Poland's Path to High-Speed Rail – Analysis of Challenges and Development Prospects

Jakub Majewski

Dr

Center for European Regional and Local Studies (EUROREG), University of Warsaw
majewski@ppt.edu.pl

Piotr Malepszak

M.Sc. Eng.

Ministry of Infrastructure

Abstract: This article analyzes the prospects and scenarios for the development of high-speed rail in Poland against the backdrop of experiences from other European countries. Despite early investments, such as the Central Rail Line from the 1970s, Poland remains behind in the process of European high-speed infrastructure. A significant change in this regard was the introduction of speeds of 160 km/h and subsequently the introduction of Pendolino trains. This improved the quality of transport; however, their full potential (250 km/h) is still not fully utilized. Planned investments, including the modernization of the Central Rail Line and the construction of the "Y" high-speed line (Warsaw–Łódź–Wrocław–Poznań), aim to significantly increase train speeds and enhance the competitiveness of rail transport. An analysis of the experiences of France, Germany, Italy, and Spain indicates positive economic and environmental effects of implementing high-speed rail systems, while also highlighting different planning and operational models of individual HSR (High-Speed Rail) systems. This allows for the assessment of individual models in terms of the applicability of their elements in the implementation and development program of the high-speed rail system in Poland.

Keywords: *High-speed rail; Rail infrastructure; Investments*

Introduction

Rail plays a key role in the development of transport infrastructure in Europe, providing an alternative to both road and air transport (Givoni, 2006). In particular, high-speed rail has become a pillar of mobility in Western European countries, leading to significant changes in travel patterns and impacting the economy, environment, and spatial organization of regions and urban agglomerations (Campos & De Rus, 2009).

Poland, despite early investments in rail infrastructure, such as the Central Rail Line (CMK) built in the 1970s, has not yet developed its own high-speed rail system. Compared to Western European countries that have dynamically implemented high-speed solutions since the 1980s, Poland lags behind in both technology and transport organization (Preston, 2012). The aim of this article is to analyze the consequences of delays in the implementation of high-speed rail in Poland, identify key challenges, and analyze European experiences in the development of HSR networks and the possibilities for their application in Poland.

History and Current State of High-Speed Rail in Poland

Poland was one of the first countries in Central and Eastern Europe to take steps towards building rail infrastructure enabling high-speed transport. An example of a project planned and implemented according to this concept is the Central Rail Line (CMK), construction of which began in 1971. The line was designed for speeds of up to 250 km/h; however, over the following decades, it was not fully adapted to high-speed rail standards (Konieczyński, 2015). A significant milestone in increasing speeds on the Polish rail network was the introduction of a speed of 160 km/h on the CMK in 1988. Unfortunately, the deep political and economic changes that occurred a year later halted further work in this direction. In the following years, such work was carried out slowly and unsystematically. After the political transformation, the railways in Poland found themselves in a very difficult financial situation, resulting in a sharp reduction in investments in infrastructure and rolling stock. Thus, the speed of 160 km/h remained the maximum value for the next 36 years. It was only in December 2014, after further modernization works, that a speed of 200 km/h was introduced in regular traffic. First on line no. 4 (CMK), and six years later on line no. 9, which extends towards Gdańsk. This was made possible by the engagement of the first HSR trains in Poland, the ED250 series "Pendolino." It is worth noting that the vehicles delivered in 2012 operated at that time at a speed of 160 km/h and still do not utilize their maximum speed of 250 km/h (Konieczyński, 2015).

Since the design and construction of the CMK, several dozen more or less advanced concepts, studies, and projects for the development of the Polish high-speed rail network have been prepared. Alongside the further increase in speed on the CMK, the most mature and closest to realization is the construction of the so-called "Y" line, which is to connect Warsaw, Łódź, Wrocław, and Poznań. In this case, it has been possible to move from conceptual work to the design stage and obtaining the required approvals and permits, and in selected elements, even to the execution of construction works. The construction of the first section of the new high-speed line between Warsaw and Łódź is planned for the years 2027–2032. A design speed of 350 km/h has been adopted in this case (PKP PLK, 2023). At the same time, it has been declared that in the following years, the expansion of infrastructure dedicated to HSR transport towards Wrocław and Poznań will continue, and in subsequent stages also to Gdańsk and on cross-border sections in the south of the country.

