ENVIRONMENTAL ASPECTS OF COMPARING RAIL AND ROAD TRANSPORT

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ABSTRACT
Social and economic development of every country should be oriented towards improvement of the living standard of the population, i.e. of every individual. Transport, as the basis of every economy, is one of the basic development factors. However, the development of classical transport branches in the last century significantly disturbed the natural balance of the eco-system, regarding all the known negative transport effects. This paper will present, from the ecological point of view the comparison of the rail and road transport at the level of the European countries. Based on the gathered data and the analysis of the condition, certain guidelines will be proposed for the optimization of the rail and road transport that should, among other things, significantly affect the reduction of harmful impact of the analyzed transport branches on the environment.

KEYWORDS
rail and road transport, ecology, energy consumption, energy saving, exhaust gas emission, transport optimisation

EKOLOŠKI ASPEKTI USPOREDBE ŽELJEZNIČKOG I CESTOVNOG PROMETA

SAŽETAK
Društveni i gospodarski razvoj svake države treba biti usmjeren ka poboljšanju životnoga standarda stanovništva, odnosno svakoga pojedinca. Promet kao osnova svakoga gospodarstva, jedan je od osnovnih čimbenika razvoja. Međutim, razvoj klasičnih grana prometa u prošlom je stoljeću znatno poremetio prirodnu ravnotežu ekosustava. S obzirom na sve poznate negativne učinke prometa, u ovome radu prikazat će se sa ekološkog aspekta usporedba željezničkog i cestovnog prometa na razini europskih zemalja. Na temelju prikupljenih podataka i analize stanja predložit će se određene smjernice za optimalizaciju željezničkog i cestovnog prometa koje bi, između ostalog, trebale znatno utjecati na smanjenje štetnog utjecaja analiziranih prometnih grana na okoliš.

KLJUČNE RIJEČI
željeznički i cestovni promet, ekologija, potrošnja energije, ušteda energije, emisija ispušnih plinova, optimizacija prometa

1. INTRODUCTION

Accepting the category of transport in a wider sense of its significance, it may be concluded that its development depends on the general policy, but also that it has in itself contributed to its design. It is possible to compare the periods when transport developed the social community and stimulated its development with the periods when the developed society, with all its advantages, started to show numerous drawbacks regarding its cause-effect relations with transport. The impact of transport on the economy is diverse since it appears as a factor: of a large consumer of industrial products, realisation of industrial products, development of agriculture, formation and stabilisation of markets, and the development and improvement of tourism. As part of the social function of transport there is also its role of cultural enhancement of the population of the region in which it connects the economically underdeveloped environments with the political, economic and cultural centres.

Apart from the positive impacts of transport, recently its negative effects on the community have been coming more significantly to the fore, such as: various climate changes, increase of ozone holes, acid rains, extinction of plant and animal species, occupying of large areas for the construction of traffic routes, large congestions due to mass transport, high consumption of limited energy resources and significant environmental pollution. The reason lies also in its uncontrolled development on the principle of continuous economic growth that was influenced, or failed to be influenced by the general policy.

Since no fast change in the social and economic relations can be expected in the modern world, the negative impacts of transport can be alleviated by adapting the general policy, by means of certain measures, as opposed to favouring natural advantages of single transport branches. A functional transport system can be realised by using selective principle of approach to its single modes in order to maximally reduce the harmful impacts on the social community. Accordingly, this paper will present certain guidelines that should primarily serve to optimise the rail and road transport regarding the reduction of negative impact on the environment, thus also enabling further development of the society in general.

2. COMPARATIVE CHARACTERISTICS OF RAIL AND ROAD TRANSPORT

2.1. In general

As special and very significant economic activity of transportation or transfer of people and cargo, transport contributes significantly by its adaptability to regional needs, to the design and evaluation of the space, as well as the overall economic and social development. By improving the environment, at the same time transport causes also numerous negative ecological consequences.

