Proposal for a

REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

on the standardisation of railway electrification systems for trans-European rail networks

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Course: Sustainable Policy

EXPLANATORY MEMORANDUM

1. EXECUTIVE SUMMARY

The European Union (EU) faces significant challenges in the interoperability of its rail network due to the lack of unified electrification standards across Member States. Current differences, such as varying voltages and different electrical current types, lead to operational complexities, increased costs and major inconveniences for rail transportation of people and goods in the EU. These key barriers discourage passengers and freight providers from choosing rail, stimulating the use of less efficient and more polluting alternatives, such as air or road transport. This obstructs the realisation of the smart-mobility plan outlined in the European Green Deal, undermining the EU vision of an interconnected and environmentally sustainable rail network.

To address this, the European Commission should adopt a Regulation establishing a unified electrification standard, based on the 25kV 50Hz AC standard. This standard is widely recognised for being an efficient and cost-effective electrification solution, especially for high-speed lines, and would apply to the Trans-European Transport Network core and extended networks, with the full implementation deadline set to 2040. By implementing this proposal, the European Commission will eliminate a key barrier to sustainable cross-border rail travel, simplifying international rail operations, and lowering the costs for both operators and passengers, all while reducing carbon emissions. This will subsequently boost the volumes of passenger and freight movement across the EU, improving regional connectivity and strengthening its Single Market, as well as contributing to the goals of the EU Green Deal.

The need to address this issue has become increasingly urgent faced by rising demand for cross-border rail services, at a time of growing environmental concerns over the excess use of air travel for small and medium distances. Further postponement of action risks missing the EU's Green Deal goal of doubling high-speed rail traffic by 2030, as well as other already adopted EU legislation aimed at enhancing sustainable transport and achieving climate targets. By implementing this proposal, the European Commission will ensure the alignment of national efforts with the Union's policy of building a sustainable and reliable integrated European railway network, securing the EU's international leadership in sustainable transport innovation.

2. CONTEXT OF THE PROPOSAL

- **Reasons**

Over the past decades, many European countries like France, Germany, Italy and Spain have developed their own efficient high-speed rail infrastructure. However, with each of them focusing entirely on domestic travel, until now they remain not well connected. While some attempts were made to fix this issue, by establishing such international services as Eurostar, linking some of the most important European capitals, these solutions failed to extend their services and instead of achieving the global goal of connecting France to England, only managed to connect Paris and London.

Alongside some other problems like different track gauges (Iberian Peninsula, Baltics), train control systems (KVB, PZB, SCMT, others) and bad end-user experience (closed data of ticket sales in operators) that led to this, differences in the electrification solutions between the Member States (see Figure 1) stand out as the only major factor still not approached on EU level.