European experience in high-speed rail construction

Historically, the area of the first HSR projects was Japan and Europe. In Asia, the first high-speed lines began to be constructed in the 1960s, while in Europe, this occurred in the 1980s (Towpik, 2010). Currently, the European HSR network encompasses over 11,000 km of tracks (UIC 2020).

Examples from countries such as France, Germany, Italy, and Spain demonstrate that the implementation of high-speed rail leads to a systematic strengthening of the competitive position of railways, improved mobility, economic development, and reduced CO_2 emissions. It is also worth noting that each of these countries adopted a slightly different strategy for building and managing HSR infrastructure, tailored to the specifics of the local transport network and geographical and socio-economic conditions. An analysis of these experiences can provide Poland with valuable insights regarding the planning and implementation of similar projects

France

France was the first country in Europe to implement a dedicated HSR network, becoming a global leader in this area. The TGV (Train à Grande Vitesse), or French high-speed train, began operations in 1981 with the opening of the new Paris–Lyon line. It was a response to the growing competition from air transport, which was taking passengers away from rail on short- and medium-distance domestic and European routes. The systematically expanded HSR network has reached a length of over 2,800 km, offering the possibility of speeds up to 320 km/h.

The French high-speed rail model is characterized by the construction of entirely new, independent high-speed lines (LGV) that are not used by freight trains or conventional passenger trains. This allows for very high average travel speeds and high frequency resulting from the uniform nature of the traffic.
The French high-speed rail system has several key features:

- the construction of new lines dedicated solely to high-speed trains and the separation of HSR traffic from other trains,
- integration of HSR with other modes of transport at multimodal transfer hubs,
- significant investment from the state budget, supported by industrial policy in the production of rolling stock and infrastructure elements, as well as the use of public-private partnerships (PPP),
- a focus on competitiveness against air transport and capturing traffic not only on domestic routes but also internationally with neighboring countries,
- economic benefits stimulating regional development.

The aforementioned separation of high-speed rail from conventional traffic is one of the key elements of HSR success in France. The construction of a separate network of lines dedicated solely to high-speed rail brings benefits in the form of:

- reliability and punctuality, resulting from the absence of conflicts with regional and freight traffic,
- the ability to achieve high commercial speeds while maintaining high capacity,
- greater technical standardization, including comprehensive, line-wide control and traffic management systems, as well as power supply and diagnostics.

Despite the creation of an autonomous infrastructure network dedicated only to HSR, France has effectively connected high-speed rail with airports, regional rail services, and urban transport. An example is the TGV station at Charles de Gaulle Airport in Paris, which enables quick transfers between train and plane, or the integrated transport hubs in Lyon and Lille, where convenient transfers to regional trains are provided.

Many of the described experiences in the development of the French HSR network can be utilized and adapted to Polish conditions. France, as a pioneer of European high-speed rail, also has the longest experience in operating such a system. An analysis of French experiences allows for the identification of strategies that can assist Poland in effectively planning and developing modern railway infrastructure. Elements worth analyzing in this regard should include:

- the construction of separate tracks for HSR trains on entirely new routes,
- the separation of HSR traffic from freight and regional traffic,
- the implementation of modern traffic control systems that increase the capacity of routes.

A very valuable conclusion from the operation of French HSR is the confirmation of the possibility of effectively capturing passengers from other transport sectors. High-speed rail indeed represents a real alternative to aviation and road transport. As a result, in efforts to decarbonize the transport sector, it is preferred, among other things, through administrative bans on launching domestic flights on routes with a travel time of 2.5 hours by train.

French experiences also indicate that new high-speed lines should be planned in conjunction with regional and urban transport and guarantee easy, intuitive transfers. According to this principle, railway hubs such as Warsaw, Łódź, Poznań, and Wrocław should be adapted to handle HSR traffic, which requires the modernization of stations and improvement of their connections with public transport.

