YEARBOOK OF UNWE (2021), PUBLISHING HOUSE – UNWE
ISSN (print): 1312-5486; ISSN (online): 2534-8949; http://unwe-yearbook.org/en/
DOI: https://doi.org/10.37075/YB.2021.1.07

ANALYZING THE FACTORS WHICH INFLUENCE THE EFFECTIVENESS OF RAILWAY PASSENGER TRANSPORT

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Abstract

Railway transport makes significant contributions to the economy of every country. Approximately 30 000 people are directly employed in this sector in Bulgaria, and the added value to the GDP amounts to approximately 2% (NSI, 2019a). Railway transport is crucial for a more sustainable transport sector, stable economic development, as well as social cohesion and connectivity of citizens. The article presents a study of the technical and operational factors for the work of railway transport as well as energy consumption during freights. The goal is to outline the way these indicators affect the stable development of railway transport and what their actual influence is in regard to carrying out railway passenger transport. The speed and energy efficiency of railway passenger transport have been analyzed, as they will serve as the foundation for specific suggestions on how to carry out passenger transport in Bulgaria more effectively.

Key words: railway transport, public passenger, energy efficiency, stable development, technical and operational indicators

JEL: R42, Q49

Introduction

Railway transport is a fundamental type of transport in all industrially developed countries in Europe and around the world. It thrives in the conditions of exceptionally serious competition with other types of transport, namely – motor, air, river, sea, unconventional, etc., which in turn leads to its perpetual development through the continuous integration of new computing and designing methods, through the introduction of vanguard and innovative technology and through the use of modern systems for testing railway equipment. The goal is to make the regular use of various railway systems in the member states possible and eliminate any problems in the inter-network passage between individual member states. Several technical solutions (the so-called "technical specifications for interoperability" or "TSI") have been developed within the respective directives (Directive 96/48/EO). They are primarily aimed at the most vital aspects such as

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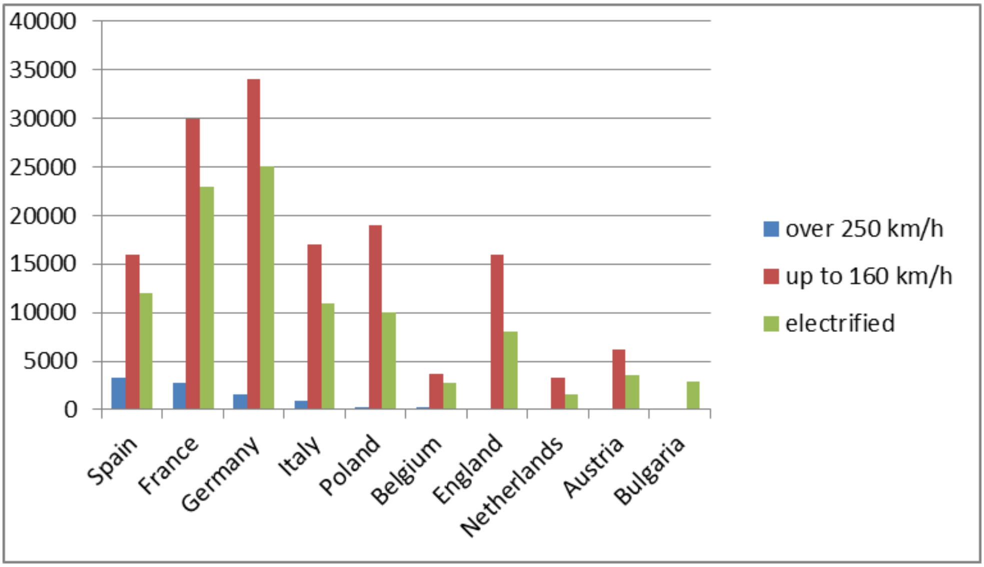
control systems, safety, signalization, telematics applications for freight traffic, the qualification of cross-border transport staff, freight wagons and noise emissions. The technical barriers to train interoperability, as well as the implementation and development of the European Rail Traffic Management System (ERTMS) are reduced within the fourth legislative package in the field of railway transport.

In order to improve the interoperability and safety of the European railway network (Regulation 881/2004), the European Railway Agency (ERA) was created; its primary goal is to harmonize, register and control the technical specifications for interoperability (TSI) for the entire European railway network, as well as determine common goals regarding the safety of European railways. In terms of contributing to the future development and effective functioning of a unified European railway space and guaranteeing a high level of safety, interoperability and improvement of railway transport, the European Railway Agency is the only competent authority involved in the issuing of safety certificates for vehicles (locomotives and wagons) used for cross-border operations and single safety certificates for railway enterprises.