Rail transport, like road transport, performs transportation/transfer of significant quantities of cargo between close countries, particularly in Europe, where transport routes are short. The differences in the regulated size of tracks in different countries prevent the extensiveness of the railway. In comparison with its biggest competitor, the road, rail transport and traffic belongs to the category of minor environmental polluters (Table 1, Figures 2 and 3) [12]. Furthermore, double-track railway line occupies a space which is 15 metres wide, and it can transport in one hour the same number of people and cargo as transported by a 16-lane motorway 122 metres wide [12]. Moreover, rail traffic saves energy based on the large mass of trains and no frequent stopping and starting. If only 5% of cargo that in the developed countries is transported by road were redirected to the transport by electrified lines, one sixth of the total quantity of petroleum imported by these countries from Middle East would be saved.

Road transport, besides all its advantages, is characterised as a transport mode that by its strong development to the satisfaction of individuals, has become very unfavourable at the expense at the collective level. Dynamic development of global road transport, and the increase in the number of vehicles of only several million vehicles at the beginning of the 20th century to more than 600 million in 1995 or according to estimates to about one billion until 2010, is the main generator (98%) of external transport costs (traffic accidents, traffic conflicts and congestions, noise, air pollution, water pollution, forest destruction, climate changes and landscape devastation), which form about 2.5% of gross domestic product of the European Union countries [3]. Especially increased are the harmful emissions of CO_2 that are directly dependent on the fuel consumption, so that, although the reduction of average fuel consumption in road traffic is noticeable, due to absolute increase in traffic an increase in the overall quantity of emitted CO_2 in the mentioned transport modes is expected. Harmful emissions that are released into the atmosphere during the combustion of fossil fuels in greater quantities contain as chemical compounds carbon dioxide (CO_2), carbon monoxide (CO), hydrocarbons (CH), nitrogen oxides (Nox), sulphur dioxide (SO_2), solid particulates, soot and heavy minerals. According to the data of the European Union Commission, about 80% of carbon monoxide (CO) are released in road transport, out of which passenger cars account for as much as 55.4% [3]. Thus, for instance, at some Zagreb intersections the

concentration of CO is as much as 35mg/m^3 which is 3.5 times more than the world standard which is 10mg/m^3 [12]. Furthermore, road transport due to the use of fossil fuels is responsible for 25% of global emission of carbon dioxide, and an average car releases annually almost as much CO_2 as it weighs itself [12]. For one hour driving along a motorway at a speed of 130 km/h a passenger car spends as much oxygen as one person breathing over a period of ten days [12]. Out of all sources of communal noise in the cities 80% is traffic-generated noise, the most of which (more than 50%) is accounted for by road transport, 18% by rail-transport, and 13% by air traffic [6].

2.2. Energy consumption and emissions

Analysis of data on final energy consumption helps estimate the scale of environmental impacts of energy use, such as air pollution, global warming and oil pollution (see correlation in Figure 1). They can be used to help monitor the performance of key policies aimed at modifying energy consumption and stimulating energy efficiency. The type and extent of energy-related pressures on the environment depends both on the sources of energy (and how they are used) and on the total amount of energy consumed. Final energy consumption covers all energy delivered to the final consumer's door (in industry, transport, household and other sectors) for all energy uses. Deliveries for transformation and/or own use in the energy producing industries, as well as network losses are not included [12].

Nearly the entire energy consumption of the transport sector consists of fossil fuels. In fact, according to the European Environment Agency, the EU-25[1] is 98 % dependent on them.