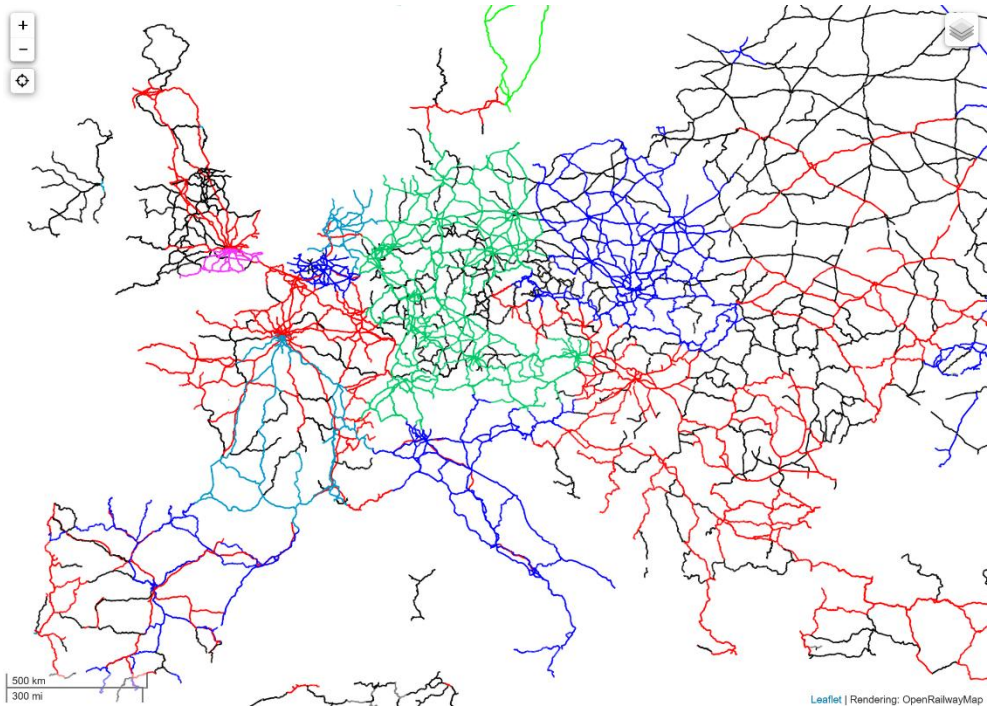

Figure 1. A map without background of the European rail network's electrification currents, with each type represented by a distinct colour and the proposed standard highlighted in red (OpenRailwayMap, 2024)

Encountering the problem, many service providers often abandon plans to extend their services outside of their country or region, creating major inconvenience for the passengers to make a

transfer to a different train. To counter the issue, many service providers invest in bi-voltage, or even tri-voltage train electrical systems to ensure compatibility of their trains through various regions. In some cases, faced with the high cost and technical complexity of maintenance of such systems, providers choose to revert to diesel-powered locomotives, in order not to rely on electrical systems throughout the route.

Regulation on the standardisation of railway electrification systems for trans-European rail networks is designed to solve this problem by providing a single electrification standard for all Member States. It includes the development of a new Technical Specification for Interoperability (TSI) by the European Union Agency for Railways (ERA) regarding electrification standards. Based on it, a single standard of 25Kv 50Hz AC will be set, which is commonly found on modern European high-speed lines and is often referred to as the most efficient and cost-effective railway electrification long-distance railways (Elbelkasi et al., 2020; Pittermann et al., n.d.). The regulation will apply specifically to routes, identified within Trans-European Transport Network (TEN-T) core and extended networks as outlined in Regulation 2024/1679 (European Union, 2024). Member States will have the year 2040 set as the target year, allowing sufficient time to implement and integrate the standard.

- **Objectives**

The Regulation on the standardisation of electrification systems thus aims to achieve the general goal of improving interoperability and interconnectivity of the railway networks, which, following Deborah Stone's Policy Paradox framework (Stone, 2012), can be divided into three specific objectives: promoting equity, efficiency, and liberty. Stone highlights that these goals are interconnected yet distinct aspects of policymaking. Equity is complex and context-dependent, involving fairness in the distribution of resources and opportunities. Efficiency focuses on achieving maximum outcomes with minimal resources, while liberty emphasizes the expansion of individual freedoms and opportunities (Stone, 2012).

Firstly, in accordance with one of the goals of the European Green Deal of accelerating the shift to sustainable smart mobility by "providing users with more affordable, accessible, healthier and cleaner alternatives to their current mobility habits" (European Commission, 2019), the standardisation of electrification across all Member States can make travelling by rail between different Member States easier. This fulfils the goal of **efficiency**, because of the improved affordability connected with the reduced costs of operation and convenience for the passengers, as well as total travel times.

Secondly, the regulation will also greatly enhance passenger's **liberty**. By eliminating the technical barriers caused by different electrification systems, the proposal increases the accessibility of rail networks across borders, granting passengers the freedom to travel seamlessly between Member States. This expanded access enables travellers to prioritize comfort and sustainability, by choosing considerably less stressful (Railway Traveller, n.d.) and environmentally cleaner (Eurostar, 2023) mode of transport over airplanes for middle-range international travel.

Thirdly, the regulation aims to improve the interoperability and interconnectivity of the railway networks from the perspective of the Member States. Following the Directive 2012/34/EU establishing a single European railway area, the standardisation of the electrification systems will significantly contribute to the EU's vision to deliver, "via an integrated system approach" (European Commission, 2022), which is represented in the current electrification standardisation proposal. It aims to create "a high capacity, flexible, multi-modal, sustainable and reliable integrated European railway network." (European Commission, 2022). By unifying the standard across the Member States, regulation will promote **equity** by ensuring that all states will benefit equally from multiple benefits including increased capacity, operation reliability, energy efficiency, and punctuality, delivering economical and logistical advantages for both national rail infrastructure management and the state economies overall.

