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Perspectives for the development of the Polish railway transport sector in the face of the energy crisis: A critical analysis

Abstract: The authors of the article *Perspectives for the development of the Polish railway transport sector in the face of the energy crisis: A critical analysis* focus on presenting key information and challenges concerning both the current state and future prospects of railway transport. This analysis is set against the backdrop of an escalating energy crisis, driven by various factors, many of which are beyond the control of energy-importing countries. According to the authors, particular attention should be given to short- and medium-term challenges resulting from Russia's aggression against Ukraine, as well as to long-term structural difficulties that, paradoxically, may be even harder to address—namely, those related to the European Union's implementation of policies aimed at achieving broad climate neutrality.

Keywords: Rail transport; Climate neutrality; Energy

Introduction

The earliest attempts to utilise the potential of railway transport date back to antiquity, when makeshift wagons carrying materials necessary for the construction of pyramids and temples moved along grooves in the ground or wooden beams. The driving force behind these vehicles was provided by horses or oxen, and at times, even by human effort. Around 600 BC, the Greeks constructed a near 8.5-kilometre-long proto-railway (Diolkos), which was used to transport ships across the Corinth Canal. The significance of this investment is evidenced by the fact that it remained in use for the next 600 years [1]. The first railway system resembling today's technical solutions was used for transporting coal from the coal basin in Darlington to the port in Stockton. This event took place on 27 October 1825 in Britain, an empire that was then a global power, its strength founded on innovative production solutions. It was the British who began large-scale coal production to utilise this resource as an energy carrier. Energy was the driving force behind industry, enabling the transition from the age of manufactories to the era of machine-based production. All of this required a reliable energy source. As the brilliant inventor, pioneer, and builder of the first railway, George Stephenson, recalled: *'Initially, I formulated the principle of a strict connection between the track and the locomotive, designing rails that could withstand the dynamic impact of locomotive wheels without any risk. I convinced the management of the benefits of applying my ideas and obtained permission for the experimental introduction of the locomotive as a driving force, but this revolutionary technical innovation still required parliamentary approval. I obtained it in 1823'* [2].

The geopolitical situation the world has been facing for several years now is compelling decision-makers across multiple levels—political, economic, and social—to undertake a profound redefinition of the concept of security assurance and resilience-building, both in highly developed countries and in those seeking to join the ranks of advanced organisations through alliances or, at times, aggression. It must be acknowledged that alongside military, climatic, or pandemic-related threats, other significant disruptions to societal functioning may arise in the near future, the nature and scope of which remain unpredictable at present. These disruptions may be minor and localised or assume a catastrophic global scale. Among the serious threats whose early signs are already clearly visible, one can include uncontrolled migration between the Global South and North, as well as the risk of limited access to both energy resources and energy itself.

As events of recent years have demonstrated, transport and connectivity constitute fundamental components of ensuring overall security. Although connectivity does not form the primary subject of this analysis, in an era of digitalisation and automation, it is intrinsically linked to transport-related considerations. Alongside connectivity, another critical factor influencing the operational readiness of transport organisations is the assurance of their driving force—energy.

The development of global transport networks has driven, and continues to drive, the expansion of railway infrastructure. Wherever 'the tracks reached,' centres of growth emerged, new metropolitan and industrial hubs were established, along with the necessary infrastructure to support them. The notion that 'civilisation arrived with the railway' has transcended academic discourse, becoming a widely accepted truth. Despite the passage of time, this remains the case. Even with the advancement of other modes of transport, the railway continues to hold a dominant position. Without directly linking security considerations to 'competitiveness,' one could argue that the main 'rival' of rail transport at present is road transport, particularly over shorter distances. When looking at longer routes, rail continues to compete with air travel in passenger transport and with maritime transport, particularly in intercontinental freight connections. Although underfunding of railway infrastructure and the resulting capacity limitations remain a global challenge, it is important to recognise that, unlike road transport, trains, though they may experience delays, do not face congestion—an undeniable advantage in the competition between rail and road transport. Another equally significant factor advocating for the use of rail as the primary mode of freight transport is its strategic role in the broader sphere of national defence and security.

Unfortunately, examples of this are not hard to find—one only needs to look at the large-scale flow of weapons, armaments, and ammunition facilitated by Poland in support of the Ukrainian armed forces [3].

The political, economic, and social awareness processes that have unfolded in Europe over the past two decades have laid the groundwork for an energy revolution driven by the necessity of environmental protection. Europe, particularly the European Union, has committed to moving away from coal and fossil fuels in favour of energy derived from renewable sources. A 'roadmap' has been devised to guide Europeans towards the ultimate goal of 'zero emissions.' However, this transition is proving to be extremely costly and fraught with numerous 'economic traps' that experts had warned about—warnings that, for the past twenty years, were largely ignored by political circles. One such challenge is the relatively low price of crude oil and petrol, which has led to an increasing reliance on road transport, facilitated by an extensive network of motorways and express roads. Unfortunately, few decision-makers seem to grasp the fact that the capacity of these road networks is already at its limit, constraining the efficiency of road transport operations. This raises a pressing dilemma: how can emissions be reduced without significant financial investment or extensive efforts when the economies of numerous EU countries remain dependent on crude oil and natural gas, as well as, to a considerable extent, on coal—both hard and lignite? In this regard, Poland serves as a prime example [5], [6].