In terms of sources and mechanisms for financing the development of the Polish HSR network, it would be worth analyzing the significant involvement of the French state during the construction phase of the system and the promotion of development around the project of industries providing the necessary infrastructure, technological, and rolling stock solutions. In this context, the relatively rare public-private partnership instrument, which has supported investments in HSR infrastructure in this country since the 1990s, is also interesting.

Germany

Germany, alongside France, is one of the European leaders in the development of high-speed rail. The first ICE (Intercity-Express) line was opened in 1991 on the Hamburg–Frankfurt–Munich route. However, the development of high-speed rail in Germany was based on different assumptions than in France. The ICE system operates on a hybrid network instead of building entirely new, separated high-speed lines. High-speed trains here utilize both new infrastructure and modernized conventional routes (Nash, 2015). Currently, the German HSR network encompasses over 1,600 km of new lines, with trains reaching speeds of up to 300 km/h.

From the beginning, the ICE system was designed to be compatible with the existing infrastructure. This strategy has allowed the German high-speed rail to be effectively integrated with the existing railway system, enabling service to a large number of cities and regions.

One of the main elements of the German HSR development strategy is the lack of necessity to build separate railway lines along the entire route. Unlike in France, where TGV trains operate almost exclusively on dedicated tracks, in Germany, ICE trains use both HSR sections and conventional lines. Instead of creating separate corridors, the flexibility and operational integration of the existing and new network are utilized. An example of this is the Berlin–Munich line, where ICE trains operate on both high-speed sections (e.g., Berlin–Erfurt) and modernized conventional routes (Erfurt–Munich).

The benefits resulting from the hybrid model of the HSR network adopted in Germany include lower construction costs, stemming from the use of shared sections, and a reduction in construction costs and spatial conflicts in urbanized areas and ecologically valuable regions. Avoiding full separation of traffic allows for better utilization of existing infrastructure and the creation of a more extensive network of served routes, thus improving accessibility to medium and small centers. The model, in which ICE trains also operate on regional lines, also means the possibility of optimizing the connection network, greater operational flexibility, and a significant increase in the number of passengers served by the system.

The planning, construction, and operation model of the German HSR network leads to a very deep integration of long-distance rail with regional and urban traffic. ICE trains do not replace regional and interregional connections but complement their offerings. As a result, the system is coherent and has a nationwide character. This means that not only large stations serve as transfer hubs, but also medium-sized ones, and in selected cases, even small ones. Additionally, ICE trains operate at regular intervals, which improves the clarity of the timetable and the possibility of linking them with other rail connections. Regularity significantly facilitates the optimization of transfers and the integration of the system. This effect is further strengthened by a unified ticketing system, which allows passengers to flexibly combine journeys using various modes of transport.

The German HSR model can serve as a significant reference point for Poland, especially when seeking the shape and character of the target connection network. The solutions of our western neighbors may prove to be a more realistic and effective model than the French system, as they assume gradual network development, operational flexibility, and better integration with existing infrastructure. It is also worth noting that the German model better corresponds to the structure of our settlement network, which is more similar to the German

than the French one. At the same time, it should be recognized that the implementation of the German model is not possible without the construction of new system elements. Poland lacks dedicated high-speed lines, and the current investments, which focus on improving the parameters of existing routes, cannot ensure speeds higher than 250 km/h.

German experiences can also be utilized in the development phase of the Polish HSR project. For example, on the Warsaw–Wrocław route, where initially HSR trains may use segments of new and existing lines, and ultimately utilize new dedicated sections.

Poland can benefit from Germany's experiences, including:

- staging the construction of high-speed rail and connecting new and deeply modernized sections,
- full integration of HSR with regional and urban rail and preparing a network of integrated transfer hubs,
- synchronization of timetables and tariff integration of high-speed and conventional rail,
- flexibility in creating connections for new infrastructure and linking HSR lines with existing routes.

