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THE ENVIRONMENTAL AND SOCIAL COSTS OF THE INTERMODAL TRANSPORT OF SEMI-TRAILERS BY RAIL

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Abstract

The dynamic development of transport recorded in recent decades is an important factor in the economic development of the world on the one hand, and on the other hand, it is a significant source of nuisance and environmental problems. The adverse impact of transport can be felt both in the natural environment and in society, where the dynamic development of this sector has enabled significant civilization development, with the effects varying depending on the level of economic development, the degree of advancement and use of the various transport sectors, geographical location (including climate), and also the sensitivity of the elements of the environment. Considering contemporary transport hazards, it is important to prevent them from occurring, and when that is not possible – limiting their impact on the environment and reducing the scale and extent of negative impacts.

In the article, the environmental and social nuisance of transport of goods loaded in semitrailers was analysed. The transport of semitrailers using intermodal wagons pulled by the diesel locomotive in accordance with the assumptions adopted in the railway with the maximum length of train composition was taken into account.

Keywords: *railway, intermodal transport, semi-trailer, environmental costs, social costs*

1. Introduction

One of the main objectives of the European Transport Policy (EPT) is to increase the share of alternative modes of transport – revitalization of rail transport, promotion of water transport and development of intermodal transport, which will help to reduce the dominance of road transport. In the European Union, railways account for 6.3% of total passenger transport and 10.9% of freight [10]. By 2020, it is planned to increase the share of railways in passenger transport to 10% and in freight to 15%, which should significantly reduce the negative impact of transport on the environment [10].

The impact of rail transport on the environment and safety is much lower compared to road transport. The impact of rail transport on the environment mainly relates to the emission of noise and vibration, pollution (from diesel locomotives) and land occupation. The emission of pollutants from rail transport in the European Union is estimated at 1-3% of total emissions from transport [8]. According to the European Environment Agency, rail transport in the EU accounts for 1.5% of total NO_x emissions [12].

It is worth mentioning that transport in the European Union is classified as a source of almost 54% of the total emissions of nitrogen oxides, 45% carbon monoxide, 23% non-methane volatile organic compounds and 23% PM10 and 28% PM2.5 dusts (particulate matter with diameters respectively 10 and 2.5 μm). It also accounts for over 41% of tropospheric ozone precursor emissions and 23% CO_2 emissions and almost 20% of other greenhouse gases emissions [12].

2. The analysis of pollutant emissions

For the purposes of this work, an authoritative environmental analysis was carried out to determine the nuisance for the environment of intermodal transport of loaded semi-trailers. The authors' experience in this field and market analysis have allowed to identify the most likely mode of transport using a train of 19 specialized intermodal wagons, carrying 38 semi-trailers (the length of the double wagon was 31.06 m). According to the rules adopted in the railway sector, the maximum train length without a locomotive did not exceed 580 m. It was also assumed that railway wagons were pulled by diesel locomotives whose engines comply with presented in Fig. 1 emission standards.

For comparative purposes, two diesel locomotives that meet the older exhaust emission standards: ORE B13 and UIC 2003, and two modern locomotives, whose drive units meet the Stage III and Stage IV standards, are indicated. The emission values per unit of energy were assumed on the basis of the data contained in the publication by Pielecha and Pielecha [9].

Figure 2 compares the percentage differences (in relation to the latest Stage IV standard) for each toxic substance. As the rolling stock is largely obsolete, a large number of locomotives only meet ORE B13 emission standards. It is clear from the calculations that when using such linear locomotives, the emission of toxic pollutants in the exhaust gas is even 24 times higher (as in the case of nitrogen oxides). Emissions of remaining gaseous compounds are 6-8 times larger.

