Net-Zero Logistics: The Contribution of Rail Transport

Europe's Rail Joint Undertaking

Policy paper

June 2025

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Europe's Rail

EY Parthenon

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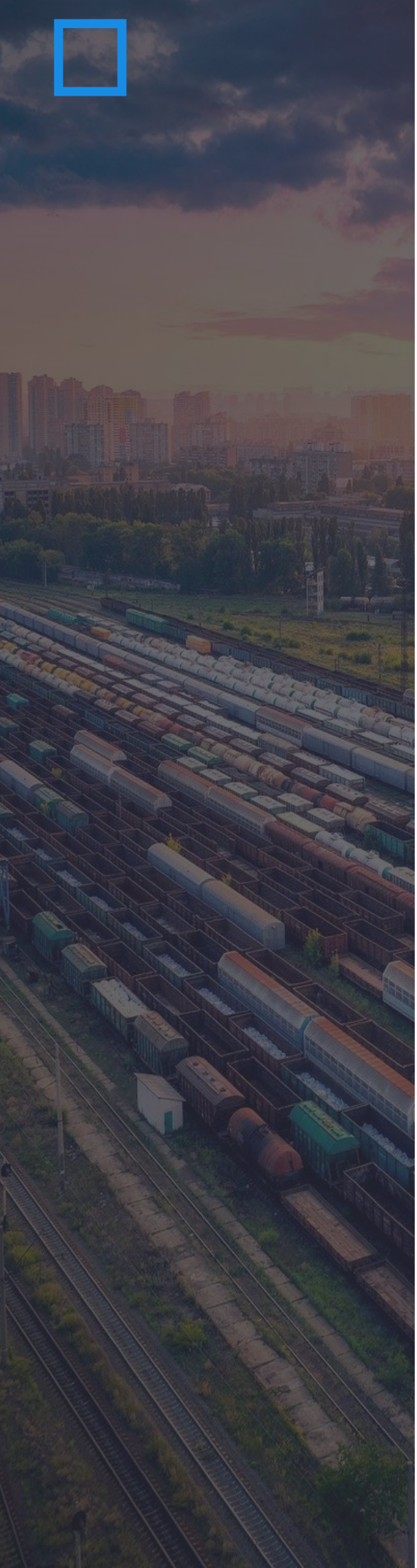

Key highlights from the report

Beyond **significant impacts on CO2 emissions**, the high ambition scenario for the development of rail transport across logistic chains, entails **significant benefits in reducing other externalities** (traffic accidents and congestion in particular) and **overall energy consumption**. Despite the investments required to implement the measures included in the scenario, the extent of the socioeconomic benefits ensures that the cost-benefit analysis yields a positive outcome, providing a compelling rationale for such investments.

The results are all the more significant as they are to be interpreted in comparison to an ambitious baseline scenario for the other transport modes such as road transport. In other words, these strong benefits associated with a better integration of rail transport across logistic chains should be seen as the **lower bound of what could be achieved**.

A corollary outcome is that the development or rail freight within logistic chains generates **substantial savings** in terms of road decarbonisation costs and infrastructure costs.

1. Why is it critically important ?

Logistic chains play a crucial role in driving economic growth and business expansion. As a key enabler of economic activity, the logistics sector contributes to nearly 14% of the EU's GDP, generating €1,5 trillion of revenue and over 7 million jobs in Europe. Logistics not only facilitates trade and enhances supply chain resilience but also supports critical military needs, making it a fundamental pillar of the European Union (EU) economy.

At the same time, decarbonising logistics is essential for the EU to achieve its climate objectives. With the EU aiming for a 55% reduction in greenhouse gas emissions by 2030 and full climate neutrality by 2050, transitioning to net-zero logistics should be a key component of this broader effort given the sector's significant environmental footprint. Currently, logistics accounts indeed for approximately 10% of final energy consumption and CO2 emissions, highlighting the need for rapid and effective decarbonisation.

