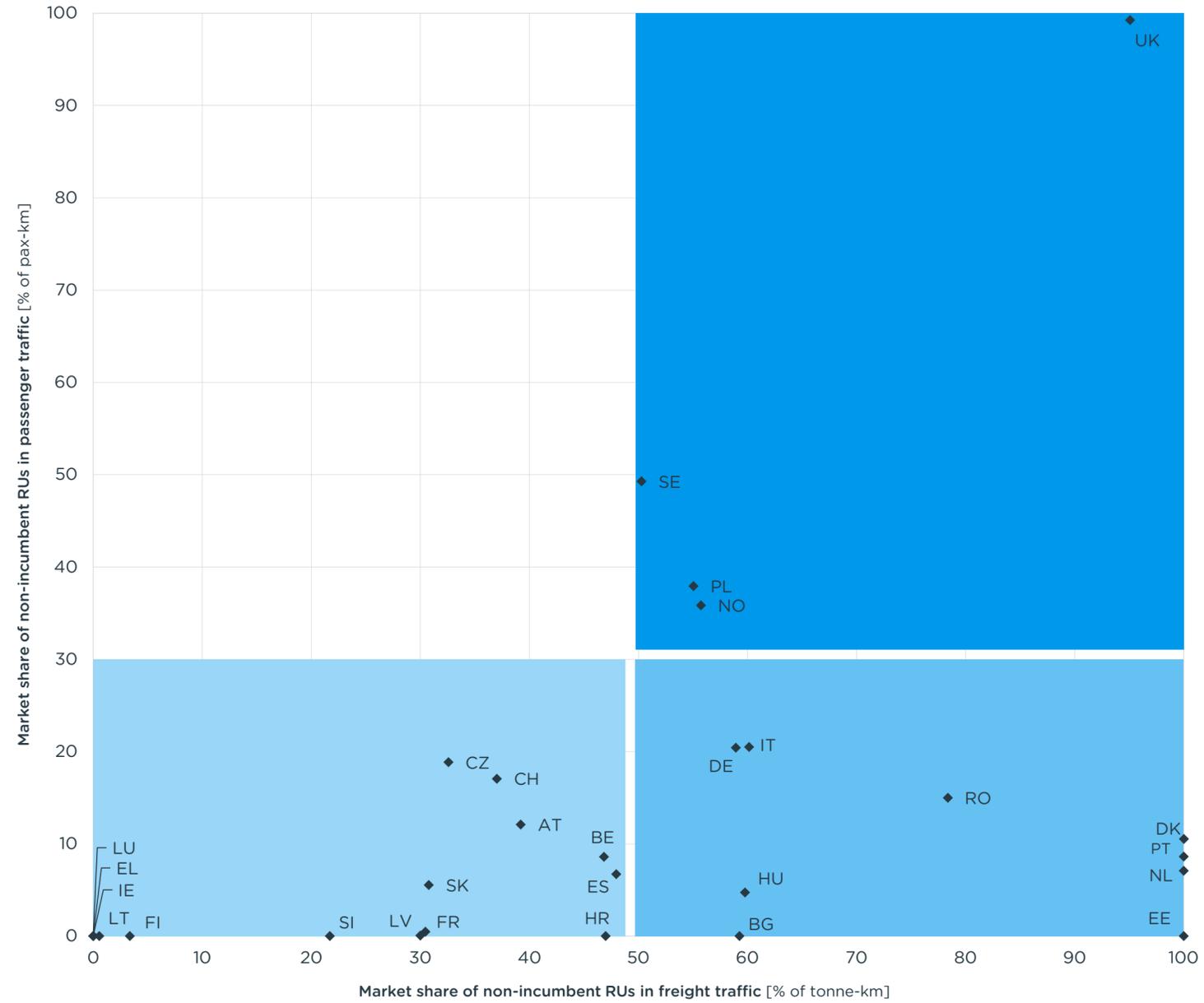
- Polycentric rail markets
- Polycentric freight markets
- Monocentric rail markets

Figure 4

- Polycentric rail markets
- Polycentric freight markets
- Monocentric rail markets

Germany

Germany is Europe's largest rail freight market, carrying over 120 billion tonne-kilometres annually, about one third of the EU total. Since the German railway system reform in 1994, freight has been fully open to competition, and more than 400 licensed operators have entered the market. This has increased service diversity and encouraged efficiency, though DB Cargo remains the largest player.

Federal strategies such as the Rail Freight Masterplan support growth by funding terminals, digitalisation, and incentives for modal shift from road to rail. At the same time, high track access charges and limited network capacity remain challenges for new entrants. The EU has also approved financial support to stabilise the sector while ensuring competition conditions.

Germany's case shows how liberalisation, investment, and regulation must work together to strengthen freight rail in a high-volume market.

Key learnings

> Liberalisation enhances competition, but outcomes vary by market structure

> Market size and infrastructure capacity shape the impact of liberalisation

> Stable frameworks encourage both incumbents and new entrants to invest.

Infrastructure financing and utilisation

The highest spending country invests 10 times more per track-km than the lowest spending country.

Investment in rail infrastructure is one of the clearest indicators of political and public support for the sector – the higher the share of investment, the higher the support to develop rail systems.

The PPP-adjusted data shows a positive correlation between investment per track-km and network utilisation, meaning that most countries rail investments are proportional to how heavily they use their networks. However, further assessment is needed to establish if this relationship is completely linear.

Divergences in investment levels

In 2022, Norway and Luxembourg investeddisproportionately more than peers that have the same level of network utilisation. In contrast, Germany, Belgium and Switzerland invested disproportionately less than their peers with the same network utilisation, such as Denmark, Italy and Austria. It is worth noting that the data represents a snapshot from 2022. A time series would give more insights about the infrastructure backlog of countries' railway systems and will be included in the next edition of the Rail Atlas.