- **Current Relevance**

The current context provides an optimal moment to address the problem of non-standardized railway electrification across the EU. The Multiple Streams Framework (MSF), introduced by John Kingdon in 1984 (Hoefer, 2022), provides a lens to understand how policies gain traction. According to the MSF, three streams—problem, policy, and politics—must align to create a "policy window," an opportune moment for change. This framework helps to explain why the standardisation of railway electrification is particularly relevant now.

In the **problem stream**, increasing year-by-year demand for cross-border rail services, driven by rising worldwide environmental concerns the excess use of air travel (Timperley, 2020) makes the inefficiencies caused by inconsistent electrification standards increasingly problematic, making the issue urgent.

In the **policy stream**, the proposed legislation seamlessly builds up on existing EU legislation and actions taken by the European Commission to popularise international rail travel. It provides a viable and effective solution to fix the problem of non-standardised electrification.

From the perspective of the **political stream**, current wide support from both the European Commission, as it is seen in its rail Action plan (European Commission, 2021) and the public, easily visible from the increased demand (Eurostat, 2024). This support highlights the importance of the current **policy window** representing the best moment for the proposal implementation. By acting now, the EU can address increasing social and environmental needs while also fulfilling its vision of an efficient, well-connected European railway network.

- **Expected Reactions of EU Institutions and Member States**

During each stage of the policy cycle, the current proposal may encounter mixed reactions from other EU institutions and Member States. The proposal is likely to gain **initial support** from the European Parliament, especially from environment-focused parties that have a high influence. However, among the Council of the EU members, representing Member States ministries position, some members with large railway networks operating on different electrification standards than the one planned to be set as a standard, may express their concerns about high implementation costs. During the next stages of **formulation and decision-making**, the general sides are expected to remain unchanged. Countries with high investments in existing infrastructure, particularly the ones electrified with different standards, may request amendments asking for additional transition periods or exemptions to protect their interests, while other EU institutions and Member States are going to push the proposal for rapid adoption. Several EU parts specialized in the transport field, such as the European Agency for Railways, DG MOVE (Commission), European Investment Bank (EIB) and Transport and Tourism Committee (Parliament) are likely to express their support for the initiative with possible minor amendments.

Once the regulation is adopted, the **implementation stage** will shift the responsibility to national railway authorities, with support from several EU Funding mechanisms providing some funding to boost the implementation. Member states with compatible systems will face fewer obstacles, while those with different standards may require years of construction work and consistent funding to fully implement the regulation, with their reactions varying based on the financial burden and the scale of potential benefits. Finally, in the **evaluation stage**, the European Commission and, if necessary, the European Court of Auditors, will assess the policy effectiveness. The reactions from the Member states will largely depend on the local social response to the implemented electrification standardisation, with the relation between the costs

and real increase in the numbers of people and goods transported, as well as the efficiency of existing transportation operations.

- **Existing EU Policies and Potential Impacts**

There is no EU legislation directly addressing the electrification aspect of rail transport. However, the Directive on the interoperability of the rail system within the European Union (EU Directive 2016/797), along with the associated Technical Specifications for Interoperability (TSI), establishes requirements relating to "the design, construction, placing in service, upgrading, renewal, operation and maintenance of the parts of the system" (European Commission, 2023). Although this framework covers some requirements for the rolling stock and overall functioning of the rail system, it leaves technical specifications of electrification up to Member states, not stimulating investments aimed at the harmonisation of the European rail electrification.

The proposed regulation supplements the EU's ongoing efforts to improve rail interoperability by addressing this critical gap. Building on the core goals of the 4 railway packages, that were progressively adopted from 2001 to 2016 (European Commission, n.d.), and the institutional vision of the European Commission mentioned in its action plan for boosting cross-border passenger travel as "removing redundant national technical and operational rules" (Directorate-General for Mobility and Transport, 2021), the regulation aligns with the broader environmental and transportation goals set by the Green Deal and TEN-T policy.

3. LEGAL BASIS, SUBSIDIARITY AND PROPORTIONALITY

• Legal basis

Article 91 of the Treaty on the Functioning of the European Union (TFEU) provides that the European Parliament and the Council shall lay down "common rules applicable to international transport " (European Union, 2012, p. 85) going to, from or passing through the territory of a Member State. The Union shall also aim at promoting the interconnection and interoperability of national networks as well as access to such networks (Article 170 TFEU) (European Union, 2012, pp. 124-125).