As part of the research undertaken, the authors of this publication employed three scientific methods from a broader set of available approaches. The most significant among them is the method of critical rationalism, rooted in the philosophical school of Karl Popper. This method enables a critical examination of existing studies to generate appropriate conclusions and, in doing so, avoid errors. It also allows for a profound modification of existing assumptions while maintaining fundamental general principles on which theories, premises, and previously developed models of action are based. When combined with other scientific research methods, this approach facilitates the development of a model for achieving strategic state objectives in the field of railway freight transport, based on existing information and statistical data. Complementary to critical rationalism are the case study method and the scenario method.

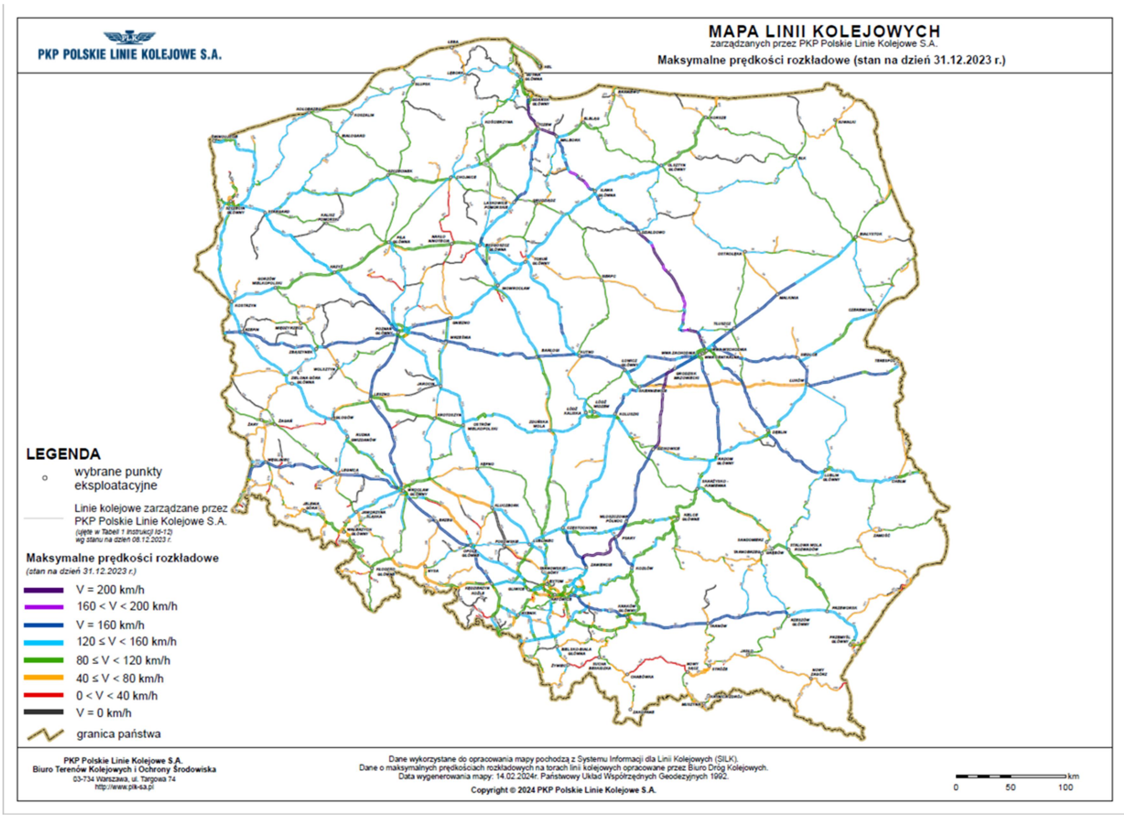
In the field of literature relevant to the scientific research, the authors focused on materials from analytical centres and information available to Polish State Railways and Polish Railway Lines—excluding, as a matter of course, any sensitive data. Complementing the conducted research is the literature characteristic of this type of study, including monographs, reports, articles in printed publications, and, naturally, netographic sources, in line with technological progress and the spirit of the times.

Polish State Railways and Polish Railway Lines in the face of challenges posed by the energy crisis

Polish State Railways and Polish Railway Lines employ over 100,000 workers, combining passenger and freight transport while managing railway infrastructure. For many years, cargo transport has been a cornerstone of the railway's strength, underscoring its significance not only in domestic economic circulation but also on a broader European—and arguably even global—scale. The total length of railway lines in Poland is approximately 19,500 kilometres, placing the country third in the European ranking, behind the Federal Republic of Germany and France. This highlights Poland's strategic transport potential [7]. The geopolitical position of our country, which should be a key element of Poland's strategic culture and serve as the foundation for considerations regarding modifications to the national raison d'état, predisposes us to a broader utilisation of transport routes than has been the case so far. Despite the ongoing war beyond our eastern borders, Polish State Railways has managed to maintain a number of railway lines that serve as a pivotal connection between the broadly defined West and East.

As a result, opportunities have arisen to utilise our transport routes for importing goods from the People's Republic of China, South Korea, and, to a certain extent, even Japan, despite its island location. The potential of Polish State Railways and Polish Railway Lines, measured by the strength and significance of existing transport routes, should therefore be considered high.