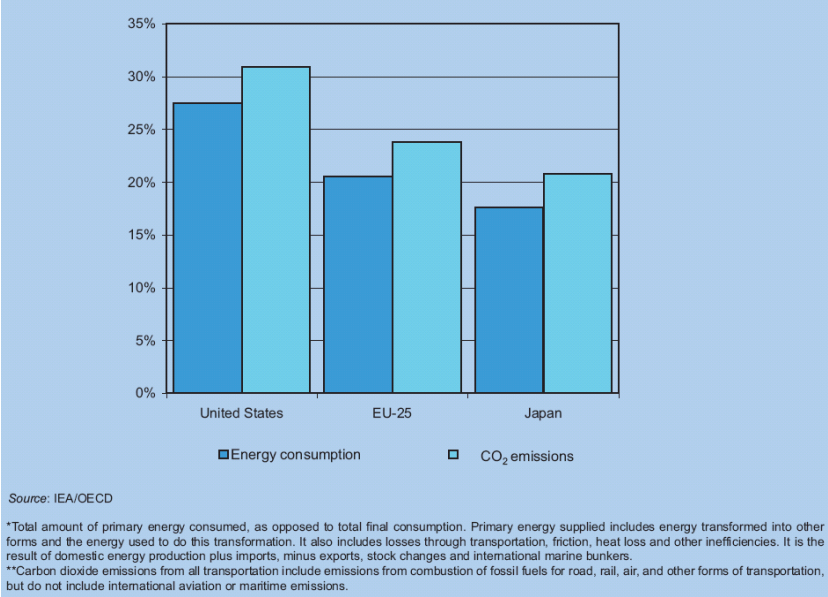


Figure 1 - Importance of transport in total primary energy supply and in total CO_2 emissions, EU-25, United States and Japan, 2004 (%)
Source: Transport energy consumption and emissions (http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Transport_energy_consumption_and_emissions)

Table 1 shows that within the transport share in the EU-25 countries, road transport was clearly the largest energy consumer, consuming almost 83% of the total in 2004, or 290 million tonnes of oil equivalent (mtoe). This translates as over a quarter of the total final energy consumption in the EU (i.e. transport, industry, households and services). Rail

[1] EU-25 - EU-15 + Poland (PL), Czech Republic (CZ), Cyprus (CY), Latvia (LV), Lithuania (LT), Slovenia (SI), Estonia (EE), Slovakia (SK), Hungary (HU), Malta (MT)

transport accounted for 2.5%, with electric traction accounting for 66% of all rail energy consumed [12].

Table 1 - Evolution of final energy consumption in transport, by transport mode, 1990-2004, EU-25 (in million toe)

	1990	1995	2000	2001	2002	2003	2004	% change 1990-2004
Transport	**272**	**295**	**334**	**337**	**339**	**345**	**352**	**29%**
Rail transport	9.1	8.8	9.2	9.1	9.0	9.1	9.3	1%
% share	3.4%	3.0%	2.8%	2.7%	2.7%	2.7%	2.6%	
Road transport	228.0	245.5	274.0	278.4	282.0	284.8	290.0	27%
% share	83.8%	83.3%	82.1%	82.7%	83.1%	82.7%	82.5%	

Source: Transport energy consumption and emissions (http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Transport_energy_consumption_and_emissions)

As illustrated in Figure 2, between 1990 and 2004 energy consumption rose by 67% in aviation, which was considerably greater than the 27% growth recorded for road transport. Energy consumption in rail transport went up only marginally by 1%. In absolute terms however, road transport consumed an extra 62 million toe (mtoe), rising from 228 mtoe to 290 mtoe. Energy consumption in rail transport went up only marginally by 1%. In the main these changes in energy consumption reflect the growth or decline in the popularity of transport modes, but also partly the development of more fuel-efficient traction technology. In rail transport for instance, the consumption of electricity for rail traction is generally increasing due to the growing share of electrified lines, which has been displacing diesel fuel usage [12].