Long term investment frameworks support stable rail development

High investment is often accompanied by long-term frameworks that provide stability beyond annual budgets. Austria, for example, allocates more than 80% of its transport infrastructure funding to rail, embedding this commitment in multi-year legislation. This creates predictable conditions for planning large-scale projects, from new high-speed corridors to station modernisation.
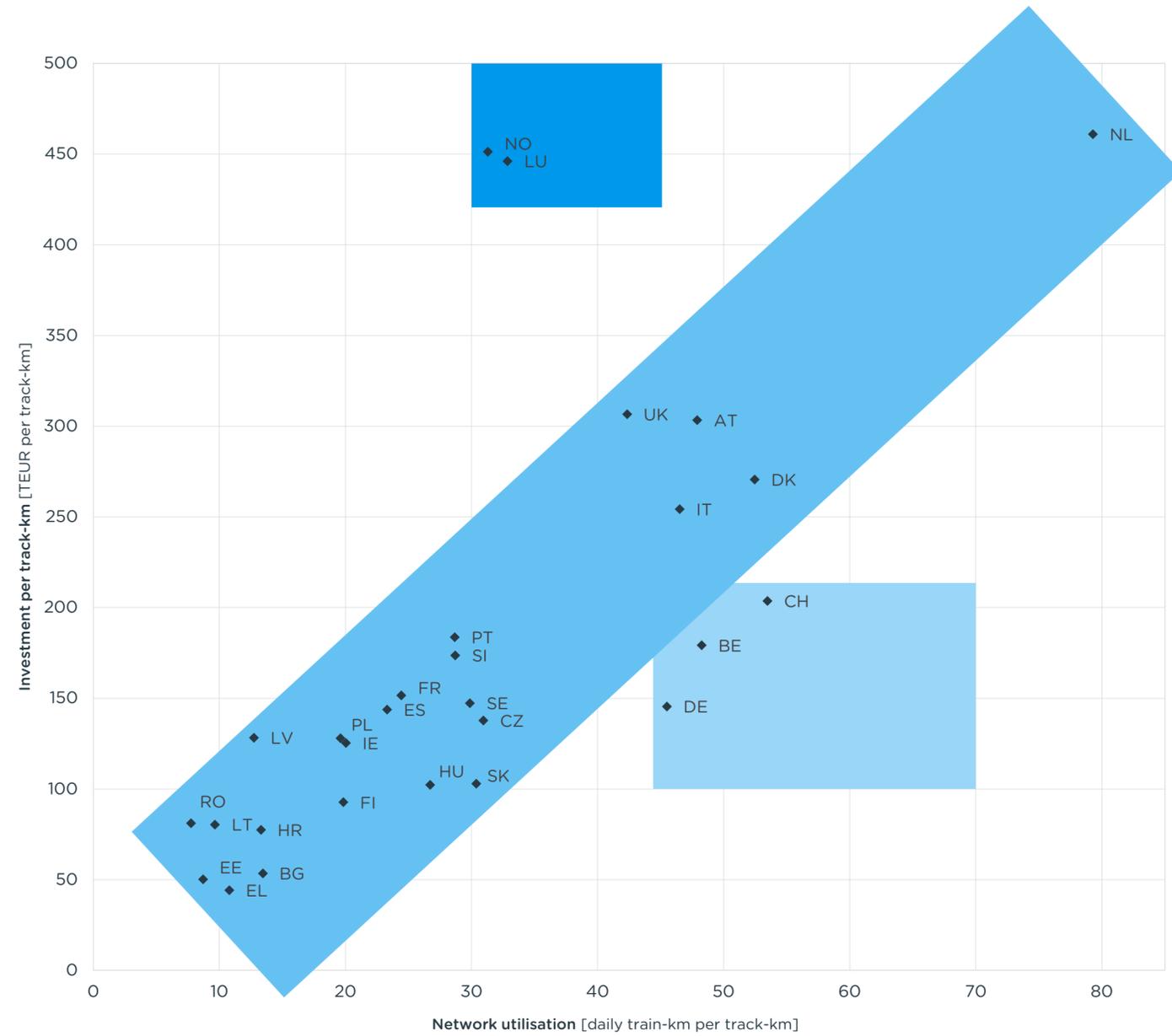
Quick facts

The highest spending country on its rail network is the Netherlands, which invests 460 EUR/track-kilometre, followed by Norway (451), Luxemburg (446), UK (306), Austria (302).
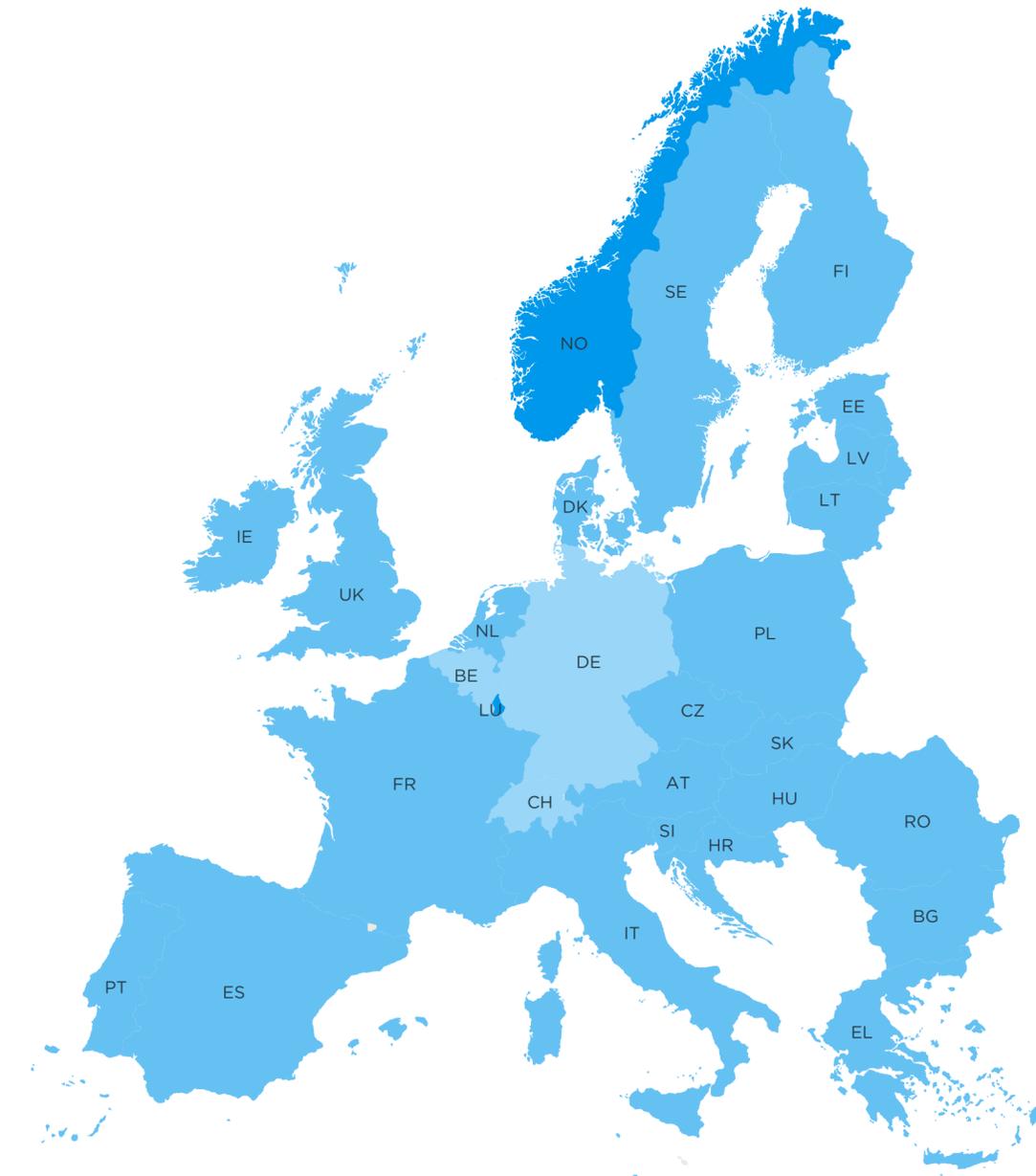
Railway systems by infrastructure investment and network utilisation