To achieve this, Article 171 TFEU authorises the Union to implement any necessary measures "to ensure the interoperability of the trans-European networks, in particular in the field of technical standardisation" (European Union, 2012, p. 125). Furthermore, the Union may also contribute, through the Cohesion Fund, set up following Article 177 TFEU, to the financing of

specific projects in Member States in the area of transport infrastructure (European Union, 2012, p. 128).

- **EU competence**

Article 4 of the TFEU (European Union, 2012, pp. 51-52), states that areas of transport and trans-European networks fall under the shared competences, meaning that both "the EU and its Member States are able to legislate and adopt legally binding acts", (Publications Office of the European Union, 2022), with the EU legislation having supremacy if it intersects with the national legislation.

According to the principle of subsidiarity stated in Article 5.3 of the Treaty on European Union, if the area does not fall within EU exclusive competence, such as in this case, action on the EU level should be only taken only if the aims "cannot be sufficiently achieved by the Member States" (European Union, 2008) and are better achieved at the Union level.

Considering the overall objectives of the proposition, action taken by the individual bordering Member States could undermine the goals of uniform international railway electrification standards across the EU, since the regional electrification solution chosen between them may differentiate from the desired EU-wide standard. In this light, common specifications determined on the EU level will represent a better, more efficient solution to achieve the goal of achieving seamless international rail travel across all Member States.

- **Proportionality**

This proposal provides a set of standards applicable to key trans-European rail routes across the Member States aiming to harmonize European cross-border travel. It does not instruct Member States on the specific methods for achieving the desired technical standard of rail electrification in their domestic contexts. Instead, it outlines the essential requirements to ensure compatibility and interoperability across international railway routes.

Therefore, the proposal takes full account of the principle of proportionality, being limited to what is necessary to achieve the objective of an interoperable trans-European railway network and thus comply with the principle of proportionality.

- **Chosen instrument justification**

Given the technical complexity of rail infrastructure, any distinction in national implementation of the proposal would undermine the interoperability essential for the

functioning of cross-border service. The use of regulation, which is directly applicable and legally binding to all member states (European Union, 2012, pp. 171-172), aligns with the goal of ensuring efficient and uniform implementations of proposed technical electrification standards across all core and extended networks of TEN-T in the EU.

- **Stakeholder Impact and Analysis**

The proposed policy will affect a wide range of stakeholders, with different levels of interest and power, as shown in Table 1: Power-Interest Matrix.

Stakeholder	Power	Interest	Impact
EU institutions:	High	High	Institutions responsible for approving the proposal will achieve greater people and freight logistical opportunities, contributing to the free movement of people and goods in a European single market.
National governments	High	Low	While some will need to adapt their railways crossing the border to new standards, governments are expected to enjoy growing passenger transit, which is going to boost the national economies of the affected countries.
Passenger Companies	Low	High	Passenger operators will likely need to adapt their rolling stock to the new technical requirements will enjoy significantly extended opportunities for service operations and lower new rolling stock prices in the long term.
Freight Companies	Low	Low	Freight operators will face adaptation costs, if the original operations relied on electricity, but will significantly benefit from long-term infrastructure consistency.

Passengers (public)	Low	High	Over time passengers will receive more affordable, comfortable and sustainable rail travel options.
Environmental groups	Low	High	Both NGOs and national ministries focused on reducing environmental pollution will be interested in taking this significant step towards improving the sustainability of rail transport.

Table 1. Power-interest matrix of the relevant stakeholders.

It is important to note, that not all stakeholders from the same groups are affected equally. For example, Germany with a huge rail network operating at a different standard will face significant adaptation challenges, while Italy which already runs all its high-speed lines on the proposed standard, will see minimal impact. However, both have almost identical power. This logic can also be applied to transport companies, as well as other categories when some may operate in the regions where the new standard will be common, not having to adapt their rolling stock, but both having the same power and equally sharing the benefits of rail infrastructure uniformity.

4. BUDGETARY IMPLICATIONS

The proposed initiative does not include any measures taken by the Union that would directly affect the EU budget, other than administrative costs. Member states will need to designate local railway authorities in charge of implementing the measures required by this legislation. However, the European Union can use its existing funding mechanisms to help coping with financial challenges introduced to the national budgets and thus encouraging faster implementation.