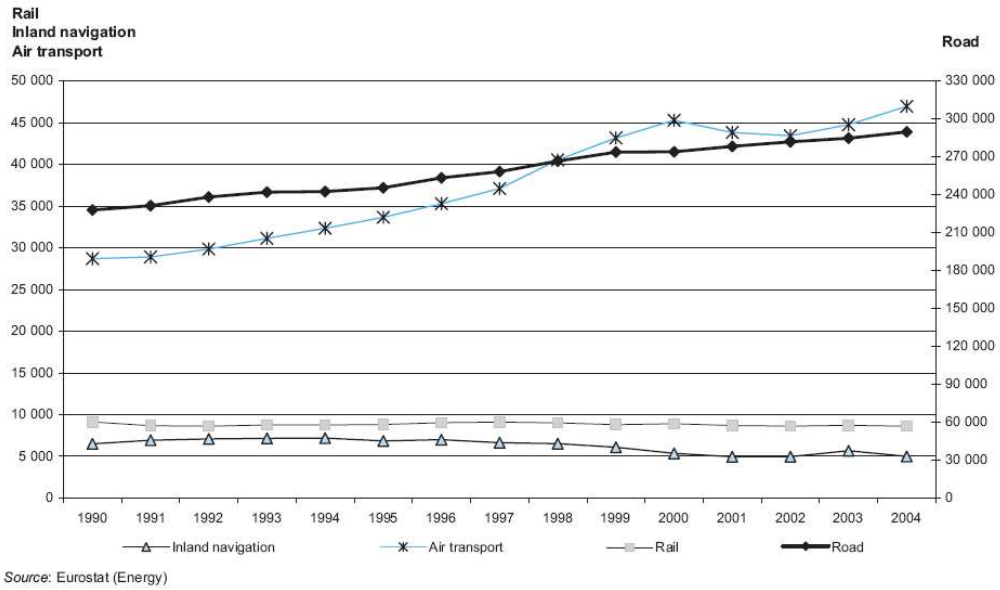


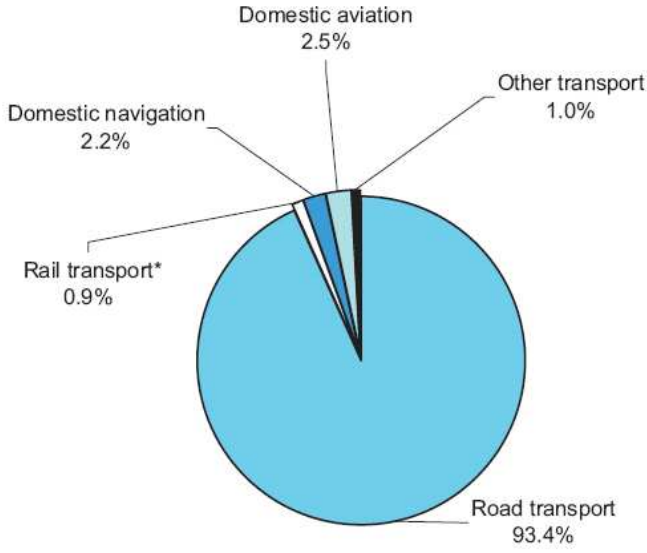
Figure 2 - Evolution of energy consumption of main fuels by transport mode, EU-25 (in thousand toe)

Source: Transport energy consumption and emissions (http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Transport_energy_consumption_and_emissions)

As one could have suspected with the 83% share of transport energy consumed by road transport (as previously mentioned), this mode remains by far the largest single emitter. According to the European Environment Agency, 93% of greenhouse gas emissions from

transport came from road transport in 2004 (see Figure 3). Moreover, although rail transport seems to have been the smallest polluter, with an apparent share of 0.9%, the true proportion would be larger than this if electric traction were also taken into consideration. The share of electricity in total rail energy consumption was 66%, twice the share of diesel energy. Perhaps not surprisingly, road transport also accounted for 76% of ozone precursor emissions, 72% of particulate matter and 71% of acidifying substances emitted in transport. However, here again, these shares are artificially inflated with a view to the particles emitted. Technologically speaking, the new emission standards under *Euro V* fuel regulations effectively make the use of particle filters and catalytic exhaust clean up compulsory [12].

Compared to road transport, rail transport undoubtedly features the advantages proven regarding traffic safety, energy consumption and environmental protection. It should be noted that in Europe every year 10 million tonnes of harmful cargo are transported without any serious incidents [3].



Source: European Environment Agency

* Data cover diesel (and some coal-powered) trains only; electric traction is therefore excluded.