1. Railway network in Europe
Source: https://mapy.net.pl/mapa-scienna-europy-koleje-karta/6854



2. Railway line map of Poland
Source: PKP Press Office, https://www.plk-sa.pl/o-spolce/biuro-prasowe/mapy (21.11.24)

Tab. 1. Freight transport in million tonnes from 2017 to 2023

2017	239.9
2018	250.3
2019	236.4
2020	222.3
2021	243.6
2022	248.5
2023	231.7

Source: Own elaboration based on data from Polish State Railways

The data summarised in the table, supplemented by railway connection maps, clearly indicate the significance of rail transport, as highlighted by the authors in the introductory part of the article, identifying rail as one of the two most important modes of transport. The noticeable decline in freight transport tonnage is influenced, among other factors, by the difficult wartime situation unfolding beyond Poland's eastern border, as well as by sanctions imposed on Russia, a key rail carrier in the European transport corridor. However, in the latter case, the sanctions do not cover a range of goods originating from Russia, nor do they significantly affect goods in transit through Poland from Asian countries [8]. On a more positive note, a record-breaking result of 61.7 billion tonne-kilometres was achieved—the highest in a decade—although profitability remains an open question. On the other hand, the extension of transport routes for both passenger and freight services is driven by the ongoing modernisation of railway networks. Unfortunately, there is still no structured programme to increase expenditure on necessary transport infrastructure, including the acquisition of new freight rolling stock, not only with varied technical specifications but also tailored to specific transport needs. In other words, a clear determination of the types of goods expected to be transported in the coming years is required, particularly in relation to potential declines in specific freight categories. It is also increasingly apparent that, as Poland continues aligning its legislation with European Union regulations, foreign economic entities are entering the Polish freight transport market. These companies often offer at least comparable and, in many cases, a broader range of services at prices similar to those proposed by Polish rail operators. Given these circumstances and the fact that by 2035, Poland will be required (unless national and supranational regulations change due to socio-economic factors and Europe's declining competitiveness) to comply with European low-emission standards, rail transport will have a crucial role in shifting a significant share of goods that are currently transported by road-based logistics companies using Poland's extensive motorway network [9], [11].

On the one hand, this presents a great opportunity; on the other, it necessitates immediate capital-intensive preparatory actions.

Freight transport costs: a comparative analysis and critical studies

Considering the above discussion, it is essential to move towards a concrete economic analysis of the profitability of rail transport in comparison to road transport. However, it must be noted that the authors of this publication are unable to account for all factors influencing the overall assessment. Nevertheless, they believe that their analysis is sufficient to articulate certain conclusions that could serve as a foundation for an inevitable discussion on the future of transport, given the significant transformations occurring in the global transport market. An analysis based on source documents from PKP Cargo and Cargo International indicates that, at present, it is not possible to definitively determine whether rail transport has a cost advantage over road transport. Naturally, this conclusion is drawn based on the current knowledge available within the examined research field. This article's argument is shaped by both internal factors, which are largely within domestic control, and external factors, which fall within the domain of international relations. Another issue is the use of rail transport for container shipping. In this case, the cost-effectiveness of container transport primarily depends on whether a train operates on a round-trip basis (charging fees for both departure from the home station and the return journey) and whether the entire train is fully loaded. Given the above considerations, it appears that achieving success, measured in terms of low cost-intensiveness while also considering transport security, depends not only on calculating a specific unit cost but also on the operator's ability to manage transport efficiently. The key lies in having the capability to make informed decisions about the appropriate choice of transport mode. Based on the above, the following conclusion can be presented to the reader: offering transport and terminal services from a single provider, as practised by Metrans or PCC Intermodal, allows the operator to retain the margin on both transport and transhipment services.

And this, in fact, may pose a significant challenge, as in road transport, specialised individuals (often even working alone (!)) handle operations with access to a computer system that pairs transport orders. This system allows a given contractor to commission transport from city X to city Y while simultaneously securing a return load from the vicinity of city Y to another designated location (for example, another city in Poland). In this way, goods are transported in both directions, reducing transport costs while increasing the profit margins of both the carrier and the logistics planners responsible for freight forwarding. Thus, the key to resolving rail transport challenges also lies in efficient management of IT systems and their integration into a widely accessible network. Unfortunately, while a road transport provider can accept an order for just a few tonnes of material, rail transport largely requires filling an entire train, which makes it unfeasible for transporting small loads unless similar or complementary shipments are found to consolidate with the initial consignment. This situation could be improved by a logistics model based on container transport. However, the main issue here is the lack of appropriate transhipment infrastructure and certified storage facilities that meet security standards. Investments in these areas are therefore essential and—crucially—require support from the Polish state as well as European Union institutions. The current state of Polish public finances, particularly the dominance of short-term priorities (such as national defence) in government spending, severely limits the possibility of significant capital investment in modernising and expanding railway infrastructure. One potential solution is financing the investment portfolio through funds channelled via European mechanisms.