The subject matter that the article studies includes BSR "Passenger transport" as well as the provided railway services; more specifically, it examines the prerequisites for its successful realization and the organizational capacity of railway carriers. The fundamental research thesis of this article is to use the analysis and evaluation of the effectiveness of the provided railway services as a basis to determine the possibilities for its future improvement, maintenance and long-term and stable development. On these grounds, inferences and recommendations for creating and maintaining successful and stable railway passenger transport have been made.

Analyzing the Indicators of Speed and Energy Efficiency

Speed is one of the primary indicators for improving the provided transport services, as well as attracting more passengers. The shortening of travel time along different routes depends greatly on it. High-speed traffic in railway transport holds great significance in Europe, and as the chart below shows, well-developed high-speed routes exist in countries like Spain, France and Germany.



Source: Statista (2021).

Figure 1: Length of high-speed railways in Europe

The total length of high-speed (i.e. over 250 km/h) railway routes in Europe is approximately 10 000 km (Statista, 2021). As the chart shows, in addition to these specialized railways, the indicated EU member states also have conventional railways which are designed for speed ranging from 140 km/h to 200 km/h; in different countries, conventional railways make up between 50% and 75% of the total length. Electrified and doubled railways also hold a large share (between 60% and 85% for different countries). Bulgaria has a well-built railway network, with doubled sections making up 10% of the total length and electrified sections making up 80% (NRIC, 2021). Only 140 km of railway lines are designed for speed as high as 160 km/h (Septemvri – Svilengrad). The purpose of building and/or expanding railway lines designed for speed of 160 km/h is to fulfill the European policies (European Commission, 2020) for railway transport development which specify that by 2050 most European citizens should be able to traverse distances of up to 150 km along the railway network for no more than 30 minutes. Increasing travel speed will increase the share of people who use railway transport as a mode of transportation, which in turn will increase the ecological levels of transport, improve travel safety, and achieve a positive economic effect. It is important to note that a train's speed of movement depends not only on the parameters of the railway infrastructure, but also largely on the condition of the rolling stock, and especially the maximum permissible speed it can reach.

Countries like Germany, France, Italy and Spain have achieved proper correlation between permissible speed of movement, in accordance with the requirements of the infrastructure and the requirements of the used rolling stock. That way, train traffic achieves optimal speed close to the maximum for the section as well as the rolling stock.

Compared to the listed countries, there is a lack of high-speed railway infrastructure in Bulgaria. There is only one section between Plovdiv and Svilengrad designed for a speed of 160 km/h. Over the past 10 years, work has been done on sections of the railway network with regard to the aforementioned construction of railways for achieving speed of 160 km/h. Table 1 presents the speed of movement along certain main routes from Bulgaria's railway network.

Table 1: Speed of movement along the railway network's main routes

Line	From station	To station	Length	Speed	Note
1	2	3	4	5	6
Line 1 - 104 km	Sofia	Elin Pelin	24 km	160 km/h	Undergoing modernization
	Elin Pelin	Septemvri	80 km	70 km/h	Undergoing reconstruction
Line 1 - Line 8 - from Sofia to Burgas - 456 km	Septemvri	Belozem	90 km	160 km/h	
Line 8 - 255 km	Belozem	Mihaylovo	50 km	60 km/h	Undergoing reconstruction
	Mihaylovo	Stara Zagora	23 km	130 km/h	
	Stara Zagora	Nova Zagora	33 km	160 km/h	
	Nova Zagora	Yambol	45 km	110 km/h	
	Yambol	Burgas	105 km	130 km/h	
Line 1 - 135 km	Krumovo	Svilengrad	131 km	160 km/h	
Line 2 - 460 km	Mezdra	Cherven bryag	53 km	120 km/h	
	Cherven bryag	Pleven	53 km	110 km/h	
	Pleven	Gorna Oryahovitsa	106 km	120 km/h	
	Gorna Oryahovitsa	Kaspichan	165 km	80 km/h	
	Kaspichan	Varna	84 km	80 km/h	

Continued

1	2	3	4	5	6
Line 3 - 500 km	Kazichene	Karlovo	135 km	100 km/h	
	Karlovo	Tulovo	74 km	70 km/h	
	Tulovo	Dabovo	8 km	100 km/h	
	Dabovo	Sliven	68 km	80 km/h	
	Sliven	Karnobat	58 km	120 km/h	
	Karnobat	Sindel	122 km	100 km/h	
	Sindel	Varna	34 km	80 km/h	
Line 5 - 210 km	Sofia	Pernik	30 km	70 km/h	
	Pernik	Radomir	18 km	80 km/h	
	Radomir	Blagoevgrad	75 km	80 km/h	
	Blagoevgrad	Kulata	87 km	70 km/h	
Line 7 - 260 km	Sofia	Mezdra	88 km	70 km/h	
	Mezdra	Vratsa	18 km	80 km/h	
	Vratsa	Vidin	159 km	80 km/h	

Source: BSR (2021) and NRIC (2021).