To achieve this transition, innovation and efficiency gains will be critical. Automation and digitalisation of freight operations can significantly improve efficiency, reducing costs while increasing the competitiveness of freight transport operations. In that sense, shifting towards sustainable logistics aligns with the ambitions of the Clean Industrial Deal, pursuing the dual objectives of competitiveness and decarbonisation as mutually reinforcing goals.

The transition to net-zero logistics presents several key challenges that must be addressed to ensure its success. Foremost among them is the need to optimise the integration of various transport modes within logistics chains to enhance both efficiency and operational resilience. Achieving this requires a coordinated effort to optimise freight flows and enable seamless multimodal connectivity. Equally critical is expanding rail connectivity, particularly in last-mile links to hubs, urban nodes, intermodal terminals and ports, as this will play a pivotal role in the success in this agenda. Finally, securing socio-economic investments through public and private funding is crucial to realise these objectives, enabling the development of infrastructure and innovation necessary to enhance efficiency, improve connectivity, and meet decarbonisation goals[1]. These investments will equip the logistics chains to adapt to evolving demands, while also contributing to sustained long-term economic growth.

In this context, a major shift in the organisation of freight logistics chains is required, along with the necessary growth in freight transport to sustain economic and trade development. Building on insights and guidance offered by a group of leading academics[2] and a Steering Committee representing key organisations[3], a recent study developed by EY-Parthenon on behalf of the EU-Rail JU aims at identifying strategies to achieve net-zero logistic chains while ensuring economic efficiency, resilience, and ensuring that the freight transport sector fully contributes to enhancing the competitiveness of the European economy. To this end, the study undertook an in-depth analysis of the potential for intermodal optimisation of freight transport across five European transport corridors representing 65% of EU rail freight demand and 95% of total EU GDP (Figure 1). The results, which cover the period 2025-2060, were then extrapolated to the entire EU.

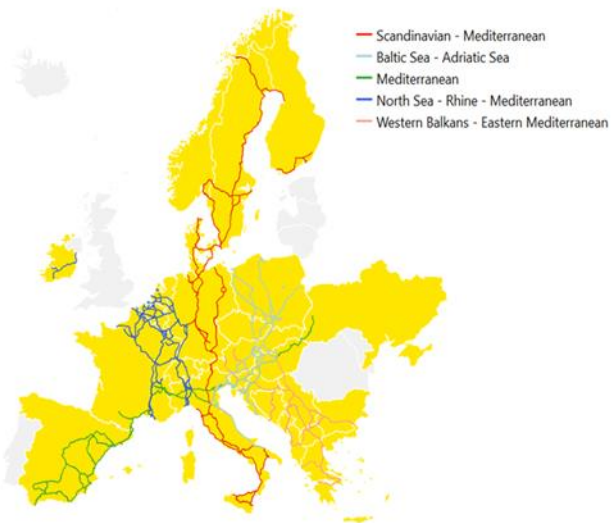

Figure 1: Corridors covered in the study

1. For more details, see EU-Rail JU - Draft Paper – A Future Policy Based Public Private Partnership For Rail - Europe's Rail.
2. The group consisted of Juan Montero (European University Institute), Florent Laroche (Laboratoire Aménagement Economie Transports), Oliviero Baccelli (Bocconi University – GREEN) and Anna Dolinayová (University of Zilina – Department of Railway Transport).
3. The Steering Committee was composed of the following organisations: EU-Rail JU, CER, UNIFE, ETP-Alice, UIRR, CLECAT, EIM, UIP, ERFA and the European Commission DG MOVE.

The Baseline Scenario

In the context of this study, it is crucial to point out that all results must be interpreted in comparison to a baseline scenario which includes the most ambitious assumptions for the decarbonisation of road transport and inland waterway (IWW) transport. This approach ensures that the results remain objective and do not bias the analysis in favour of rail transport by underestimating the potential development of other transport modes. The table presented above (Table 1) highlights specific assumptions considered in the baseline for each transport mode[4].