Figure 3 - Greenhouse gas emissions from transport by transport mode, EU-25, 2004 (in %) *(http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Transport_energy_consumption_and_emissions)*

3. PROPOSAL OF GUIDELINES FOR OPTIMISATION OF RAIL AND ROAD TRANSPORT

Starting from the previously indicated assumption that the developed world is already faced today by the shortage of propelling energy and increasing environmental pollution with the highest participation of transport, the transport system needs to be rationalised and its development harmonised with the social and economic requirements. Recently, international institutions, social and economic associations, professional circles as well as individuals have been engaged in these issues. The measures that are proposed and undertaken are mainly directed to finding the possibilities of substituting the current method of fuel production by some new solutions. This partial approach supports the sustaining of the current situation not changing in any major way the resulting relations. The transport system rationalisation regarding distance transport can certainly be done by combining road and rail transport mode using the natural advantages of each one of them. The basic guidelines that might contribute to the reduction of the harmful impact of the considered transport sectors as a set of measures should include:

- revitalisation of railways,
- improvement of the quality of road transport and reduction of its growth,
- turning multimodality of transport into reality,
- development of high-quality urban transport,
- greater implementation of technologies at service to clean and efficient transport.

3.1. Railway revitalisation

Rail transport is at the same time both old and modern transport depending on the approach applied to it by the social and economic community. Thus, there was a period of the implementation of steam engine at the railways in the distant past to the implementation of a system which uses the principle of magnetic levitation today and will probably use it even more in the future. Regarding the previously mentioned advantages of the railway, and with the aim of greater implementation, it is necessary to adjust the approach through the following activities:

- increase the market share of railway in cargo transport by at least 5%, and in passenger transport by 10%,
- triple the operability of labour at the railways,
- increase the efficiency of propelling energy by 50%,
- increase the capacity of infrastructure so that it would be proportional to transport objectives,
- adjust the transport capacities to the transport market requirements.

3.2. Improvement of road transport quality and reduction of its growth

Over the last several dozens of years, due to the simplicity of using passenger cars, road transport has experienced sudden growth with the tendency of further uncontrolled increase. On the other hand, it is the most harmful factor in the transportation system regarding harmful emissions, fuel consumption, occupying substantial areas of land, noise generation, etc. Therefore, this unwanted and harmful phenomena have to be put under control by acting on the efficiency plan of this transport mode in compliance with the sustainability of the quality of living and the environmental system on the Earth. The measures to control the development of road transport should be oriented towards:

- reduction of the share of road transport by shifting a part of the transportation of people, cargo and goods to the railways;
- reduction of the number of vehicles in urban environments by shifting to public urban transport;
- production and use of road vehicles of lower power in order to reduce pollution and fuel consumption,
- production and greater application of road vehicles using alternative fuels and fuels with less sulphur;
- production and use of electric cars in spite of shorter range, but with cheaper and regarding energy more rational alternative.

3.3. Turning multimodality of transport into reality

Multimodal transport refers to the use of two or more carriers of different modes during the movement of a shipment from one country to another. The basic reasons for using multimodal transport are the characteristics of each single transport mode. One may say that multimodal transport connects the points of origin and of destination in the best possible way. Owing to the development of advanced transport technologies such as: palletisation,

containerisation, RO-RO, LO-LO, RO-LO, FO-FO, Huckepack and Bimodal transport technologies, multimodal transport has gained increasingly in significance, and based its consideration focus on an integrated approach, directing it to all the essential factors that participate or can participate in the transportation of cargo from the point of receipt to the point of delivery and thus contribute to the increase in the efficiency and effectiveness of the transport and traffic system as a whole, with minimum negative effects for the health of people, nature and the environment. Being familiar with the advantages and drawbacks of advanced transport technologies makes it possible to select the optimal combination of the mentioned technologies and to minimise the negative consequences which destroy the ecosystem. However, it has not been significantly implemented in practice. This is due to the fact of free behaviour of the economic subjects regarding the meeting of their partial interests. The social community, having learnt from this experience, should use certain measures to protect the general interests of people. These measures can be administrative, developing or practical ones. The measures that would stimulate multimodal transport should highlight its advantages for the community recognising the natural advantages of single transport modes. In other words, each transport branch would act on the principle of increasing the usage of its advantages and reducing its drawbacks.