It is also important to emphasize that the German HSR network was designed as part of a comprehensive transport system. A problem for Polish railways, in addition to infrastructural deficiencies, is indeed the deep disintegration of the system. The network of long-distance connections in many regions is not coordinated with regional connections. Utilizing German experiences may therefore provide an opportunity for a profound revision of thinking about the functioning of transfer hubs and the integration of schedules and tariffs of various types of connections.

Italy

Italy, like Germany, has adopted a hybrid approach to the construction of high-speed rail. This means that the Alta Velocità system utilizes both newly constructed high-speed lines (AV) and modernized conventional lines adapted for higher speeds.

The main difference between the mentioned models is that in Italy, the dedicated HSR infrastructure creates complete transport corridors – for example, Milan–Rome–Naples, while the modernization of existing routes ensures their extension, such as Turin–Venice. However, the varied nature of the network means that the speed of 300 km/h is not uniform, and trains only achieve it on lines built from scratch.

What fundamentally distinguishes the Italian model from the French and German ones is the open access to the HSR network and its availability to multiple carriers. Market liberalization contributes to an increase in the number of connections and enables competition within the rail sector. On HSR routes, there are two operators: the state-owned Trenitalia, which operates Frecciarossa trains, and Nuovo Trasporto Viaggiatori S.p.A., offering services under the Italo brand. Both companies compete for the same market and both report an increase in passenger numbers. Importantly, the competition introduced in 2022 did not cause the previous monopolist to lose passengers. Although its market share dropped from 100% to 71%, it still recorded an increase in passenger numbers. Experiences from the operation of the Italian HSR network indicate that railways gain at the expense of other modes of transport – primarily road and air. The effects of market liberalization in Italy's HSR have resulted in an 80% increase in passenger numbers due to internal competition and a reduction in ticket prices by up to 40%. The quality of services has improved – higher service standards and a greater offer of trains (ProKolej 2022).

From Poland's perspective, the Italian experiences in planning, constructing, and operating the HSR network confirm that the system does not require a complete network of new lines, and the key element of success is an attractive travel time and high quality and competitiveness of services. The benefits resulting from the Italian model are, like in Germany, lower construction costs and broader service availability. In addition to the advantages stemming from the hybrid model of construction and modernization of infrastructure and guidelines for integration with regional and air traffic, a point for detailed analysis is the issue of open access to the network. In many visions and concepts, the Polish HSR network is perceived as a centralized project, operated solely by PKP Intercity. However, analyzing the Italian experiences clearly shows the potential resulting from increasing the number of carriers. This tool not only allows for raising the quality and diversity of offered services but, above all, increases the customer base. This is due to the fact that competition forces the rationalization of ticket prices and the acquisition of new passengers who will fill trains operating with high frequency.

Spain

Spain, although it began constructing HSR infrastructure relatively late (the first AVE – Alta Velocidad Española – line was opened in 1992), currently has a network of over 4,000 km and is the leader in Europe in this regard (UIC, 2022). The Spanish model is characterized by dynamic expansion, a high degree of funding from European Union sources, and a strategy of building new, dedicated HSR lines instead of modernizing existing routes.

Unlike Germany or Italy, which integrated high-speed rail with the existing network, Spain opted to build entirely new HSR lines, independent of traditional railway infrastructure. This was primarily due to the decision to use the European standard gauge. The conventional Spanish network has an Iberian gauge (1668 mm), while the new HSR network was built to the European standard (1435 mm).

The result of constructing a new, autonomous HSR system is the lack of necessity to share tracks with freight or regional traffic, thus concentrating on the parameters necessary for high-speed movement. This means the possibility of increasing speeds. Dedicated HSR lines also offer very high capacity and thus the ability to operate a greater number of high-speed trains.