Tab. 2. Bulk goods

		Price [€/tona]		Route [km]	Price [€/tonne]	Total [€]	Unit cost [€]
		from	to				
Coking coal	Train transport (2 to 2.2 thousand tonnes)	18,2	20	600	19,1	38 200,00	19,1
	Truck transport (29-30 tonnes)	25	26	600	25,5	51 000,00	25,5

Tab. 3. Containers: 40-foot

	Price [€/tona]		Route 600 km [€/unit avg.]	Qu-antity [units]	Cost [€]	Average unit cost [€]	Land terminal + last mile [€]	Total [€]
	from	to						
PTrain 42 units one way for roundtrip organisation	260	350	305	42	12 810	305	200	505
Roundtrip 42 units	510	700	605	42	25 410	605	400	1 010
Truck	1,25		750	42	31 500	750	0	750

In the analysed case, the rate per container depends on the gross weight of the entire train (which results from access charges to the PLK network infrastructure) in which the container is transported, as well as on the number of wagons in the train (the more wagons, the lower the unit price). If we add the margin of the carrier/forwarder, we can assume PKPCI calculations, although terminal costs at Paskov (200 EUR per container) should be added. However, for the analysis to be meaningful, the handling rate in rail transport (highlighted in yellow) should be compared to the road transport rate. Road transport operates on directional rates that cover the cost of an empty return journey.

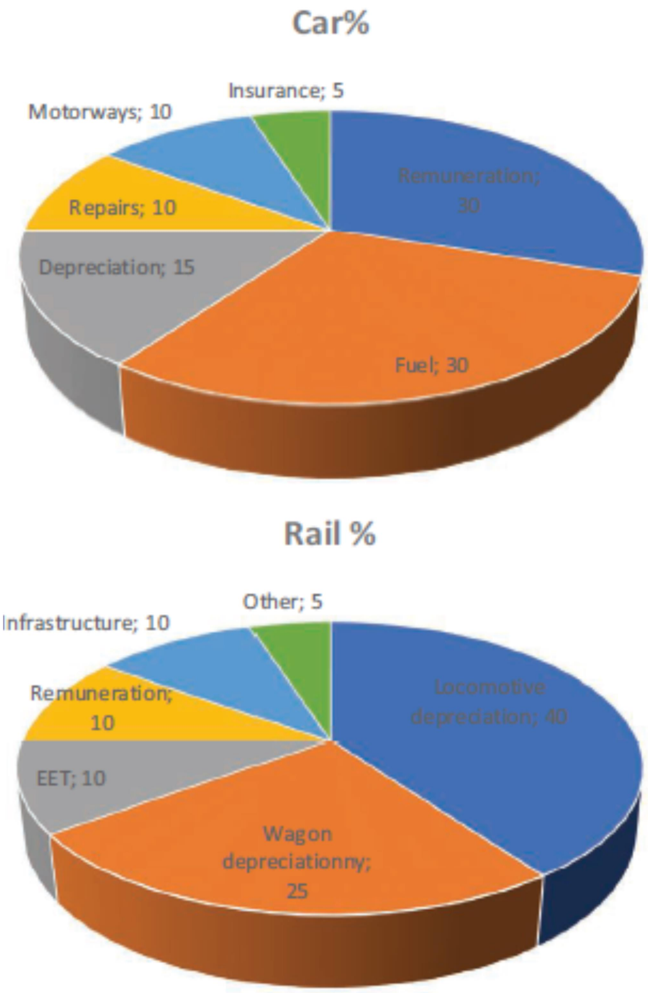
In rail transport, however, rates are calculated for the entire cycle because including the empty return of the wagon set to the departure station would make rail transport non-competitive from the outset. Additionally, terminal costs at the land terminal and delivery to the consignee should also be included; port costs remain the same for a container, regardless of the type of transport. A standard lorry from the port delivers the goods to the final customer under the so-called door-to-door service, which is the main difference between road and intermodal transport. Returning to container transport, the container from the train must be reloaded onto a lorry at the terminal (assumed cost of 50 EUR) and delivered to the final customer (assumed cost of 150 EUR for delivery up to 50 km). Rail freight rates can be reduced by extending the train where possible. On the Paskov route, it is certainly possible to use 620-metre-long trains, allowing for the calculation of 44 containers instead of 42.

The second optimisation factor is transporting containers loaded in both directions, where possible. In this case, the highest rate per container is paid, but the client is charged twice for transporting the container in both directions. Another crucial element of this analysis is the simultaneous offering of transport and terminal services.

It should also be noted that it is not possible to establish a universal cost share for rail transport. In the case of an old, fully depreciated diesel locomotive, the cost burden will be significantly lower than for a multi-system electric locomotive. Furthermore, if own depreciated wagons are used, the costs will be considerably lower than when transporting rented tank containers, pocket wagons, or standard wagons. If private wagons (belonging to the client) are used, they are free of charge, and the proportion of other costs increases relatively. The duration of loading and unloading is also significant—whether the locomotive waits or leaves impacts the final price. Another key consideration is whether the cost of the locomotive's arrival at the loading point must be included in the price; in many cases, the client does not wish to pay for it, but the company still incurs the cost. Additionally, infrastructure charges for intermodal and conventional transport differ.

Overall, there has been a decline in the domestic freight market involving low-cost diesel locomotives (such as coal transport and servicing steel mills). New projects are increasingly geared towards cross-border transport, where it is more convenient to complete the entire route with a single locomotive. However, this requires the implementation of multi-system locomotives, whose costs remain high until they are fully utilised.

In the same way, modern wagons may have higher prices but often offer greater capacity—therefore, an optimal solution should always be sought for the client.
The cost structure of the freight transport process is presented in Fig. **3**:



3. Cost structure of the freight transport process
Source: Own elaboration based on PKP data P

The above calculations clearly highlight both similarities and differences between the two types of transport. The most prominent factor is locomotive depreciation, which accounts for 40% of expenditure. In the case of road transport, this figure is only 15%.