As the table shows, there are no railways that allow speed in the 100-160 km/h range along its entire direction and length in existence. Such speed is only achieved along certain sections of the railway network. It is noticeable that there are two problematic sections along the Sofia – Burgas route, which is one of the most perspective ones – Elin Pelin – Septemvri (80 km) and Belozem – Mihaylovo (50 km). Reconstruction and modernization work is being done on both sections with the goal of achieving a speed of 140-160 km/h. Once these activities are completed, the distance from Sofia to Burgas (456 km) with four stops (September, Plovdiv, Stara Zagora and Karnobat) can be traversed in 4 hours. This travel time will provide serious competition not just for bus transport but for private cars as well. Additionally, the speed of movement along the direction of the third line, which used to be traversed by the famous “Seagull” train, is around 100 km/h and over, excluding the section between Karlovo and Sliven, where the speed is 80 km/h. This is also the shortest distance between Sofia and Burgas – 420 km. On the other hand, the Sofia – Mezdra – Vratsa (Vidin) line, which is the busiest one, is in the most unsatisfactory condition. Its entire length does not allow a speed higher than the 70-80 km/h range. There is also a lack of projects to be realized in the next 10 years. The fifth line, Sofia – Kulata, is in the same condition and has the same perspectives. Our “northern” line, Sofia – Varna, can be divided into three zones. The first zone is Sofia – Mezdra, the second zone is Mezdra – Gorna Oryahovitsa, and the third zone is Gorna Oryahovitsa – Varna. The second zone is the only one that fulfills the requirements of the customers of BSR "Passenger Freights" in terms of speed of movement; however, we are talking about a length of a little over 200 km from a total of 540 km.

The poor condition of the railway tracks and the lack of proper rolling stock do not allow for a significant increase in the speed of movement and, by extension, the provision of high-quality railway services by BSR "Passenger transport". Over the past 10 years, the NRIC's reconstruction activities have included the following sections:

Completed projects:

- 1st main railroad, the Belovo – Plovdiv – Svilengrad section (completed);
- 8th main railroad, the Mihaylovo – Stara Zagora – Yambol – Karnobat – Burgas section.
- Projects currently in development:
- 1st main railroad, the Sofia – Elin Pelin section.
- Projects pending completion:
- 1st main railroad in the Elin Pelin – Ihtiman – Belovo – Septemvri section;
- 8th main railroad in the Orizovo – Mihaylovo section.

The goal of these reconstruction activities is to achieve a speed of 160 km/h. The low speed of movement reduces the competitiveness of the railway transport, which in turn leads to an outflow of passengers. A specific example is the Sofia – Plovdiv train, which traverses the distance of 150 km for two hours and fifty minutes, i.e. with an average speed of 60 km/h. Obviously, this is a very low speed to traverse this essential and perspective route with – it lowers the quality of the provided railway service and it makes it difficult to achieve a normal level of competition with motor transport. The completion of the project for the Septemvri – Plovdiv section (with a length of 53 km) helped shorten travel time by about 30 minutes. The completion of the projects for the Sofia – Elin Pelin and the Elin Pelin – Septemvri sections will shave off 60 more minutes from the time necessary to traverse the Sofia – Plovdiv line, which in turn will make the travel time between Sofia and Plovdiv approximately 1 hour.

In addition to the state of the railway infrastructure, delays and failure to adhere to train traffic schedules also have a significant impact on travel time. This indicator in particular is what makes the transport services provided by BSR "Passenger transport" appealing or unappealing to passengers, hence why it is the subject of direct and exceptionally critical scrutiny. Another important factor for the strict adherence to train traffic schedules is the reliability of the rolling stock. A considerable portion of the cases of delayed or cancelled trains[2] is due to malfunctions which primarily involve the age and wear and tear of the used vehicles. A key factor for the poor

[2] „Cancelled train" is a situation where the used traction rolling stock (motor-coach train or locomotive) is incapable of continuing to service the train to the final station due to malfunction or damage.

quality of the transport services provided by BSR "Passenger transport" is the lack and the critical condition of the available rolling stock. This has led to a drastic rise in passenger train delays over the past several years (table 2) – in 2019 the rise in delays is 4 times as high in comparison to 2010.