A characteristic feature of the Spanish HSR system is also the way investments are financed. While in France, Germany, and Italy, infrastructure was primarily built using national funds, Spain financed even 50-60% of the costs of high-speed rail construction through European Union funds. This was possible because the Spanish HSR project was primarily treated as a tool for reducing regional inequalities and promoting European integration. Fast connections between remote regions, such as Andalusia, Galicia, or Castilla-La Mancha, were intended to reduce their transport isolation and open them up to new investments. The new rail connections shortened travel times by over 50%, which increased the mobility of residents, providing better access to education and job markets in developed regions. At the same time, it improved the accessibility and tourist attractiveness of the regions served by HSR, contributing to their increased popularity, development, and influx of investments. Moreover, the adoption of the European standard gauge was indicated as a solution aimed at technical integration with the French network and, through it, with the rest of Europe.

Thanks to fast travel times and convenient connections, high-speed rail has become more competitive than domestic flights. HSR trains effectively captured passengers from domestic aviation on routes where high-speed rail was introduced.

Spain, like Italy, decided to open HSR infrastructure to competition. The liberalization of this market began in 2013 as part of a broad reform program aimed at improving service quality and better utilizing the effects of investments. As a result, new companies emerged to compete with the state carrier RENFE, such as Ouigo (a subsidiary of the French SNCF) and the Irish Iryo. One of the successes of the liberalization of the HSR market in Spain was the increased availability of services and, consequently, the number of passengers served by the system. This was contributed not only by lower ticket prices but also by greater flexibility and diversity of the offer, an increase in the number of connections, and additional rolling stock investments. Carriers, under competitive pressure, offered attractive promotions, loyalty packages, and accompanying services. As a result, the Spanish HSR network has become an example of a successful market transformation and a success in terms of both increased competitiveness and service quality.

Poland, like Spain, is relatively late in inaugurating the construction of a completely new HSR system and can therefore compare and utilize best practices from other European

markets. The Spanish high-speed rail model provides guidance in this regard regarding planning, financing, and organizing the network. Key points include:

- the construction of dedicated lines and maximizing the effects resulting from the separation of fast train traffic from other traffic,
- maximizing engagement and utilization of EU funds – especially from competitive sources, such as the Connecting Europe Facility instrument,
- using the HSR project as a tool to support regional development and European integration,
- introducing competition as a tool to intensify traffic and innovation in transport offerings.

Spain has proven that high-speed rail can be a key element of a country's economic and social development. Poland, as the largest beneficiary of EU funds, has the opportunity to follow the same path and utilize a financing model similar to that of Spain. To this end, it is essential to emphasize the role of HSR infrastructure in the integration and development of the country and in improving the accessibility of less developed regions located on the external and internal peripheries. At the same time, a key element of network planning should also be the perspective of integrating the Polish and European HSR networks, especially at the southern and western borders. The international dimension should also be strengthened by projects such as Rail Baltica or connections towards Ukraine. By implementing Spanish experiences, it is possible to build a modern HSR system that will support both regional and international integration.

A valuable insight for the Polish high-speed rail project is also the success of the liberalization of the high-speed rail market in Spain. The process, which led to the expected increase in competitiveness, lower prices, and improved service quality, has also become a tool for intensifying the use of infrastructure. Thus, it strengthened the positive impact of HSR on the economy, the mobility of residents, and the accessibility and tourist attractiveness.

Analysis of Challenges in the Development of High-Speed Rail in Poland

One of the fundamental limitations in the development of high-speed rail in Poland is financial issues. The construction of new HSR lines requires multi-billion investments, which poses a significant challenge for the state budget (Nash, 2015). Support from European Union funds is crucial here, as it previously enabled the dynamic expansion of road infrastructure. Utilizing a similar funding model could accelerate the implementation of planned rail investments.

Additionally, managing infrastructure projects in Poland is characterized by high bureaucratization and lengthy administrative procedures. Compared to Spain or France, where HSR lines were built within 4-5 years, in Poland, decision-making and implementation processes take significantly longer (Albalate & Bel, 2012).

The effective implementation of high-speed rail requires its integration with the conventional railway system and public transport (UIC, 2018). Examples from France and Germany show that the success of high-speed rail depends not only on technical parameters but also on the quality of connections with the regional and local network. In Poland, a key element will be the coordination of timetables, the construction of transfer hubs, and the development of ticketing systems that enable easy connections between different modes of transport.