Rail transport, on the other hand, stands out positively in terms of wages and—most importantly—fuel. Fuel costs make up 30% of the expenses in road transport.

Considering the need to transition from hydrocarbon-based fuels to renewable energy sources (RES), road transport would have to rely on electric propulsion. Given the current state of the electric vehicle market, the efficiency of such projects remains highly debatable. Thus, investing in rail transport in an era of climate policy changes appears to be a well-thought-out decision. However, this is only valid under rational assumptions regarding the timeframe and costs of the energy transition—factors that have not yet been accounted for.

Referring to the thesis adopted by the authors of this study, and assuming that the plans set out by EU policymakers to replace internal combustion engines with electric engines by 2035 will indeed materialise, it is necessary to consider not only the efficiency of electric engines (which, given the current state of technological development, remains questionable) but also the costs arising from the need to generate additional energy capacity. If we assume that road transport accounts for 33% of the total transport market in Poland, an increase in energy capacity would be required to replace liquid fuels as part of the transition to new propulsion systems. Although this process would be spread over time due to the gradual phasing out of internal combustion engine vehicles, the burden on the Polish energy system would involve the need to generate an additional 312.51 TWh. Poland currently has a total of 875,861 km of power transmission lines: 15,964 km of 750 kV, 400 kV, and 220 kV lines, 34,376 km of 110 kV lines, 321,089 km of medium-voltage (SN) lines, and 504,492 km of low-voltage lines. Following this line of reasoning, national Transmission System Operators would have to significantly expand the length and capacity of the network (some experts even suggest a doubling of distribution and transmission capabilities). It is important to note that the increasing failure rate of the grid due to weather conditions, combined with the limited capacity of high-voltage transmission and distribution lines (110 kV) at higher temperatures, already poses a significant risk to system stability. This is especially critical given the growing demand for energy and the uncontrolled, rapid increase in the connection of unstable power sources.

These calculations provide a strong basis for discussion regarding the rationality of the adopted solutions in this area. Total investment expenditures (as of 2022/2023) would amount to approximately PLN 650 billion. The estimated cost of constructing 1 km of a 110 kV line is around PLN 1.2 million, for a medium-voltage (SN) cable line, approximately PLN 400,000, and for railway traction, between PLN 800,000 and PLN 1 million.

It is worth noting that the barrier to infrastructure development is not only the availability of financial resources but also the organisational and operational capacity of investors and contractors/designers available on the market.

Unfortunately, the above costs do not represent the total costs of the energy sector transition, that is, the shift from hydrocarbon-based fuels to clean energy. The necessary additional energy capacity to sustain such a system would require the construction of a number of nuclear power plants (with renewable energy sources playing only a supplementary role, not only due to their insufficient efficiency but also their instability in supply). An additional 72,393 MW would need to be introduced into the system, with the financial scale of this challenge amounting to PLN 1.86 trillion. Two years ago, the cost of servicing the transition and building new capacity in Poland was estimated at PLN 1.4 trillion, and this amount continues to grow. At that time, the cost of strengthening distribution networks in line with the EU Green Deal was estimated by EDSO (the European Distribution System Operators' organisation) at EUR 600 billion.

To summarise, the phasing out of internal combustion engines as the primary transport power source must be extended beyond the timeline set at the EU member state level. A gradual transition to a system that utilises not only renewable energy sources but, above all, nuclear energy is essential. Additionally, the balance between centralised management of energy generation and distribution and the development of local networks and generation sources must be maintained. At present, the Polish state lacks the financial capacity to undertake expenditures of this magnitude, particularly given its substantial budget deficit, which—contrary to political promises—is likely to necessitate investment cuts rather than further stimulus. Worse still, over the next five years, even with budgetary expenditure reforms, the authorities will not be able to eliminate the deficit entirely, but only significantly reduce it at best.

Undoubtedly, rail transport is key to the energy transition, but only on the condition of substantial investments in railway infrastructure, alongside essential investments in energy production and distribution infrastructure. The transition from hydrocarbon-based energy to emission-free energy, initiated by the EU authorities and set to be implemented by the Polish government, is fundamentally a sound strategy, but it must be rationalised—meaning it should be extended over time and take into account various needs, including the costs of railway modernisation.

The involvement of EU member states in developing legal regulations to support rail transport while limiting the attractiveness and profitability of road transport is also of great significance.

One such approach is government programmes like 'Trucks on Rails,' which, despite being heavily criticised and obstructed by the road transport lobby, aim to shift freight from roads to railways. It must be emphasised that the apparent cost advantages of road transport are offset by measurable expenses, including the degradation of road infrastructure, greenhouse gas emissions, and the social cost of congested roads and their associated negative impacts. Consequently, legislation plays a crucial role in increasing the importance of rail transport and safeguarding the legitimate interests of the state and its citizens.

EU institutions and the development of rail transport in light of the new climate policy

In recent years, the efforts to provide greater support for rail transport have accelerated, following an earlier, intense debate within the European Union's decision-making circles, which are responsible for laying the groundwork for the future common transport policy. At present, it is difficult to definitively assess whether there will be sufficient resources, funding, and perseverance to successfully implement the projects that are essential for European single markets.