- **Potential costs and benefits**

Costs	Benefits
Direct	
Administrative costs ▪ Costs for EU institutions and local authorities to plan the construction	**Environment**

<table>
<tr><td>works as well as administrative costs of service providers and national authorities.</td><td>▪ Reduced ticket costs when travelling internationally and the number of transfers.
▪ Reduced CO2 emission by diesel locomotives per journey, contributing to the European Green Deal goal of “making the EU climate-neutral by 2050” (Directorate-General for Mobility and Transport, 2021).
▪ Reduced use of electricity due to the absence of mandatory stops at the border.
▪ Reduced costs and use of personnel on servicing border stations.</td></tr>
<tr><td>Adjustment costs
▪ Re-electrification costs on routes with different electrification, as well as sub-station replacement.
▪ Costs for purchase or modification of compatible locomotives for service providers.
▪ Personnel training on the new electrification standard and the skills to operate and maintain new equipment.</td><td>Cost savings
• Decreased cost of operation and service by removing the need to have bi or tri-voltage locomotives.
• No inefficiency of 2 service providers only servicing people up until border stations.</td></tr>
<tr><td>Enforcement costs
• Cost of informing the public, service providers and local authorities.
• Inspections of the European Commission on compliance with the standard.</td><td>Improved range of services
• Stimulus for the rise of private international rail travel due to standardisation, if allowed by the state.</td></tr>
<tr><td colspan="2">Indirect</td></tr>
</table>

Other indirect costs	Wider economic benefits
• Temporary transportation substitutes to the affected population during the construction works.	• Improved functioning of the EU single market by removing extra complexities of transferring goods and services.
Aggregate impacts	
• Improved GDP growth and regional development (Basboga, 2020). • Shift of average consumer habits of mid-range travel to trains. • More interconnected and unified EU transport network, enhancing political and social integration. • Decreased level of labour shortage due to decreased number of personnel required to operate on a single route.	

Table 2. Regulatory costs and benefits, following the typology of Better Regulation Toolbox tool #56 (European Commission, 2023, p. 504)

- **EU funding scheme**

There are several existing EU funding instruments that can be used to help fund the proposal:

- **Connecting Europe Facility (CEF)** is a key scheme of "targeted infrastructure investment on the European level" (European Commission, n.d.). The sub-programme CEF Transport (CEF-T) has substantially invested more than €26 billion in Europe's railway network (see Figure 2), with priority being given to the TEN-T networks (European Climate, Infrastructure and Environment Executive Agency, 2024). This funding instrument can be used to support construction works required for core and extended lines of TEN-T, as well as auxiliary lines after the backbone of the uniform Trans-European railway network is completed.

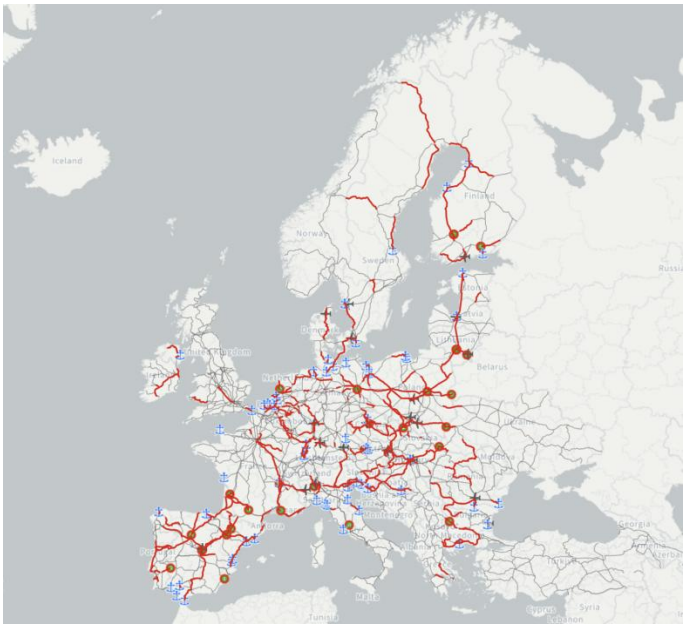

Figure 2. Map of all CEF-funded rail projects since 2014 (European Climate, Infrastructure and Environment Executive Agency, 2024)

- The **Cohesion Fund (CF)** provides support to Member States "with a gross national income per capita below 90% (EU-27 average)" (European Commission, n.d.). Its primary objective is to reinforce the economic, social and territorial cohesion of the EU. The fund primarily focuses on trans-European networks, particularly in the area of transport infrastructure, and therefore can be used to partially finance the implementation of the proposal in the eligible countries.
- While the **European Regional Development Fund** (ERDF) is targeting its funding to the EU regions to reduce their economic, social and territorial disparities, investments to make them "more connected by enhancing mobility" (European Commission, n.d.) is also part of the programme. This, while not allowing the use of its funds for the main trans-European railways, makes them available for funding of smaller, local-level rail lines that, despite predominantly not being included in the core and extended networks of TEN-T, have the potential to operate international passenger service operating on them, if the electrification standardisation will take place.