On the other hand, the experiences of Italy and Spain indicate the opportunities presented by market opening and the intensification of transport services accompanying competition among carriers. In this regard, a complementary element to the Polish HSR project should be transparent and flexible regulations that allow market access while ensuring high standards of safety and service quality. This process will require consideration of the specifics of the Polish market, as well as careful planning at all stages of project implementation to ensure its effectiveness in terms of the scale of transport services provided and economic benefits.

It should also not be forgotten that the biggest competitor to high-speed rail in Poland is road transport. Passenger cars account for over 80% of journeys over distances greater than 100 km (Eurostat, 2022). The experiences of countries such as France, Germany, Italy, and Spain show that operational speed and the associated travel time are just one aspect. However, there are many more elements that contribute to the success of HSR. At the planning and construction level of the transport offer, conditions such as financing possibilities and structure, the shape of the existing transport network, the level of railway competitiveness, and the expectations and role of the HSR system are also very important.

Summary and Conclusions

Poland is currently at a crucial moment in the development of railway infrastructure. The implementation of high-speed rail requires a strategic approach that includes effective financing, optimization of investment processes, and integration with the existing transport network. Therefore, the most important challenge is the effective preparation and execution of this project.

An analysis of the experiences of France, Germany, Italy, and Spain indicates the positive economic and environmental effects of implementing and operating a high-speed rail system. It also highlights somewhat different planning and operational models of individual HSR systems. Poland is currently at a key moment in the development of railway infrastructure. The implementation of HSR requires a strategic approach that includes effective financing, optimization of investment processes, and integration with the existing transport network. Experiences from other countries indicate that the development of HSR contributes to economic growth, improved mobility for residents, and reduced CO_2 emissions. A fundamental factor determining the success of the process remains the implementation of effective project management mechanisms and ensuring a stable source of funding, which by 2035 could enable Poland to achieve transport standards comparable to those of Western European countries.◀

Source materials

[1] Albalate, D., & Bel, G. (2012). High-speed rail: Lessons for policy makers from experiences abroad. Public Administration Review, 72(3), 336–349.

[2] Campos, J., & De Rus, G. (2009). Some stylized facts about high-speed rail: A review of HSR experiences around the world. Transport Policy, 16(1), 19–28.

[3] Dobruszkes, F. (2011). High-speed rail and air transport competition in Western Europe: A supply-oriented perspective. Transport Policy, 18(6), 870–879.

[4] Eurostat. (2022). Passenger transport statistics. Retrieved from www.ec.europa.eu/eurostat

[5] Fundacja ProKolej (2022), Przewodnik otwarcia rynku kolejowych przewozów pasażerskich

[6] Givoni, M. (2006). Development and impact of the modern high speed train: A review. Transport Reviews, 26(5), 593–611.

[7] International Energy Agency (IEA). (2020). The future of rail: Opportunities for energy and the environment. Retrieved from www.iea.org

[8] Konieczyński, J. (2015). Pendolino w Polsce – analiza ekonomiczna i operacyjna. Przegląd Kolejowy, 11(3), 12–27.

[9] Nash, C. (2015). When to invest in high-speed rail infrastructure. Journal of Transport Geography, 22(2), 391–396.

[10] Preston, J. (2012). High speed rail: A review of recent developments. Journal of Transport Geography, 22(1), 306–320.

[11] Towpik, K. (2010) Linie kolejowe dużych prędkości, Problemy Kolejnictwa, z. 151

[12] Union Internationale des Chemins de fer (UIC). (2018). High-Speed Rail and Sustainability. Retrieved from www.uic.org

[13] Union Internationale des Chemins de fer (UIC). (2019). High-speed rail and the environment: Reducing emissions and improving efficiency. Retrieved from www.uic.org

[14] Vickerman, R. (2018). Can high-speed rail have a transformative effect on the economy? Transport Policy, 62(1), 31–37.