In an attempt to evaluate both the potential and limitations of the EU's sectoral policy in the broadly defined transport sector, the authors of this study have chosen to focus on two key documents that, in their view, were created specifically to guide EU policymakers. Accordingly, it is worth noting and subjecting to critical analysis two recently published reports commissioned by the European Commission, both of which suggest the necessity of redefining the existing rail transport policy while simultaneously developing a new, more synchronised framework, but this time at the EU institutional level.

The first of the reports, focusing on the mechanisms and rules governing the EU Single Market, is a document authored by Dr Enrico Letta, President of the Jacques Delors Institute, legal scholar, political scientist, and Member of the European Parliament. The report, *Much More than a Market. Speed, Security, Solidarity. Empowering the Single Market to Deliver a Sustainable Future and Prosperity for All EU Citizens* [12], outlines key recommendations aimed at strengthening the Single Market to ensure sustainability and economic well-being for EU citizens.

Tab. 4. Key conclusions from Enrico Letta's report

Conclusion	Adaptation of freight and passenger rail transport to meet the requirements of the EU climate policy implementation
Conclusion	*Digitalisation of rail transport*
Conclusion	*Improvement of railway and railway-related infrastructure*
Conclusion	*Creation of legal, institutional, and technological conditions for the development of high-speed rail*

Source: Own elaboration based on E. Letta, *Much More than a Market. Speed, Security, Solidarity. Empowering the Single Market to Deliver a Sustainable Future and Prosperity for All EU Citizens,* Brussels 2024.

The second report, which lays the groundwork for changes in the perception of sectoral policies, including the European Union's transport policy—a key area of interest for the authors of this publication—is a document authored by former Italian Prime Minister and Professor of Economics Mario Draghi, The Future of European Competitiveness. This document was commissioned by the President of the European Commission, Ursula von der Leyen, who recognised the necessity of introducing new economic initiatives aimed at revitalising the stagnating European economy [14].

Tab. 5. Conclusions from Mario Draghi's report

Conclusion	Increased pro-investment expenditure aimed at accelerating the development pace of the European Union
Conclusion	Increased funding for science
Conclusion	Focus on innovation and new technologies as a response to the expansionist policies of the PRC and the USA in this area (eliminating existing delays)
Conclusion	Integration of European economic development with the EU's new climate policy, based on alternative energy sources in relation to existing ones
Conclusion	Investments in the broadly defined security sector of the European Union

Source: Own elaboration based on M. Draghi, *The Future of European Competitiveness, https://commission.europa.eu/topics/strengthening-european-competitiveness/eu-competitiveness-looking-ahead_en* (19.11.24)

The document prepared by Mario Draghi, with expert support, provides some hope for the realisation of the main theses contained in the report, including those related to the railway sector. The latter, based on new technologies that utilise renewable energy sources as propulsion while emitting no atmospheric pollution, appears to be a natural candidate for investment. Rail transport is an investment in the future—this is well understood by all those involved in global transport. However, the challenge lies in translating declarations into action. As the era of internal combustion engines draws to a close—whether at a faster or slower pace, depending on expert assessments—an alternative to road transport must be found. Developing innovative solutions based on mature technologies will be essential; without this, it will be difficult to establish the foundations not only for a modern railway system but also for transport as a whole [16].

Moreover, in the later sections of the report, its author firmly emphasises that in order to fill missing links and modernise transport infrastructure, it is necessary to generate financial resources that are crucial from the perspective of European strategy in the analysed area of sectoral policies. For example, the modernisation and expansion of the TEN-T network, which is preliminarily planned for completion by 2040, will cost European taxpayers nearly €845 billion, of which €210 billion is earmarked for strategic cross-border connections. It is expected that EU public funding will cover only a small portion of these investments (with projected expenditure of up to €87 billion by 2027). However, the total amount of planned funds may prove to be vastly insufficient in relation to the ever-growing needs. The question of private financing also remains open. This issue concerns not only the feasibility or scale of private funding but also, equally importantly, the legal instruments that will enable the smooth implementation of projects in this area. So far, private financing has been difficult to secure despite, it is worth noting, a mature portfolio of TEN-T projects. This is due to their high level of risk, substantial initial costs, and, more recently—amid the economic instability in Europe—the short-term loss of profitability. To date, rail transport, despite numerous promises, has not received particularly generous funding from EU resources. Other modes of transport have enjoyed significantly greater support, especially when considering the scale of investments. As of 2025, the planned road network remains by far the most developed compared to other forms of transport—as if the issue of phasing out hydrocarbons did not exist or there were still ample time to implement this undoubtedly transformative process in the history of not only the European but also the global economy. Thus, the key challenge now facing EU decision-makers is to ensure that non-road investments are realised over the next decade. Beyond what has been planned within the TEN-T framework, the development of a high-speed rail network connecting all EU capitals and major cities would enhance the attractiveness of rail transport and further amplify investment needs [17].

In his report, Mario Draghi also highlights the increasing volume of road transport, despite the implementation of the new climate policy. EU member states continue to prioritise investments in road infrastructure. This approach yields quick returns and is easier to implement compared to railway investments, which require significantly more advanced technological input and a broader scope of work.