Network utilisation [daily train-km per track-km]

Investment per track-km [TEUR per track-km]

Investment above utilisation
Use-aligned investment
Underfunded systems

Source: 9th RMMS report (2022 data)

Investment above utilisation
Use-aligned investment
Underfunded systems

BEST PRACTICES CASE STUDY

Austria

Austria stands out in Europe for its strong and stable commitment to rail investment. In 2021, around 82 percent of transport infrastructure spending went to rail, one of the highest shares on the continent[3].

This approach is anchored in legislation: the Austrian Federal Railways Act requires the government to adopt a rolling six-year framework plan that secures long-term funding for Austria's rail owner and operator, ÖBB-Infrastruktur. The current plan for 2024–2029 allocates more than €21 billion to network upgrades, expansions, and digitalisation, continuing the steady growth from previous investment cycles.

This financing model not only supports passenger growth but also strengthens Austria's role in European freight corridors. Furthermore, broad political consensus ensures continuity across governments, and public support for rail remains high.

Key learnings

› Embedding rail funding in law ensures stability across political cycles.

› High investment shares strengthen both passenger satisfaction and freight competitiveness.

› Multi-year framework planning provides predictability for infrastructure delivery.

Employment and automation

An ageing rail workforce is a challenge in some countries, which could be addressed with an increased focus on gender balance.

Attracting all demographic groups to the workforce is going to be vital in the following decades for railway sector. Many infrastructure managers, and railway undertakings, and particularly those in Eastern Europe, report that a significant share of staff are approaching retirement age, creating a need for both recruitment and skills transfer.

At the same time, there is a gender gap with the share of women working for the main railway operator and infrastructure manager averaging 24% across Europe with a low of 10% in Ireland. The Baltic and Nordic countries have the highest shares of women in the railway sector while Finland and Sweden demonstrate that it is possible to attract both female and younger employees.

Correlation between automation and employee numbers

Automation and digitalisation including modern signalling systems, centralised traffic control, and computerised maintenance planning are transforming how railways are operated and staffed.

They are key drivers in addressing the rail sector's shortage of skilled-labour by enabling more efficient use of the available workforce.

In this simplified analysis, the Rail Atlas uses the share of fully automated (electronic) interlockings as an indicative measure of the overall level of network automation and digitalisation. Whilst this data is not available for all countries, there is a strong negative correlation between the number of employees and the level of automation, meaning that those railway systems with progressed automation have a comparatively low number of employees and vice versa. The cost of labour is another important factor influencing this correlation. The regional picture is diverse. In Western Europe, automation is relatively widespread whilst in Eastern Europe it is generally advancing more gradually.

The shift to more automated systems is not simply about reducing staff. Some railways are investing in reskilling, moving employees into roles that support digital systems, passenger information, and intermodal logistics[4].
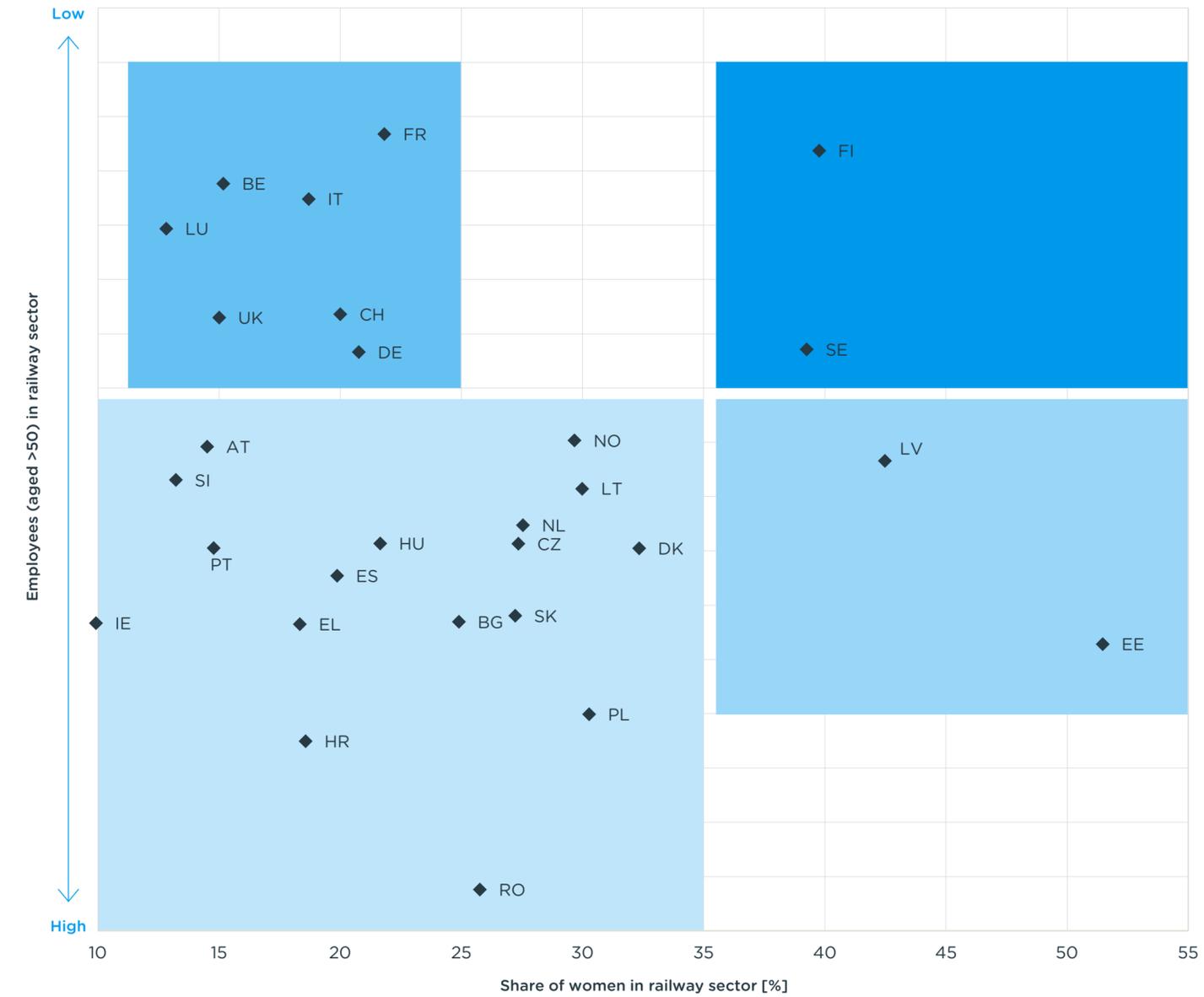
Quick facts