- **Sustainability**

The proposed legislation establishes a policy that is economically, socially and politically viable and thus is sustainable because it:

- Has the administrative capability of the member states, human capacity of their national rail authorities (Infrabel News, 2022) and established sources of both EU (CEF, CF, ERDF) and local funding (national governments).
- Enjoys public support and a real demand (Bavykin, 2024; Eurostat, 2024) for the establishment of the services that are not efficiently realisable without the implementation of the proposal.
- Aligns with the EU's broader goals of economic integration (EU Single Railway Area) and green transition (EU Green Deal) and enjoys sufficient support from the key political actors in the member states and EU institutions (European Parliament, 2022; Directorate-General for Mobility and Transport, 2021).

5. CHALLENGES

- **Consequences of inaction**

If the EU does not take any proactive measures regarding the variety of electrification systems within its borders, short- and middle-distance travel across the EU will continue to be dominated by buses and airplanes. This will obstruct the EU action plan for "boosting long-distance and cross-border passenger rail", which is essential for the goal of the European Green Deal to double high-speed rail traffic by 2030 (Directorate-General for Mobility and Transport, 2021), Under current conditions, further development of a national railway high-speed network outside of the EU's TEN-T framework is not expected to give a significant boost to passengers compared to the current situation.

Additionally, continuing issues such as high ticket prices for high-speed international services and the inconvenience of numerous transfers for cheaper alternatives would persist, limiting the rise of demand for international travel. Meeting demand lower than expected can create further complications in justifying financial investments needed to meet a requirement set in Regulation 2024/1679 for all railways in the core and extended network of TEN-T to be able to "support trains at speeds 160 km/h or faster" (European Commission, n.d.), undermining its implementation.

These issues are caused by missing EU-wide electrification standards for international rail lines and will critically undermine any other initiatives such as unification of rail gauge, improvement in multi-modal ticketing or increase in popularity of uniform European Train Control System (ETCS) in reaching the goal of boosting international rail travel in Europe.

- **Potential Challenges and Proposed Solutions**

There are several challenges that the EU and Member States can encounter during the process of realising the proposal. Firstly, the resistance of some countries, namely Germany, Austria and Poland, that use electrification systems that differ significantly from the proposed standard. These countries will require the most construction work, facing bigger challenges during implementation. However, the biggest scale of changes would also mean that they will receive the most funds from the European Union through different funding mechanisms which are going to offset countries financial concerns. Moreover, these countries are also going to benefit the most after the proposal is fully implemented.

Secondly, bringing the international rail line on both sides of the border to the new standard will require a high level of coordination. Taking into consideration the large number of lines that would need to be re-electrified, some miscommunication may take place. And if one country starts or finishes the construction at a different time, it will result in an extended period of substitute transport running in the affected regions that will lead to a bigger economic expense of the transition for both member states. This issue can be solved by making the Directorate General for Mobility and Transport responsible, as a part of the European Commission, to oversee and coordinate the member states throughout the process to effectively ensure the alignment in construction schedules, minimizing delays and excess economic impact.

Finally, national train operators such as NS (Netherlands), DB (Germany) and others may resist the change. These train services providers, whose rolling stock is almost exclusively designed for the domestic market with a different electrification systems, may be hostile to the change due to potential disruptions of their existing services. Additionally, they may view the change as a threat to their competitive advantage, leading to internal political discussions and delays in approving the proposal. To address this, in addition to the help with construction and rolling stock upgrading costs provided by several EU funding mechanisms, the EU may use this opportunity to recommend member states to introduce private operators into their rail markets, especially when it comes to international services. Encouraging rail operator liberalisation is a part of the EU's long-lasting policy for a single European railway area (European Commission, n.d.) and separating train operators from national rail infrastructure management, which was addressed in Directive 2012/34/EU (European Union, 2012). It will generally improve

the competitiveness and efficiency of the railway network while avoiding the necessity for the national train operators to make changes to their rolling stock.

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