Another issue raised in the report is the so-called "bottleneck" in freight transport via rail, which significantly limits its capacity. However, these limitations are a direct consequence of investment shortfalls. Without the EU's commitment to building new and modernising critical connections, rail transport will remain at a disadvantage compared to road transport. The latter, however, is unsustainable in its current form due to the implementation of the climate neutrality policy. Without the necessary investments, the operational viability of railway rolling stock is becoming increasingly deficit-ridden, particularly given the rapid rise in demand for freight transport, which member states persistently choose to handle via road transport. This approach contradicts efforts to resolve existing "climate dilemmas" and is further complicated by the decreasing capacity of key transport routes (e.g. the Suez Canal, the Panama Canal). Additionally, limited capabilities in ensuring the security of maritime shipping routes further exacerbate the problem. This is due to the increasing prevalence of piracy (e.g. off the coast of Somalia) as well as terrorist attacks targeting shipping lanes, particularly those involved in transporting energy resources, as evidenced by Houthi attacks in the Gulf of Aden [16].

The challenges requiring a reinterpretation of the European Union's transport market also stem from the lack of integration within EU transport systems, which accumulates various negative economic phenomena and directly affects the low competitiveness of EU member states in the global transport sector. It is also difficult not to observe that, despite significant progress in building an integrated EU transport market, numerous barriers still hinder the final implementation of this much-needed common policy. Among these, attention should be drawn to the issues surrounding the interpretation of applicable legal norms arising from the EU legal order or other organisations such as the WTO. Unfortunately, the Member States of the Community have a tendency to interpret EU regulations inconsistently. This is particularly difficult to prove, as the mere translation of legal acts generates numerous problems and, at times, even fosters interpretations that are unfavourable from a broader perspective. Another issue is the sluggishness of decision-making processes in the implementation of new or the updating of existing legal norms. This hinders, and in some areas outright prevents, the emergence of new EU entities in transport, travel, and the broadly defined logistics sector. The latter remains a proverbial 'Achilles' heel,' manifesting itself in the lack of a digitalisation programme that is adequate to the challenges posed by the global market. The analysed report indicates that currently, only 1% of cross-border operations within the EU can be conducted entirely digitally; in other words, just one in a hundred transport operations does not require physical documentation at various stages of the process. It is estimated that newly adopted digitisation rules, particularly those concerning the exchange of information in freight transport (road, rail, inland waterway, and air transport), could yield savings of nearly USD 30 billion over the next two decades. Artificial intelligence is set to enable increasingly automated functions that enhance safety and quality, optimise navigation and routing, support predictive maintenance, and reduce fuel or energy consumption. A major challenge remains the implementation of AI-based solutions. Artificial intelligence appears indispensable in shaping the objectives of an integrated transport strategy within the EU, particularly in the railway sector. In this area of integrated transport, AI could facilitate planning changes, improve energy efficiency, and enable the rapid deployment of service planning or real-time disruption management. Compared to other global powers, particularly the USA and China, the EU lags significantly behind in this regard [16].

Another key objective for the EU in the coming years, according to the assumptions outlined in the analysed report, is the complete decarbonisation of the economy, which will significantly impact transport, particularly rail transport. Data provided by the European Commission clearly indicate that moving away from the "coal era"—a distant echo of the industrial revolution of the 18th and 19th centuries—will reduce CO2 emissions by 80%. However, achieving this will require substantial financial resources to implement the necessary changes, launch further projects in both the economic and social spheres, and introduce new innovative solutions. Investment needs for the decarbonisation of EU transport between 2025 and 2030 are estimated at €150 billion, with an additional €869 billion required between 2031 and 2050, which serves as the timeframe for EU policy objectives. It is worth noting that these estimates encompass the decarbonisation of all modes of transport (excluding the costs of maintaining railway and road infrastructure), meaning they do not provide a complete picture of the financial scope of this undertaking. A separate issue in this context concerns Poland, which, apart from the Czech Republic's minimal remaining contribution, is the last coal producer in the EU. This raises the question of Poland's decarbonisation prospects. So far, Polish policymakers have maintained a remarkably passive stance, seemingly waiting for someone else to resolve this issue, which is crucial for the future of the national economy. This indirectly affects the railway sector as well, given that electrified rail transport in Poland is primarily powered by electricity generated from hard coal and lignite [18].

The EU transport sector, much like the broader community economy, is struggling with a shortage of adequately skilled specialists—those capable of carrying out tasks arising from the implementation of new sectoral policies. These challenges are particularly pronounced in the transport industry. Unfortunately, the sector offers relatively unattractive working conditions, influenced by factors such as high occupational stress and, ultimately, remuneration levels. A significant challenge is the increasing proportion of older workers, which is notably higher in the transport industry than in other sectors of the EU economy. According to statistical data provided by the European Commission, as many as 41.9% of railway transport employees are over the age of 50, and the average age of truck drivers in the EU is the highest in the world. This trend also applies to the average age of train drivers operating freight and passenger services. Additionally, the participation rate of women in the transport sector remains low. According to Eurostat statistics, women account for only 22% of transport industry employees [16].