Transport mode	Assumptions in the baseline
Road	▪ 90% reduction in trucks' emissions by 2050 ▪ 90% of electricity usage produced via clean energy sources by 2050
IWW	▪ 100% reduction in vessels' emissions by 2050 ▪ 90% of electricity usage produced via clean energy sources by 2050
Rail	▪ Gradual growth of green power (e.g. through PPAs / autoproduction / evolution of power mix in the grid) available for electrified rail lines, reaching a 100% share by 2040

Table 1: Baseline assumptions per mode

Measures considered for a more ambitious and impactful role for rail across logistics chains

The approach adopted involves defining three project scenarios (Table 2) that vary in their level of ambition. Each project scenario encompasses a set of measures aiming at achieving a better integration of rail freight across logistics chains.

The scenarios are cumulative in nature: the 'Moderate' scenario incorporates the measures outlined in the 'Low' 'scenario, and the 'High' scenario adds on both the 'Low' and 'Moderate' scenarios. The modelling exercise evaluates their effects on CO2 emissions, other external impacts as well as cost savings, in comparison to the reference scenario. A simplified cost-benefit analysis (CBA) is then developed to assess the socio-economic benefits associated with each scenario.

Measures	Scenario ambition		
	Low	Moderate	High
▪ Operational rules harmonisation	Low		Full
▪ Increasing train length to 740m			✓
▪ Rail infrastructure capacity allocation (EU-level)		✓	✓
▪ Investments in multimodal hubs, urban nodes and ports in particular		Partial	Full
▪ European Rail Traffic Management System (ERTMS)		Partial	Full
▪ Digital Automatic Coupling (DAC)		✓	✓
▪ Alternative Fuel Locomotives	Low	Partial	Full
▪ Full deployment of EU-Rail JU technical outputs[5]			✓

Table 2: List of measures per scenario

4. It is worth noting that the investments associated with these assumptions are not included in the cost-benefit analysis, as they pertain to the baseline. Nevertheless, the cost of decarbonising road transport is estimated at € 211 billion (not discounted).
5. The technologies included within this measure are expected to further boost some of the other measures such as ERTMS deployment. The game changers can for example fully unlock the capacity-enhancing potential of ERTMS.

2. Key outcomes of the scenario analysis

The results (Table 3 and Figure 2 below) highlight that, **despite the scale of investments required (€33 bn for the five corridors, which corresponds to €51 bn at EU level[6]), the high ambition scenario offers the most economically beneficial pathway, providing the highest socio-economic returns in the transition towards net-zero logistic chains in Europe.** Under this scenario, €1 invested in sustainable and efficient logistics will generate €5 euro of added value for European society.

	2025	2050	
Key metrics (unit)		Moderate	Ambitious
Rail utilisation (modal mix in %)	18	24	34
Benefit/cost ratio	N/A	3,7	5