Table 2: Passenger train delays in 2019

Train category	International trains	Domestic long-distance trains	Regional and suburban trains
Total amount of delays at final stations, %	45.53%	48.73%	11.26%
Delays of up to 60 min., %	33.18%	42.51%	7.15%
Delays ranging from 61 min. to 120 min., %	8.21%	4.84%	1.32%
Delays exceeding 120 min., %	4.73%	1.29%	1.24%

Source: BSR (2021).

As the table shows, international and domestic long-distance trains have registered the biggest delays within 60 minutes at final stations. The extended travel time which results from the low speed of movement that leads to these delays causes additional inconvenience for passengers traveling long distances due to disruptions in train traffic schedules.

Train cancellation and/or delays are a common phenomenon caused primarily by the lack of operationally fit traction rolling stock. The available rolling stock does not fulfill European standards regarding comfort, hygiene and quality, and the maintenance and repair of the obsolete fleet falls behind the determined deadlines and requires a considerable amount of resources. A large portion of the available rolling stock cannot be used to its fullest not just in terms of the rehabilitated and modernized railway infrastructure, but also in terms of the one which has not been invested in yet. This is due to systemic delays in the execution of repair programs due to a shortage of spare parts, equipment and qualified personnel. One of the reasons for the systemic shortage of spare parts and equipment is the specific nature of the BSR "Passenger Freights" company. As a commercial company with 100% state participation, railway carriers are obligated to fulfill the requirements of the Public Procurement Law (PPL). The procedures for public procurement assignment are quite lengthy and often difficult to prognosticate, which is due to the specificity of the parts and consumables that are the subject of public procurement, as well as the option to file an appeal against the choice of suppliers which interested parties frequently use. This necessitates the maintenance of a large reserve of parts and consumables that are capable of covering the needs of carriers during assignment procedures which often last for years. The shortage of qualified staff, for its part, results from a combination of difficult working conditions and non-competitive remunerations, especially in major cities.

It is evident that travel time depends mostly on the speed of passenger trains, but also on the overall organization and management of the traffic, as well as the state of the rolling stock. Regardless of the complex dependency of travel time on various parameters, updating the traction rolling stock designed to service passenger trains with one that provides increased reliability and higher speed will contribute to the improvement of this indicator. For example, the shortening of the travel time along the Sofia – Plovdiv – Burgas destination could suggest, with a considerable degree of credibility, an increased number of passengers in the future. At present, travel time along this route is approximately six hours and thirty minutes. Increasing the speed of movement to 120 km/h will enable train freights to measure up to motor transport freights, thus increasing the competitiveness of railways.

Another indicator which influences the appeal of railway transport is its energy efficiency. In today's conditions of the ever-growing global economy, the perpetual trend of the total number of the Earth's population increasing, the rapid decrease and depletion of fossil energy sources, climate changes and environmental changes, serious measures for the permanent and stable reduction of energy consumption need to be adopted not just on a European scale, but a global one as well. The mitigation of the negative effects that transport activity has on the environment necessitates taking action in regards to harmful emissions. The problems related to energy efficiency in transport can be solved by adopting specific measures which involve increasing the competitiveness of railway transport (Nikolova, Minkov, 2014). For European countries in particular, the total reduction of energy consumption and increase of the share of used electrical energy will reduce the dependency on fossil fuels and their import from other countries. It is indisputable that energy efficiency is directly linked to ecology and environmental protection. It is no coincidence that the EU's strategy for the stable development of transport states that the purpose of "achieving stable levels of energy consumption by transport and reducing greenhouse gases" is to reduce the harmful effect on the environment (CEC, 2010). The transition to low-carbon economy and the ever-increasing demands for energy security suggests reorientation towards producing and providing energy from renewable sources.