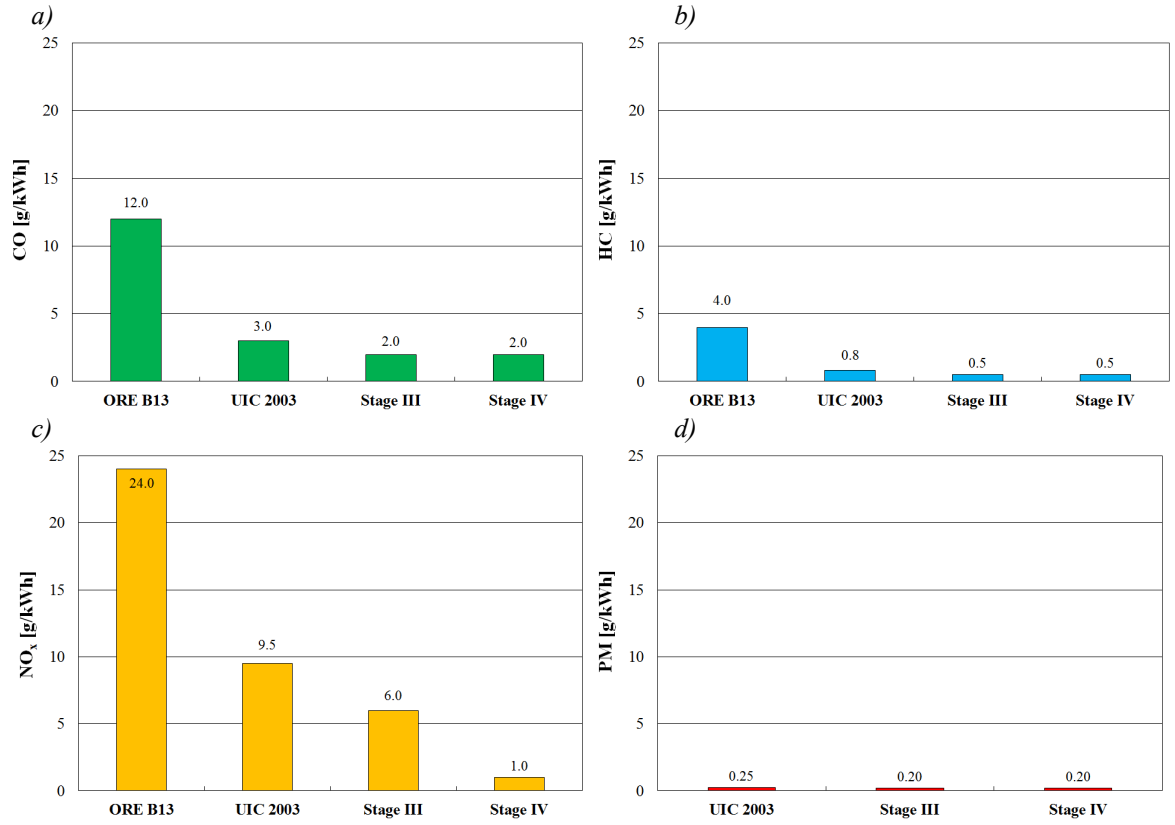

Fig. 1. The emission values of the individual toxic compounds for the respective emission standards of locomotives [10]: a) carbon monoxide, b) hydrocarbons, c) nitrogen oxides, d) particulate matter

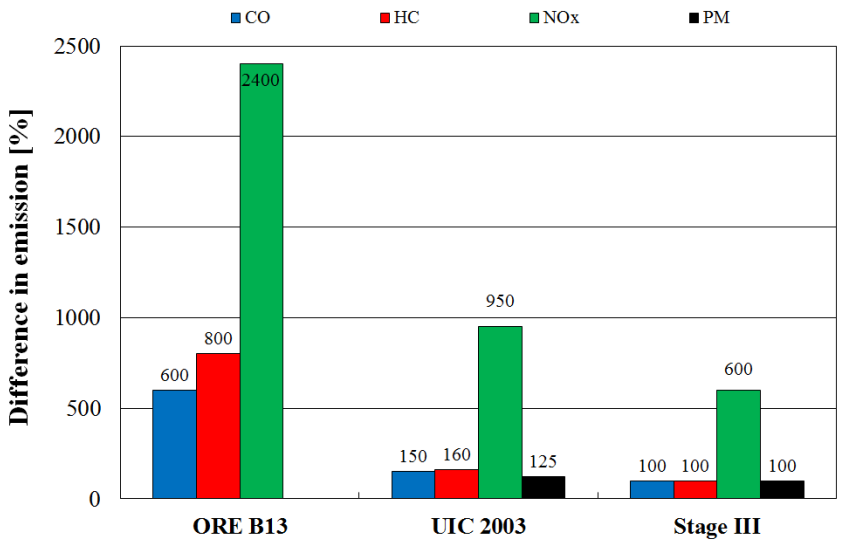

Fig. 2. Relative difference in emissions of harmful substances (Stage IV = 100%)

3. The analysis of the costs for society

External costs are one of the most important factors that are currently being considered in the assessment of individual transport sectors at strategic or general level, while the profitability analysis of services determines the assessment of the suitability of transport for its users. The external costs of transport are all the costs of consuming the resources to produce a transport service that is not borne by the service provider but by the general public [7]. External transport costs include costs associated with negative environmental and human impacts from transport activities, which are primarily attributable to [1, 7]:

- accidents,
- congestion,
- emission of noise,
- greenhouse gas emissions,
- pollution of water, soil and air,
- land occupancy and impact on landscape changes.