Table 3: Key results for the medium and high ambition scenarios

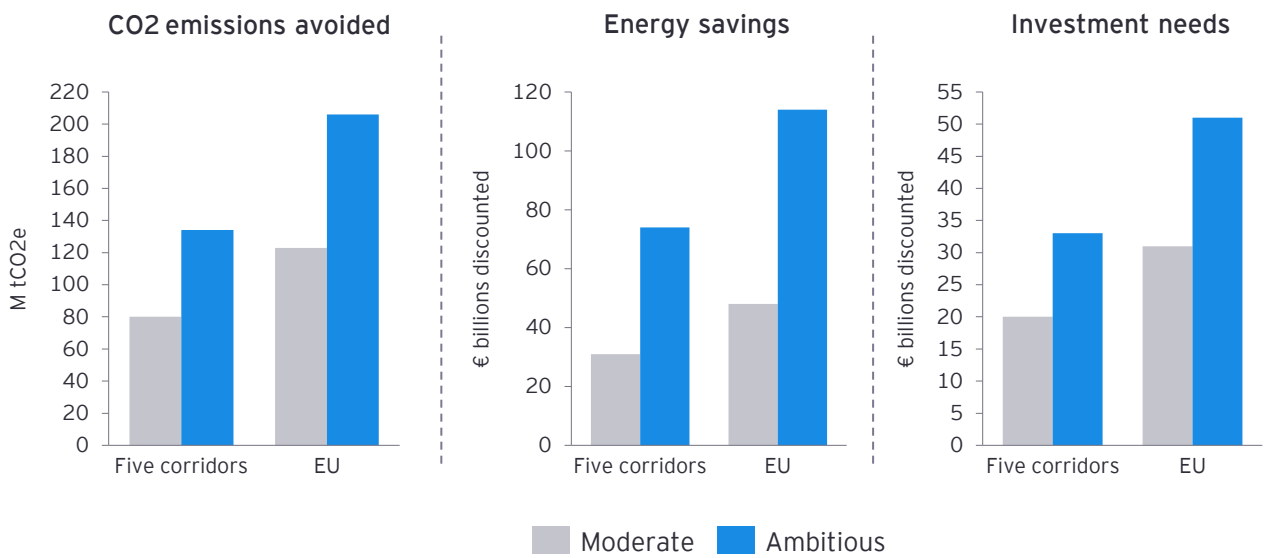

Figure 2: Key results for the moderate and high ambition scenarios

By combining measures such as increased train lengths, full deployment of market-ready and future European rail innovations, harmonisation of operational rules, and significant investments in logistics hubs, it provides a robust framework for achieving the highest level of carbon reduction, infrastructure capacity exploitation as well as significant energy-efficiency gains across EU logistic chains.

The very positive outcome of the high ambition scenario is driven by three major effects enabled by the set of measures included: accelerated CO2 abatement, important benefits in reducing other externalities and significant cost savings in operational and capital expenses.

6. This value, which is discounted, corresponds to the total investments required for the group of measures included in the high ambition scenario.