The European rail workforce has a gender gap with women accounting for just 24% of employees. Only Estonia employs more women than men.

In terms of rail network automation, Spain leads with 62% of its interlockings being electronic.
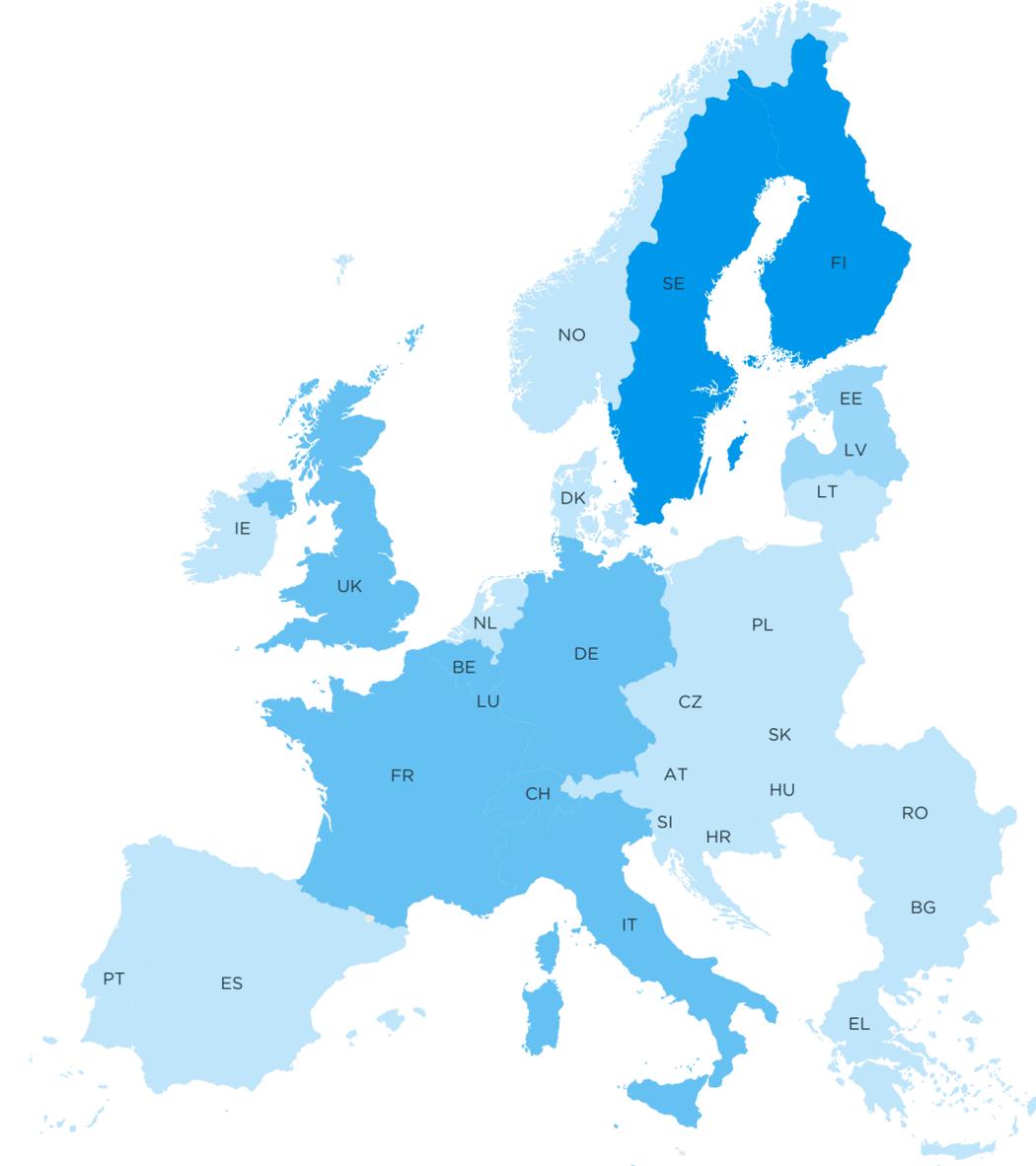
Workforce demographics in Rail: Age vs. Gender

Graph 6

Figure 6

Legend (Graph 6):
- Young, gender-diverse workforce
- Young, male-dominated workforce
- Ageing, gender-diverse workforce
- Ageing, male-dominated workforce

Legend (Figure 6):
- Young, gender-diverse workforce
- Young, male-dominated workforce
- Ageing, gender-diverse workforce
- Ageing, male-dominated workforce

Railway systems by level of automation

Share of automated interlockings [%]

Number of employees [# per thousand train-km]

BG
FR
HR
SK
HU
PL
CZ
SI
CH
AT
ES
DE
FI
SE

Progressed automation
Automation in progress
No or very low automation

Progressed automation
Automation in progress
No or very low automation
No categorisation

Finland

Finland is among Europe's leaders in labour productivity in rail due to a strategic focus on automation and a modern workforce structure. Nearly the entire 6,500 km network is managed remotely through centralised traffic control centres, replacing the need for on-site station staffing. The system allows a single controller to remotely oversee multiple lines simultaneously, enhancing efficiency while reducing labour intensity.