3.4. Development of high-quality urban transport

The only alternative to the congestion in big cities by road vehicles is the development of a modern public urban transport. All the previous unorganised solutions of the civilisation regarding concentration of the public, administrative, catering, economic, cultural, and other facilities into the big cities have now started to take their toll. On the other hand, it is not possible for this alternative to follow by far the resulting needs. Today, in different countries and their cities we have different solutions that have a common denominator, which is that they are insufficient. This problem results from the lack of the right ideas with concrete solutions, too slow decision making and indolent approach to their realisation. On the contrary, the individuals with passenger cars act operatively, following the line of least resistance and without rejecting comfort, which is not exactly comfort in case of congestion. Consequently, it is hard today to come to momentary solutions since the development of high-quality urban transport is subject to a long-term cycle. However, the unsustainability of the current traffic situation, particularly in big cities, imposes the need for immediate action. It is possible to act parallel at the strategic, tactical and operative levels:

a) Strategic level:

- qualitative and quantitative analysis of the concrete conditions,
- conceiving and making long-term plans,
- making mid-term plans for the realisation of long-term objectives.

b) Tactical level:

- integration of urban and suburban public transport,
- expansion of current infrastructure of public transport,
- increase in the public transportation capacities,
- raising of travelling comfort quality,
- regulation of traffic that favours public transport.

c) Operative level:

- giving significant priority to public urban transport,
- more available information about the timetable of public transport components,
- greater punctuality of public transport,

- better and faster transportation capacities,
- passenger terminals made more attractive,
- purchase of a single fare online for all transport means.

3.5. Greater implementation of technology supporting clean and efficient transport

Since it has been proven that the transport is a significant factor of environmental pollution and fuel consumption, in order to alleviate the negative effects of this fact it is necessary to act also through the implementation of the technologies that support cleaner and more efficient transport. At today's level of development of such technologies in relation to the needs to reduce the harmful effects, no revolutionary results can be achieved. However, it is possible to improve the situation by partial solutions, and to mitigate the condition by a set of measures.

Certain technologies that may be available include:

- implementation of intelligent transport systems that rationalise transport per quantity and travelling time, at the same time reducing the environmental pollution and fuel consumption,
- intermodal regional and national transport,
- implementation of clean vehicle propelling technologies,
- development of clean and efficient engines,
- implementation of alternative and cleaner fuels,
- implementation of propelling energy outside the fossil fuels.

4. CONCLUSION

The aim of elaborating the problems in this paper has been to give incentive to a different approach and method of considering the existing and run-in conditions of the transport systems in order to stimulate the preparation and introduction of newer and more advanced technologies. Today's world is facing the necessary evil called transport, which, considered over a long term, functioning in this way, is threatening the humans, their ecological system on earth and depletion of the natural energy sources. Apart from favouring the transport systems, it is important for the social community to stimulate at the global level the rationalisation of every kind, and especially referring to significant savings of energy sources and environmental protection. Road transport, apart from its main negative characteristic reflected in the emission of harmful gases, features an entire number of positive characteristics, some of which include: higher transport speed, greater mobility, and possibility of direct door-to-door transport. The advantages of rail transport reflected primarily from the ecological aspect through the reduction of harmful gas emissions, and the high occupancy of transport i.e. transport of a large number of passengers and greater cargo mass, as well as the aspect of safety should lead to the renaissance of the rail system in the future.

As the generator of transport and traffic demands, the population should set new targets for the advanced economy, related to the environmental protection, in order to prevent the current economic and transport trends from leading to a more serious degradation of the environment. Transport and traffic face a special problem of finding an efficient response to the resulting needs through the implementation of the proposed guidelines and greater implementation of advanced transport technologies and its transport modes.

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