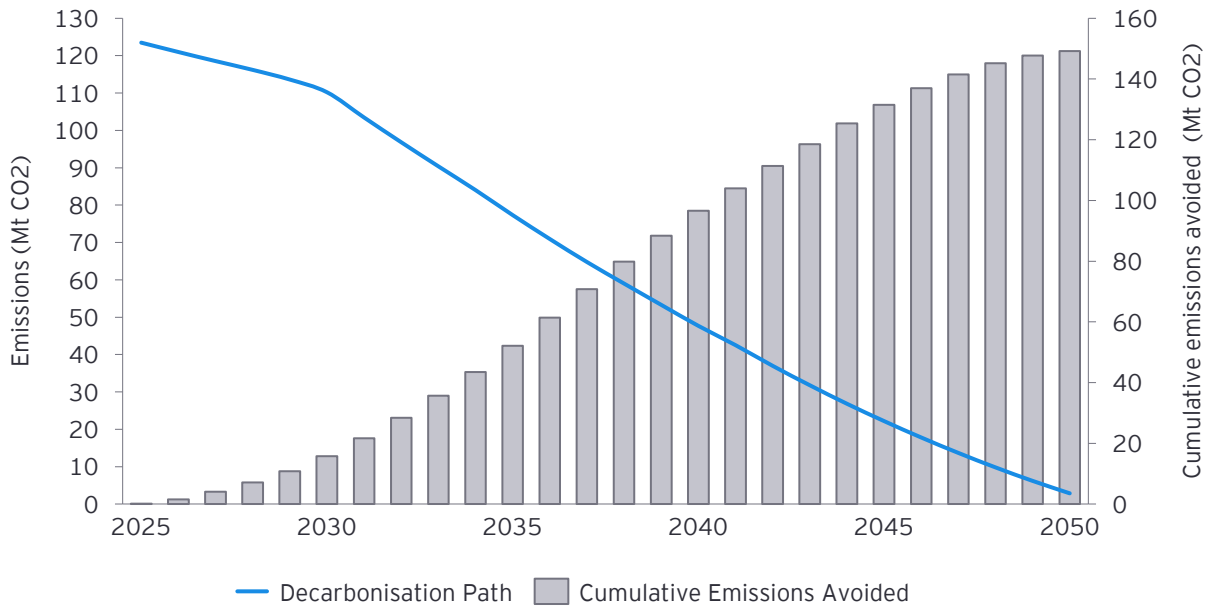

Figure 3: CO2 emissions development - High ambition scenario

The CO2 emissions reduction in the high ambition scenario (Figure 3) is driven by two main factors: the increased share of rail freight within logistics chains[7] (Figure 4) and the improvement of rail freight energy efficiency over the period (Figure 5). This further highlights the benefits that can be achieved by leveraging the energy efficiency of rail in transportation systems.