Automation has advanced further through Finland's early adoption of computerised interlockings, with only 1% of lines fitted with older mechanical relay systems[5].

By adopting open-standard signalling interfaces (EULYNX), Finland enables modular and cost-effective upgrades that strengthen productivity.

On the employment side, the rail sector remains attractive with high rates of permanent contracts and competitive wage levels that help retain skilled staff. This goes some way to explaining why the demographics of Finland's rail staff are relatively balanced with one of the youngest workforces in Europe and higher than average representation of women at 40%.

Key learnings

> Initiatives designed to attract women can unlock new recruitment potential.

> Staff upskilling is needed as rail networks become increasingly automated.

> Centralised control and automated interlockings enable lean and efficient operations.

European Rail Traffic Management System deployment

The average rate of ERTMS digital signalling deployment in Europe remains very low, despite its mandatory rollout on the TEN-T core network by 2030.

The European Rail Traffic Management System (ERTMS) is designed to automate and harmonise signalling systems across Europe with a view to enabling seamless cross-border travel and significantly reducing signalling related delays. ERTMS deployment is mandatory for the completion of the TEN-T core network by 2030, on the extended network by 2040, and on the entire network by 2050.

Progress on ERTMS rollout varies widely. With the exception of Luxembourg, Belgium, Switzerland, Slovenia, and Denmark, all countries have deployment rates below 20%.

Large networks such as Germany, France, and Poland remain below 5% coverage, reflecting the scale of the task. Denmark represents a distinctive case, as it has committed to migrating its entire national network to ERTMS Level 2 by 2033.

Complexity and scale hindering rate of ERTMS roll out

The Rail Atlas also shows that different ERTMS levels are being deployed depending on the nature of the lines. Busy passenger corridors often use Level 2, while other routes may employ Level 1. This tailored approach demonstrates how technical choices are matched to operational needs.

Overall, the data highlights both the ambition and the complexity of ERTMS. While complete interoperability remains a long-term goal, the variation in national progress reflects different priorities, financial commitments, and network sizes.