External costs are difficult to quantify accurately because it is not possible to determine who and to what extent is responsible for the damage caused. Some damage is also delayed, and there are also interactions between effects, both between the effects of human activity (and not just resulting from transport services) and natural phenomena. Furthermore, the damage itself cannot be directly converted into monetary value. This requires the development of methods of valuation based on, for example, willingness to pay or readiness to accept. Thus, the choice of technique used can influence the cost value, which in turn raises doubts about the level of correctness of evaluation [3, 4, 6]. In addition, costs vary depending on the specific location of transport infrastructure and transport [3, 6]. There are significant differences between the occurrence and extent of external costs depending on the transport sector.

The most important social cost is accidents. This especially applies to countries with high traffic accident statistics. In Poland, as much as 71% of external costs are the human and material effects of transport accidents. The remaining 29% is the cost of destructive impact of transport on the environment, of which:

- noise costs 11%,
- costs of air pollution 11%,
- costs of climate change 5%,
- other environmental costs 2%.

Transferring freight from road to rail transport causes a reduction in traffic flow on the roads, which directly contributes to reducing congestion in some traffic nodes and consequently reducing accidents and increasing road safety.

Table 1 shows the total external costs generated for transport operations of 1000 tkm, depending on the transport mode (for road and rail transport medium congestion costs were used). The average value of external costs for road transport is € 26.56 per 1000 tkm, while for rail transport only € 5.7 per 1000 tkm. Road transport costs four and a half times as much as rail transport and six to eight times as much as water transport. In cost calculation, the impact of the type of building, time of day and type of roads was averaged. Compared to the European Commission's 2002 estimates [5], the external costs of transporting goods by rail are 40% lower as a result of lower costs associated with accidents, noise and air pollution. External costs for road transport increased at the same time by 28%.

Tab. 1. The external global costs generated by different modes of transport [2, 11]

[€/1000 tkm]	**Road transport (semi-trailers)**	**Railway transport**	**Inland shipping**	**Short sea shipping**
Accidents	10.2	0.2	0	0
Noise level	1.8	1.0	0	0
Air pollution	6.7	1.1	3.6	2
Greenhouse gas emissions	1.7	0.2	0.6	irrelevant
Infrastructure	2.5	2.9	1	< 1
Congestion costs*	0.4-7.0	0.1-0.5	irrelevant	irrelevant
Sum	**23.2-29.9**	**5.5-5.9**	**about 4.2**	**about 3.0**

** Depending on the type of roads and buildings*

By analysing the total external cost, 93% of the share is transported by road, with 61% of the costs of passenger cars, trucks for 13%, vans for 9%, single wheels for 6% and buses for 4% [2]. Air transport generated in the EU (internal flights only within the EU) 5% of external costs; rail transport 2% and inland water transport 0.3%. The high share of road transport is due to the significant share of this mode in transport, as well as to the high average external costs of the passenger-kilometre and tonne-kilometre.

By evaluating the scale of external accident costs, the most important factor in social impacts, it turns out that rail transport (assuming 348 Mg by train) reduces the cost of accidents in urban areas by 98% and 91% in undeveloped areas – in relation to the transport of the 33 Mg semi-trailer [1]. By using intermodal transport, it is possible to reduce the external costs of accidents by 82 to 88% for railways at 90% of usage and 55 to 59% for rail share at 60%.

4. Conclusions

Development of multimodal transport improves the prospects for global markets. In the case of Poland, it is possible to strengthen the country as a liaison between Western Europe and Eastern Europe and Russia. For customers on long haul routes, multimodal transport gives economic advantages and enables savings. As for the benefits in terms of ecological aspects, they occur when modern diesel locomotives are used for transport. The use of old rolling stock causes high levels of pollutant emissions in the exhaust gases.

The most important economic benefits of combined transport are generated at a macroeconomic level in a broad socio-economic context. These benefits are expressed by the cost savings associated with reduced external costs and infrastructure costs.

Further work on the subject will include, inter alia, a comparative analysis of the transport of semi-trailers by rail and the use of trucks.

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