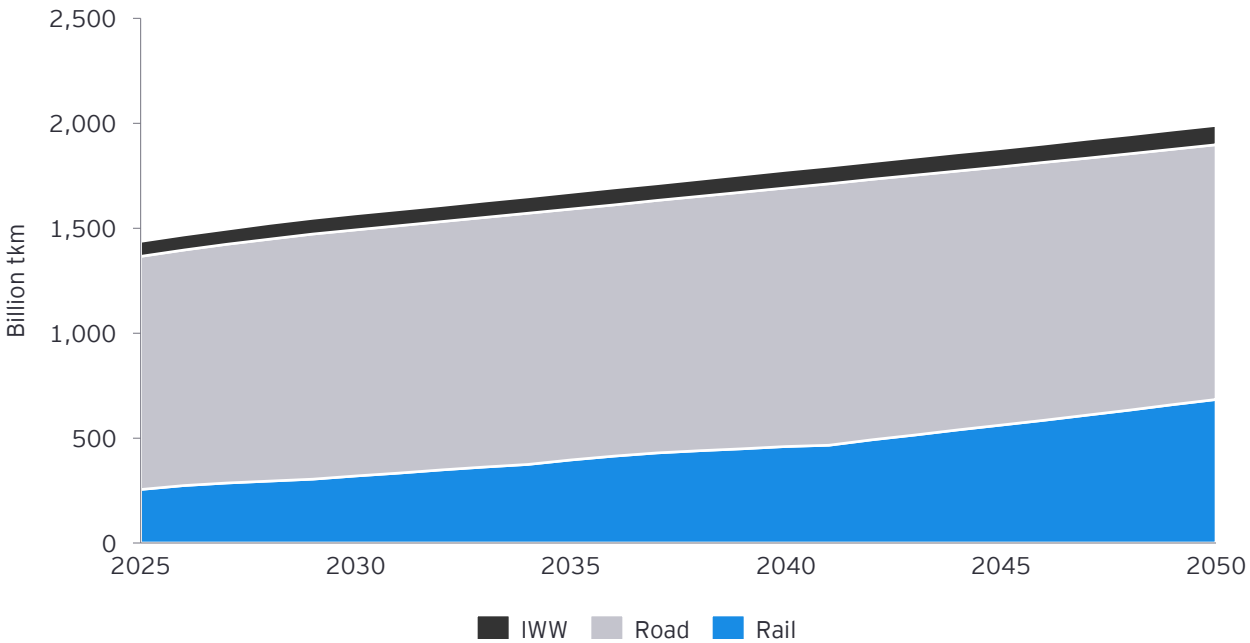

Figure 4: Freight demand - high ambition scenario

7. The modal split of inland rail freight reaches 34% in the high ambition scenario.

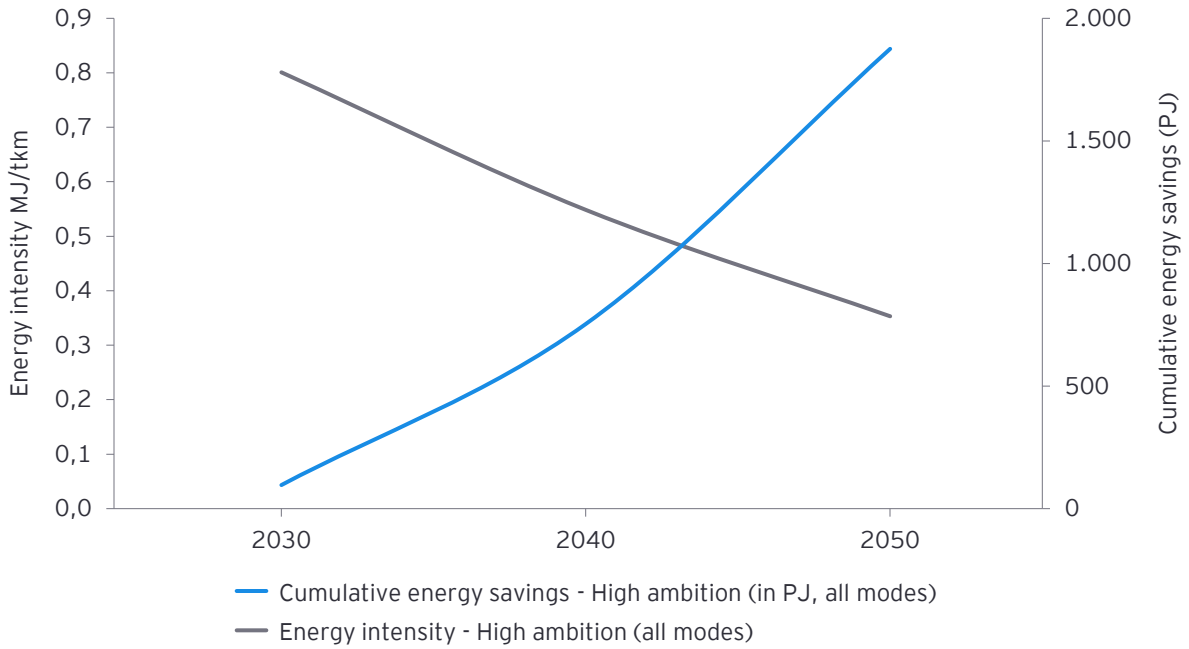

Figure 5: Evolution of energy intensity and energy savings - High ambition scenario

- **Reduction in externalities:** Beyond CO2 emissions reductions, the analysis underscores that development of rail freight strongly mitigates externalities such as road congestion and accidents, leading to total external cost savings of € 85 bn[8] in the high ambition scenario for the five corridors (Figure 6). This outcome is important from a policy perspective. Indeed, even if the ambitious decarbonisation assumptions embedded in the model for road transport in particular were not fully realised, the measures assessed in this study would still deliver a notable impact of CO2 emissions and very significant effect on external costs reductions. The multidimensional nature of these impacts reinforces the importance of evaluating the measures in a comprehensive manner, rather than through a single lens of CO2 emissions reduction. By incorporating the range of externalities into the analysis, the study provides a comprehensive assessment of the expected positive effects of the development of rail transport within logistic chains in the EU.