ⓘ

ERTMS levels 1 and 2 explained

ERTMS level 1 uses trackside balises (fixed transponders) to transmit movement authority to trains. Level 2 eliminates the need for lineside signals by using GSM-R radio to provide continuous, real-time communication between the trackside radio block centre and the train's onboard system, enabling higher train speeds and increased network capacity.
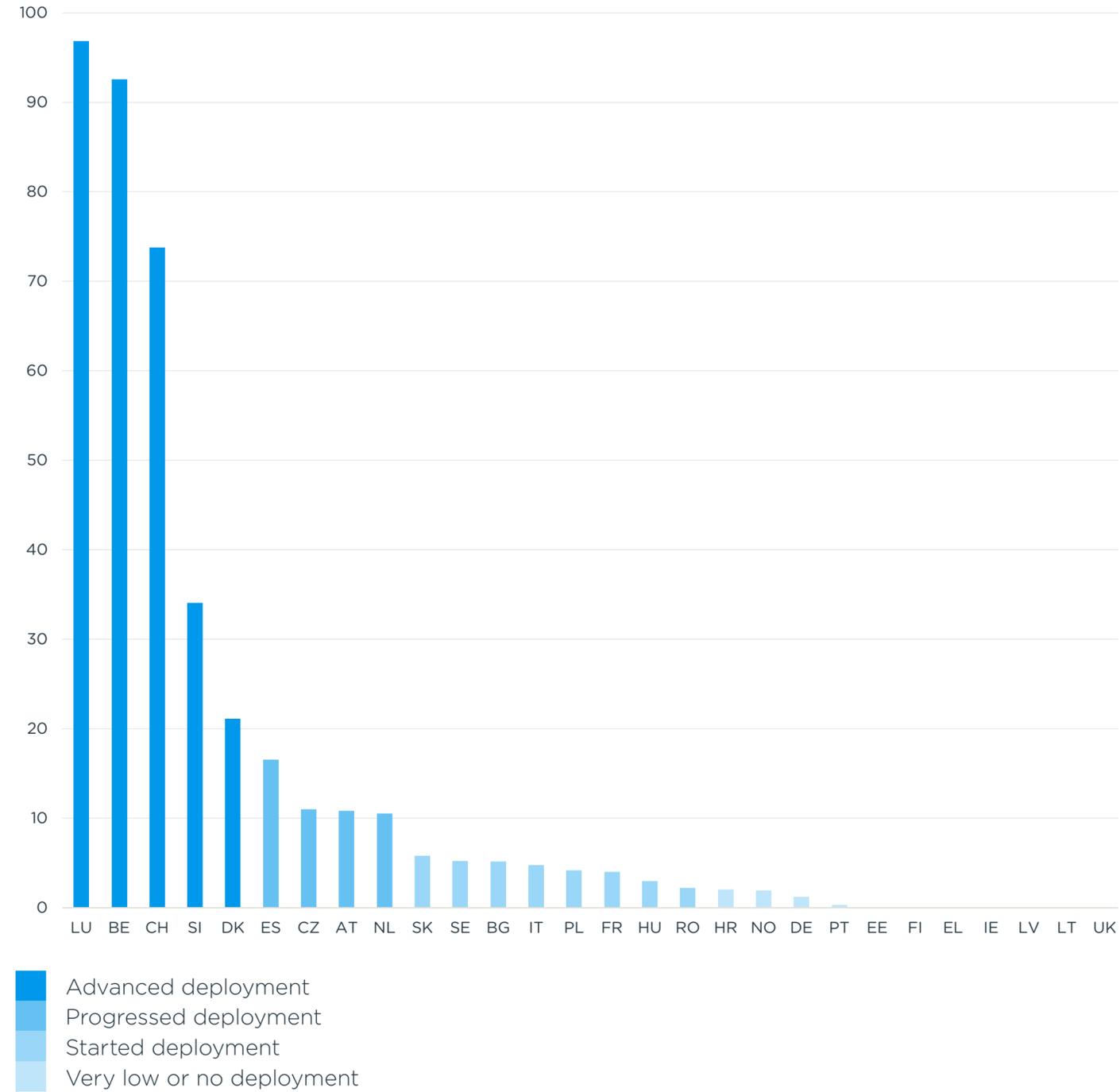
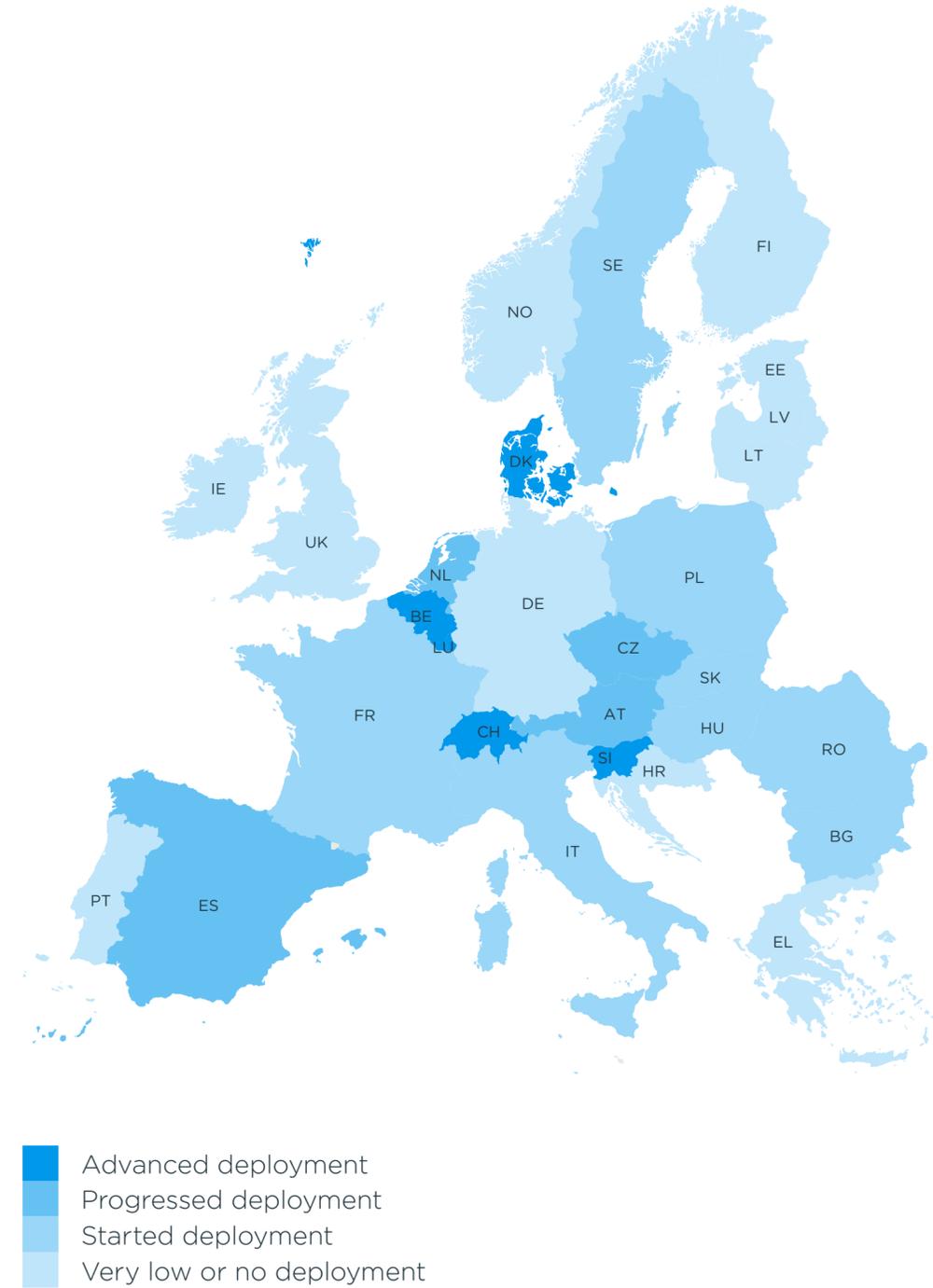## Share of rail network equipped with ERTMS, %

Graph 8

Legend:
- Advanced deployment
- Progressed deployment
- Started deployment
- Very low or no deployment

Figure 8

Legend:
- Advanced deployment
- Progressed deployment
- Started deployment
- Very low or no deployment

Denmark

In 2009, the Danish parliament agreed on a national green transport policy that included the migration of the entire rail network to ERTMS Level 2. Unlike most European countries that are undertaking incremental roll-outs and restricting deployment to main corridors, Denmark's plan is comprehensive and will cover the full network including regional lines by 2033, with cross-border routes to Germany and Sweden due 2025–2028 and the Fehmarnbelt link opening ERTMS-ready in 2029.

The programme is designed to deliver more regular services, higher speed profiles, and better passenger information. According to Banedanmark, the new system replaces traditional trackside signals with computer-based in-cab screens using GSM-R radio, balises, and axle counters. Installation covers both trackside equipment and rolling stock, while more than 4,000 employees across Banedanmark, DSB and other operators are being trained and certified in use of these systems.

The migration has faced delays and cost increases, but its scope and ambition make Denmark a frontrunner in digital signalling.

Key learnings

> Full-network ERTMS deployment secures long-term consistency and interoperability.

> Strong political consensus ensures programme stability.

> Workforce training and new operational rules are essential for safe migration.

Sustainability and environment

A large spread in rail electrification rates results in significant variations in energy consumption and carbon emissions

Lowering emissions is one of the key challenges for the railway sector in the coming decades. Rail is already recognised as one of the most sustainable modes of transport with high energy efficiency and up to five times lower greenhouse gas emissions per passenger kilometre compared to cars[6], but the Rail Atlas reveals significant national differences in emission levels.

Increasing the share of electrified lines and reducing the share of diesel-powered trains are the two most important approaches to reducing emissions. On average, 57% of rail networks across Europe are electrified. The high degree of electrification in Switzerland, Luxembourg, and Belgium means that these countries railway systems produce very low emissions.

In contrast, the Baltic countries and Ireland have low electrification rates, resulting in high emissions per train-km. Romania and the UK record high emissions despite reasonably advanced electrification of 38% of their networks.

The share of trains powered by renewable energy also has a direct influence on emissions.