It should be noted that the railway markets of the EU Member States remain highly decentralised. While decentralisation is generally regarded as a tool for positively shaping reality, its doctrinal application has not proved particularly effective in the case of rail transport. There are several reasons for this state of affairs. It is undeniable that, despite numerous assurances and declarations from EU policymakers, the planning and coordination of both passenger and freight transport are still not effectively managed on a cross-border scale. Instead, these responsibilities remain—one could argue almost exclusively—the domain of individual Member States, which often act contrary to the ideal of European unity, prioritising national policies that fail to account for global challenges. According to Eurostat data, there are still nearly 800 national regulations governing railway transport across the EU. Operational requirements also vary significantly across Member States. Moreover, market barriers persist for new entities seeking to enter the railway sector, despite the declared commitment to fostering competition. One example of such restrictive policies is the high track access charges, not to mention the numerous difficulties in accessing rolling stock and ticketing systems—elements that, according to policymakers, were supposed to be a shared space for cooperation among various railway operators. This undoubtedly has a negative impact on the potential ability of service providers to scale up their operations, and even more so on their capacity to conduct business on a cross-border level. Operators active in more than one national market remain exceptions across the EU. These facts have clear consequences. The number of long-distance cross-border rail services in Europe has, over the past twenty years, remained practically stagnant, showing no real growth. Among other issues, there is a lack of high-speed connections—despite the fact that time, much like information, plays a key role in the global economy—the complexity of the booking system for multi-stage journeys, and the absence of in-depth studies on passenger rights. In this last case, changes are necessary, not least because of the expanding catalogue of rights, freedoms, and civil liberties, which are an essential part of a modern civic society [16].

Significant changes are required in rail freight transport, which has experienced a relative decline in priority, even compared to passenger rail services. This leads to delays, directly affecting the perceived reliability of this mode of transport. And yet, the foundations exist for the further sustainable development of intermodal freight transport. There are EU legal standards aimed at promoting intermodal transport, with the key piece of legislation being the Combined Transport Directive adopted in 1992. Unfortunately, the rapidly changing reality—including developments in both passenger and freight transport—necessitates an update of legal provisions that were initially introduced to address the challenges of the early 1990s, while humanity has long since entered the third decade of the 21st century. Despite these challenges, intermodal transport has seen substantial growth, as evidenced by Eurostat data from 1996 to 2016, showing an increase of approximately 400%. However, nearly 50% of intermodal operations currently carried out within the EU remain outside the scope of support envisaged under the now highly outdated directive [16].

Among other key issues, the need to integrate digital solutions with existing older generations of railway traffic management systems also deserves attention. The lack of full harmonisation of member states' railway networks at the central EU level hampers the creation of an interoperable system for railway management, control, and signalling, despite the efforts of several EU institutions working towards this goal. The European Rail Traffic Management System (ERTMS), which has been successfully implemented in several non-EU countries and was introduced by the EU as a mandatory system for member states, is still rarely applied in practice. According to data from the European Commission, by 2050 (the target year for the EU's strategy), the estimated investment required for full implementation should reach nearly USD 250 billion. An open question remains as to whether the financial resources planned by the EU will be sufficient to meet the objectives set for implementation, particularly given the necessity of undertaking multiple strategically significant investments. These include projects aimed at increasing railway capacity: Future Railway Mobile Communication System (FRMCS), Digital Capacity Management (DCM), and, no less importantly, Digital Automatic Couplers (DAC). Given the anticipated evolution of these solutions, the EU must be prepared for the rapid deployment of an automated capacity allocation system. At present, capacity allocation occurs only at the national level and is typically carried out without the use of modern digital tools. One might venture the opinion that the world is outpacing European railways—at least in this specific area highlighted by the authors of this publication [16].

Conclusion

The above scientific article serves as an introduction to a necessary discussion in light of changes driven by numerous external and internal factors. The first category includes the inevitable shifts in the global balance of power, not only at the political level but also in the areas of security and the economy. A manifestation of this is the war taking place beyond our eastern border, where railways, as a primary means of transport, play a crucial role in NATO's transport strategy. The second category of challenges—those of an internal nature—affects not only Polish State Railways but also the state authorities. Adapting to the regulations set to take effect under the Green Deal requires massive investment in modernisation, expansion, and technological development of the existing production and transmission capacities within our energy sector. The costs of this process far exceed the financial capabilities of our state, as demonstrated in the economic analysis presented in the earlier sections of this publication.

It is therefore essential to rationalise this process while simultaneously shifting transport from road to rail. This is particularly significant given that rail transport accounts for only 1.5% of CO_2 emissions into the atmosphere—an almost negligible figure in environmental terms when compared to the emissions generated by road transport. However, the current financial capacity of the railway sector to fund necessary investments remains severely limited.

Examples of serious financial problems faced by the Romanian, Czech, German, and now unfortunately also Polish railways in the transport sector seem to contradict the assumptions of the Green Deal.

We are dealing with an incomprehensible paradox: while committing to phasing out internal combustion engines by 2035, we simultaneously take measures to strengthen road transport (expanding road networks, offering toll-free motorways, and maintaining low fuel prices).

In such a defined reality, rail transport becomes unprofitable, which must inevitably lead to an absurd situation where, in constructing the new Green Deal, we ultimately base it entirely on hydrocarbons—achieving an outcome entirely opposite to the intended objectives.

An immediate transformation is therefore necessary in the form of expanding railway infrastructure, making use of existing opportunities, such as land ownership, from which the railway already benefits. This process must be spread over years, include concrete solutions, and have a defined budget with substantial financial resources. Without these resources—without a rational and, unfortunately, costly strategy to prioritise rail as an environmentally friendly, safe, and efficient mode of transport—it will be difficult to speak of a full energy transition, let alone a broader economic transformation of our country. The European Union should also play a crucial role in this process, as it has a vested interest in Poland's railway infrastructure, which serves as a key link between the West and the East, as well as a strategic element of security on NATO's eastern flank.

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