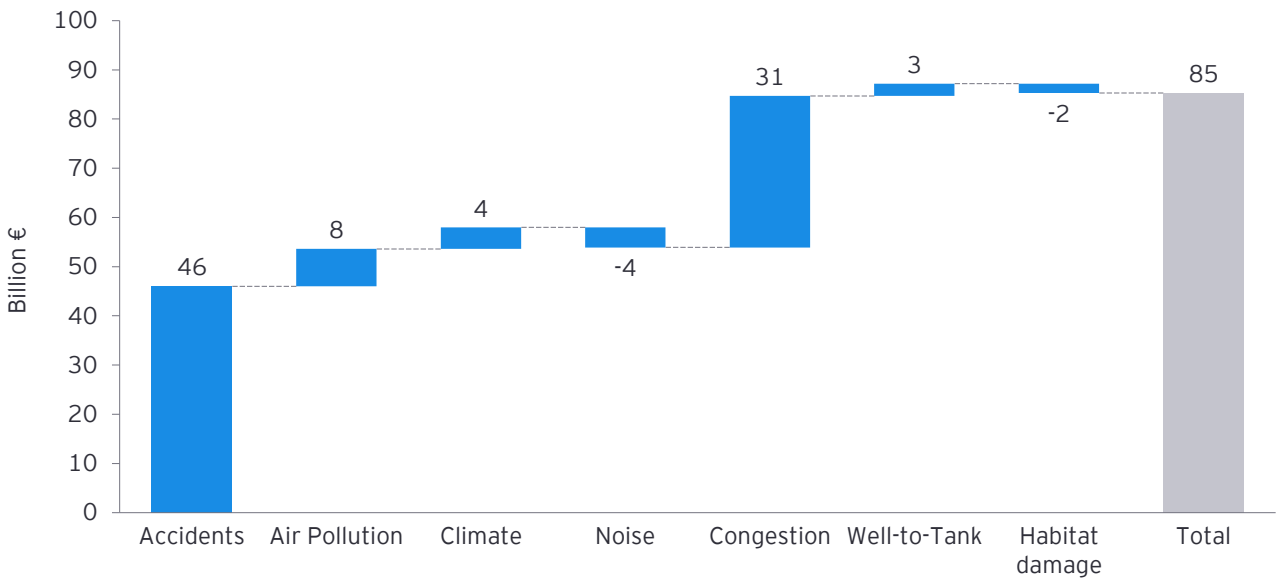

Figure 6: Reduction in externalities - High ambition scenario

8. This value is discounted.

- **Sharp reduction in operational and capital expenses:** A corollary outcome of the study is to highlight that the development or rail freight within logistic chains generates substantial cost savings across four key dimensions. First, it significantly reduces the need for costly measures to curb emissions from road transport. The study estimates that the high ambition scenario would save approximately €44 bn in road transport decarbonisation costs, out of a total of €211 bn[9] in the baseline scenario (if this amount is not included in the cost-benefit analysis as it is part of the baseline, it remains that it is significantly higher than the investments associated with the high ambition scenario). Second, the superior energy efficiency of rail leads to a marked reduction in overall energy consumption by €74 bn[10] (equivalent to 3344 petajoule[11]) over the period considered in the high ambition scenario, while also mitigating exposure to energy price volatility. Third, by alleviating pressure on road infrastructure, the development of rail freight reduces the need for costly road expansions and maintenance to accommodate the expansion of freight traffic, generating substantial infrastructure savings. Lastly, the improved efficiency and capacity utilisation of rail networks contribute to lower overall transport costs, enhancing the competitiveness of freight transport while supporting long-term economic and environmental objectives.

All in all, this scenario provides a compelling case for integrating rail freight at the heart of Europe's industrial strategies to drive both environmental and economic progress.

9. These values, which are not discounted, were calculated using a road transport decarbonisation cost of €1.28 per kg CO2 saved.
10. This value is discounted and covers only for five corridors considered in the report.
11. This value represents the cumulated savings until 2060. Figure 5 present the savings until 2050

3. Recommendations to move this agenda forward

Three main policy implications can be drawn from the study:

- **Major socio-economic gains can be expected from the high ambition scenario,** therefore holding the potential to bring a very significant contribution to the Clean Industrial Deal as well as the Sustainable and Smart Mobility Strategy. Achieving this will require a fundamental shift in how transport modes are integrated across logistics chains to unveil the potential of rail freight. This rebalancing will allow each transport mode to focus on where it is most effective, improving overall system efficiency by leveraging their respective strengths.
- **Bundling measures and ensuring a whole network roll-out is critical to harness synergies and ensure maximum impact.** While measures such as investments in intermodal terminals or capacity management at the EU level deliver the highest individual benefits, the analysis makes a strong case for bundling measures together. Many of them exhibit indeed strong synergies, such as the combination of ERTMS with innovations like the Digital Automated Coupling (DAC) or the game changers included in the EU-Rail JU technical outputs, which can for example fully unlock the capacity-enhancing potential of ERTMS. Additionally, certain measures present a high degree of interdependency – for instance, the deployment of the DAC plays a crucial role in enabling longer freight trains and optimising operations including the EU wide implementation of common operational rules. Moreover, grouping measures enables to fully capture the spillover effects of investments in this sector, amplifying the overall benefits across the whole logistics system. For these reasons, pursuing these measures in isolation or without proper coordination would result in significant missed opportunities.
- **Technology supports the optimisation of network capacity** without the need for extensive infrastructure investments as well as the pre-deployment activities of system innovations, such as DAC. In this regard, EU-Rail JU is playing a key role in driving forward innovation to accelerate the transformation or rail freight and optimise its integration across logistic chains.

Building on the outcomes of the study, a set of key recommendations can be derived to drive the transition towards more sustainable and efficient logistic chains which, in turn, should contribute to strengthening the competitiveness of the European industry. These recommendations, presented in the box below, aim to provide actionable measures to unlock the full potential of the high ambition scenario. It should be highlighted that the development of the high ambition scenario should also significantly strengthen the capacity to meet evolving military mobility requirements.

Key recommendations

The report highlights that the high ambition scenario should be prioritised. Unlocking its full potential will requires careful strategic planning and coordination, with the ultimate goal of fully contributing to the Clean Industrial Deal as well as the Sustainable and Smart Mobility Strategy. A holistic vision is needed, not only for rail freight but for the entire transport system, ensuring that these measures are embedded within a broader strategy which fully supports Europe's transition towards a more sustainable and competitive economy. While some of the actions identified in the study are already underway, they must be integrated into a more comprehensive strategic framework to advance this agenda effectively.

Such framework should, in particular, focus on the following priorities:

- **Strategic planning**:
  - Develop a **strategic roadmap** defining clear priorities, possible regulatory changes, quantified targets, timeline and responsibilities to advance this agenda forward. Such roadmap should notably facilitate a coordinated technology deployment.
- **Infrastructure and capacity management:**
  - **Drive forward the innovation agenda** to optimise network capacity and foster the integration of rail freight transport across logistic chains.
  - **Accelerate the set-up of Net-Zero multimodal hubs** across the EU corridors and according to Member States' specific needs (which should be delineated as per the national action plans for the development of a multimodal freight terminal network that have to elaborated by July 2027[12]).
  - Ensure **last mile connectivity** of hubs, intermodal terminals, urban nodes and seaports.
  - **Unlock cross-country rail infrastructure capacity management**, to enable its best use, especially over long distances.
- **Funding:**
  - **Exploit synergies of interest between the public and private sectors** to drive investments funding, particularly given the significant potential in dual-use (military-commercial) infrastructure. This approach, which should be developed in line with hubs's specialisation trends and the associated value chains' transformation, holds significant promise for effectively addressing the challenges of last-mile connectivity in particular.
  - Provide, notably through appropriate incentives, **encouraging market conditions for private investments** in net-zero optimised business models.
  - **Leverage revenue from the Emissions Trading System 2** to support targeted investments in the development of net-zero logistic chains.
- **Stakeholder engagement**:
  - Keep **engaging with stakeholders** to ensure that these developments align with market needs and operational realities. Engaging the relevant actors across the different modes will be essential to successfully implementing the necessary transformations.

12. Regulation (EU) 2024/1679 of the European Parliament and of the Council of 13 June 2024 on Union guidelines for the development of the trans-European transport network.

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