For instance, the Netherlands reports some of the lowest carbon intensities in Europe as 100% of its trains in are wind-powered. Sweden combines high electrification with a renewable energy mix of hydro and wind power, reinforcing rail's position as a leading climate-friendly option even where single-track infrastructure dominates.

Alternative approaches to decarbonising rail

Diesel powered trains, which contribute to higher emissions, still play a role in many countries, particularly on rural and regional lines. To address this, several nations have implemented or are testing alternatives such as hydrogen or battery-electric trains. These innovations highlight how railways are seeking to decarbonise even where full electrification may not be feasible.

What emerges from the data is that sustainability in the rail sector is closely linked to energy policy. Countries that align their railways with national renewable strategies achieve the strongest results, demonstrating how transport and energy transitions reinforce one another.
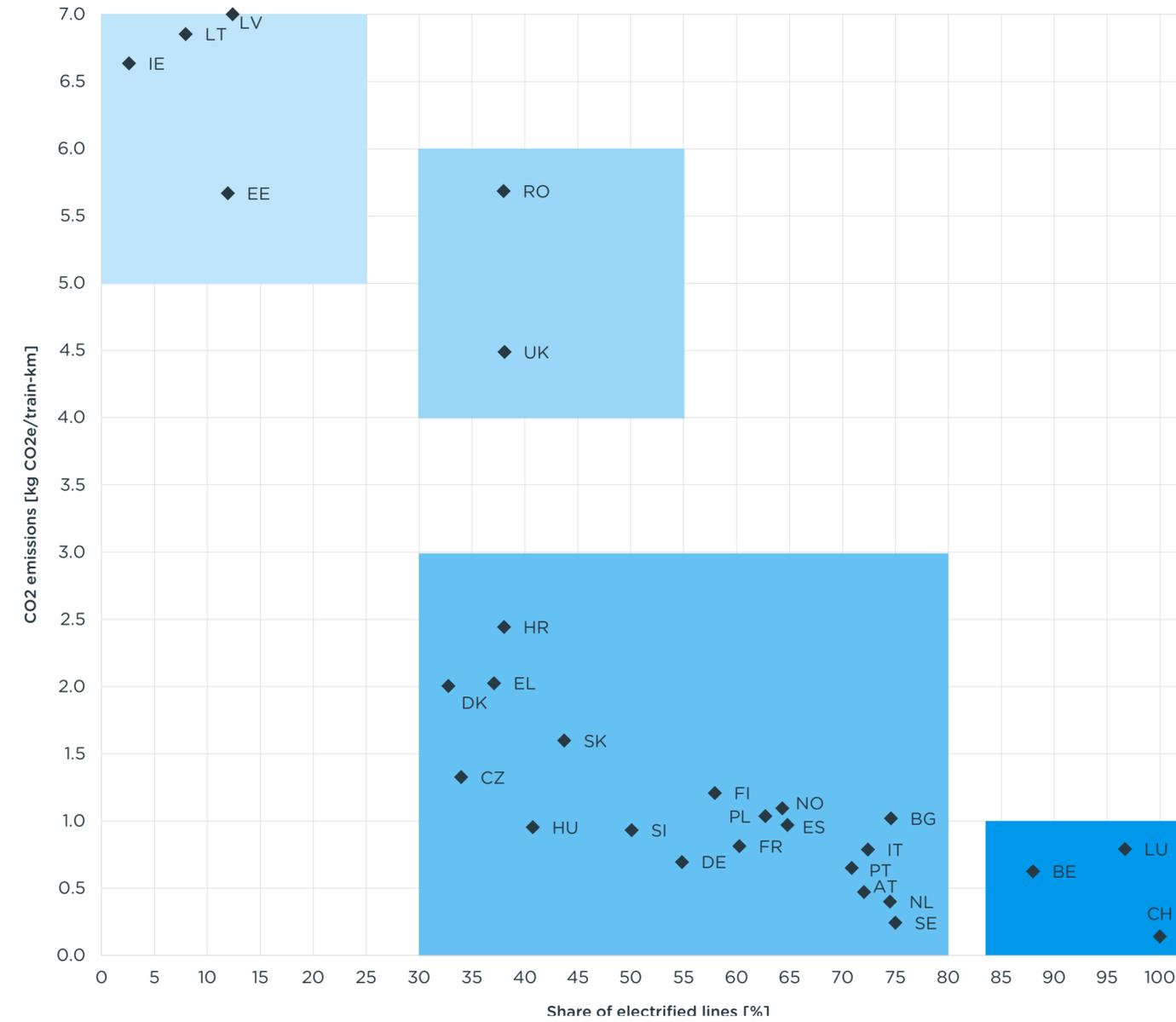