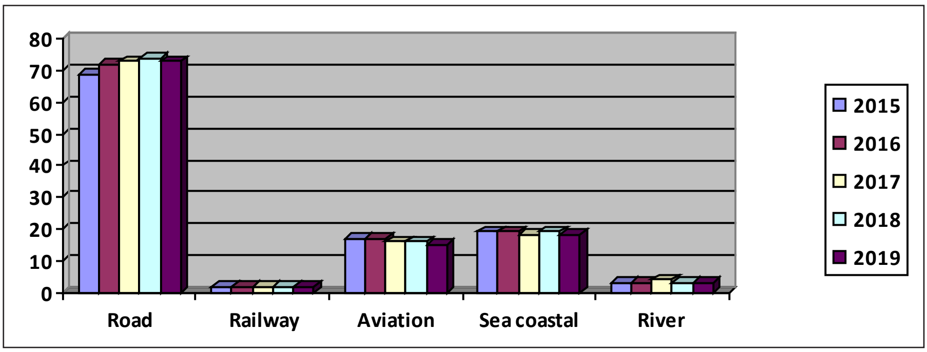
Energy efficiency in transport is measured on the basis of a quantitative indicator related to the energy contents of a unit of produced GDP. The commonly accepted name for this indicator, which is defined as the correlation between consumed energy and the created GDP (Ministry of Energy, 2019), is "energy intensity"[3]. Consumed energy refers to the total amount of final energy consumption (including the energy costs of power plants and transference). The energy intensity in the "Transport" sector is calculated with regard to the entire GDP due to the fact that it services all economic sectors. Table 3 shows energy consumption by sectors for the examined period.

Table 3: Final energy consumption by sectors (in thousands of T.O.E.)[4]

Sectors	2014	2015	2016	2017	2018	2019
Industry	2617,5	2719,6	2655,5	2753,6	2730,6	2856,5
Transport	2916,5	3211,6	3268,1	3324,9	3372,2	3412,4
Households	2165	2192,9	2252,1	2318,7	2229,7	2289,2
Agriculture	190,5	185,8	185,3	177,6	185,9	191,3
Services	992	1078,7	1157	1167,2	1231,2	1258,7

Source: NSI (2020).

The table shows that transport in Bulgaria holds the largest share, making up 34% of the total energy consumption. The chart below shows the allocation by types of transport (NSI, 2019b).



Source: NSI (2019b).

Figure 2: Final energy consumption by types of transport

The chart makes it very clear that railway transport holds the lowest share of energy consumption compared to other types of transport – an average of 1.6% for the examined period. Only river transport has similar data; however, if the

[3] Energy intensity reflects consumed energy (in tons of oil equivalent) during the making of one unit of transport production (in passenger kilometers).

[4] Thousands of tons of oil equivalent – consumption includes the heat from the environment and excludes the fuels for international aviation flights.

volume of carried out work is taken into account, then railway transport has better characteristics. Motor transport holds the largest share of energy consumption – a little over 70%. Even more unfavorably, motor transport consumes fuels based on 100% imported petroleum, whereas railway transport is much more energy efficient – electric power makes up a little over 80% of its consumption. The analyzed values emphatically show that railway transport has the highest energy efficiency. The integration of a new rolling stock will improve the quality of the provided transport service, thus increasing the share of railway transport in passenger freights, which in turn will help improve energy efficiency in Bulgaria as a whole.

In conclusion, it can be summarized that increasing the share of railway transport passenger freights will improve the total energy efficiency in the country, thus reducing the share of liquid fuel consumption in the transport department as well. This in turn will reduce the harmful ecological effects of transport and, given the importance of railway transport, have an overall positive impact on the stable development of the field. Increasing the share of railway transport freights would also lead to partial relief of existing motor highways, with all the positive effects that will result from it.

Conclusion

Increasing the efficiency and competitiveness of passenger railway freights requires constant development and perfection of the material and technical foundation, especially on the basis of integrating innovations. In the last twenty years railway transport has been systematically neglected, and the failure to modernize it is the primary reason which has led passengers to seek alternative methods of transportation. This worrying trend involving the sharp drop in the volume of carried out work (measured in passenger kilometers) is the result of two fundamental causes:

- Unfair competition with motor transport, which is based on failure to pay the full cost of carrying out freights, thus putting motor transport in a much more advantageous position compared to railway transport.
- The poor condition of railway tracks and the rolling stock.
- Railway passenger transport in Bulgaria has to fulfill three fundamental requirements in order to be effective in terms of its stable development. Firstly, it needs to guarantee the improved quality of the services it provides, increase their volume and make them more accessible. This requirement corresponds with the concept of economic stability. Secondly, it needs to guarantee the growth of passenger flows, as well as the highest possible improvement of the quality of life in society, which corresponds to the concept of ecological stability. Thirdly, the benefits of more high-quality

railway passenger transport need to be allocated to all social groups of the population, which in turn concerns social stability.

Achieving railway stability is the most important condition for creating a consistent policy regarding the development of this type of transport. Passengers desire reliable, comfortable and accessible railway freights which are worth their money. Society as a whole desires railway transport that contributes to economic development as well as to facing the challenges of environmental protection. Therefore, railways can respond to these needs only if they have the capacity necessary to satisfy the demands of passengers who wish to use this type of transport.

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