Quick facts

Line electrification is directly related to decarbonisation. The share of electrified rail lines in Switzerland is 100% and it has the lowest emissions in Europe. Sweden uses 100% fossil free electricity to power trains (wind, hydro and trialling solar) and has the second lowest emissions.
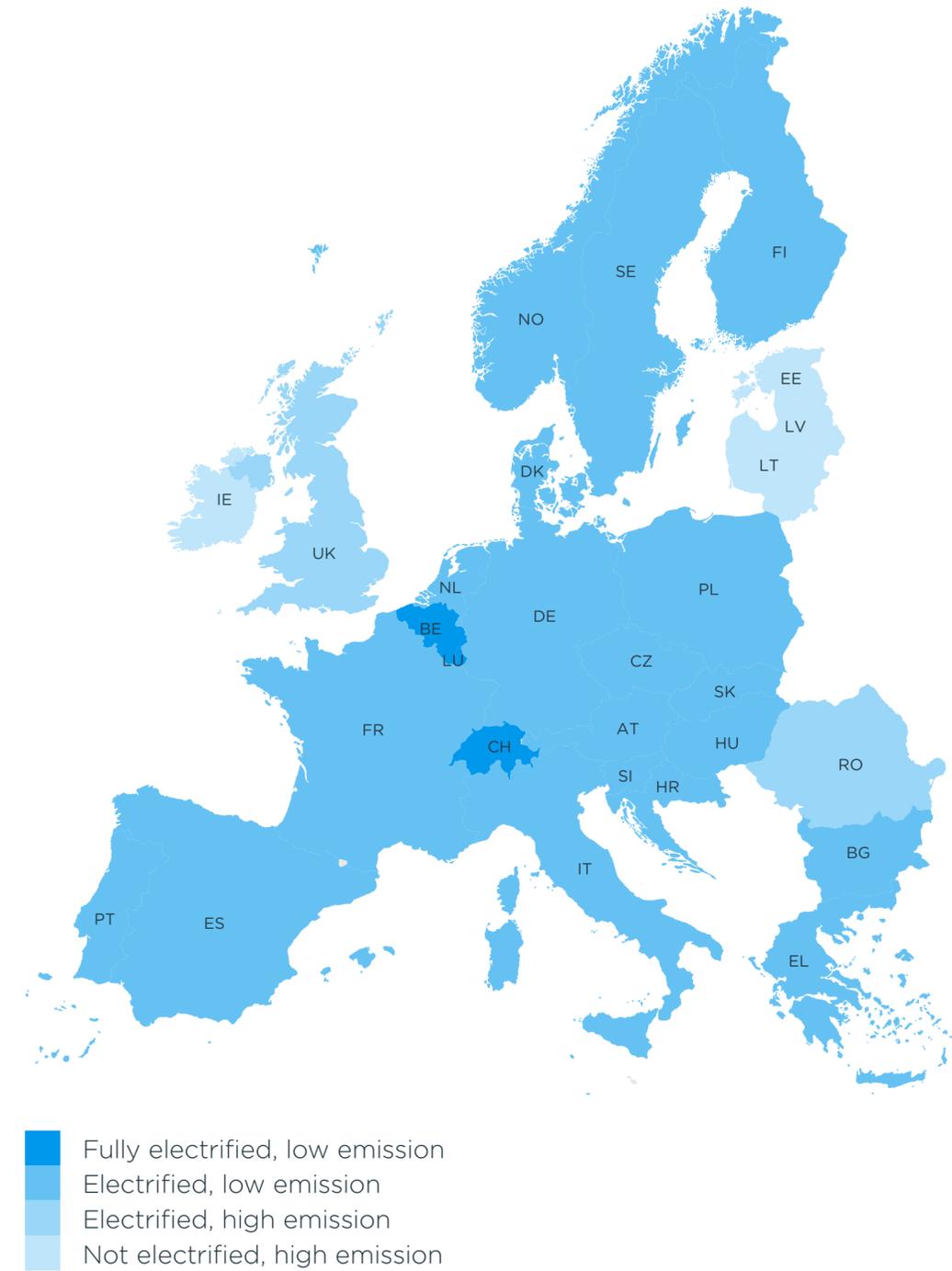
Railway systems by electrification and CO2 emissions

Share of electrified lines [%]

CO2 emissions [kg CO2e/train-km]

Legend:
- Fully electrified, low emission
- Electrified, low emission
- Electrified, high emission
- Not electrified, high emission

Source: 9th RMMS report (2022 data)

Legend:
- Fully electrified, low emission
- Electrified, low emission
- Electrified, high emission
- Not electrified, high emission

Sweden

Sweden is among Europe's top performers in rail sustainability. The country records some of the lowest carbon emissions per train-kilometre, alongside Switzerland and the Netherlands due to a highly electrified network and a clean energy mix.

Passenger rail holds an 11% modal share, while freight accounts for 29%, supported by initiatives such as Railport Scandinavia, which links the Port of Gothenburg to inland terminals and shifts container flows from road to rail.

Sweden's rail infrastructure manager, Trafikverket, has increased traffic volumes on the network in recent years, but over 80% of lines remain single track, creating a long-term capacity challenge.

SJ and other operators already run services on renewable electricity, aligning with Sweden's national 2045 net-zero climate target. Investments in power stability, new rolling stock, and selective electrification upgrades are therefore central to sustaining low emissions while expanding capacity.

Key learnings

› A clean power mix and electrified network are the backbone of low rail emissions.

› Hydrogen and battery-electric trains offer an alternative to decarbonising non-electrified or rural lines.

› Aligning rail and energy policies help ensure sustainability goals are achievable.

Methodology

Key performance indicators

The European Rail Atlas is based on 431 data points. Each dimension of the atlas is measured by multiple key performance indicators (KPIs) listed in the table. While not every KPI is illustrated in the Atlas, all KPIs are incorporated into the overall maturity calculation.

Sources

Data sources are 9th RMMS Report, Eurostat, IRG Rail 2024 report, Office of Rail and Road, Bundesamt für Statistik Switzerland and ERADIS. All data refers to 2022 unless stated otherwise.

Scoring

For each KPI, countries are ranked from first to last where the first country receives one point and the last country receives the highest number of points. For each dimension, KPI scores are averaged to calculate the dimension score.

For the overall maturity level of railway systems, all KPI scores across all dimensions are averaged. The resulting averages are then ranked from lowest to highest.

Dimension	Key performance indicators
National relevance of rail	• Modal split of rail in passenger transport [%] (Source: Eurostat) • Modal split of rail in freight transport [%] (Source: Eurostat) • Train service per capita [yearly train-km per capita] (Source: Calculated based on RMMS)
Performance	• Punctuality of passenger trains [%] (Source: RMMS) • Punctuality of freight trains [%] (Source: RMMS)
Safety	• Safety Score (Source: Calculated based on ERADIS. Fatalities are weighted by a factor of 10)
Infrastructure financing and infrastructure utilisation	• Infrastructure expenditure [EUR per track-km] (Source: Calculated based on RMMS, PPP-adjusted) • Network utilisation [train-km/track-km] (Source: Calculated based on RMMS)
Market competition	• Market share of non-incumbent RUs in passenger transport (Source: IRG Rail) • Market share of non-incumbent RUs in freight transport (Source: IRG Rail)
Employment and automation	• Number of employees in the rail sector [FTE/train-km] (Source: Calculated based on RMMS) • Share of employees >50 years [%] (Source: Calculated based on RMMS) • Share of women in total employees [%] (Source: RMMS)
ERTMS deployment	• Share of rail network equipped with ERTMS [%] (Source: IRG Rail)
Sustainability and environment	• Energy consumption [toe per train-km] (Source: Calculated based on RMMS) • CO_2 emissions [CO2e/train-km] (Source: Calculated based on RMMS)

About Ramboll

With over 1,300 dedicated rail engineers and consultants, Ramboll covers all aspects of rail infrastructure, systems, rolling stock as well as operations and systems maintenance. We also support the entire planning process: from strategic advisory and feasibility studies to the conception, design, and tender of all operational and maintenance elements as well as life cycle cost evaluations. Learn more at **ramboll.com/rail**

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